ARR040000 Recertification Notice of Intent for Regulated Small Municipal Separate Storm Sewer Systems (MS4�s) General Permit

version 1.17

(Submission #: HQ3-3PAR-W36KZ, version 1)

Details

AFIN	10-00514
Submission ID	HQ3-3PAR-W36KZ
Submission Reason	Renewal

Form Input

Permit Information

Recertification Instruction

Please review all fields carefully for typos or inaccurate information. If the information in the corresponding field is incorrect, please update the corresponding field with the correct information by typing over the existing information.

If the Permittee (Legal Name) changes, you will need to also submit a permit transfer form.

The update SWMP must be submitted in accordance with the permit.

Permittee (Legal Name)

The permittee means any person (an individual, association, partnership, corporation, municipality, state, or federal agency) who has the primary management and ultimate decision-making responsibility over the operation of a facility or activity.

Permit No.
ARR040064

AFIN
10-00514

Permittee (Legal Name)
City of Arkadelphia

Site Contact Person

Contact Person Information

First Name	Last Name
Gary	*Brinkley*

Title
City Manager

Phone Type	Number	Extension
Mobile	8704036860	

Email
gary.brinkley@arkadelphia.gov

Urbanized/Core Areas
Arkadelphia

Receiving Stream
Maddox and Mill Creek

Is this MS4 identified on the list of the EPA approved Total Maximum Daily Loads (TMDL)?
No

From our database, the Responsible Official are listed in the following

Responsible Official First Name
Gary

Responsible Official Last Name
Brinkley

Responsible Official Title
City Manager

Did the Responsible Official Change?
No

Please provide the Responsible Official Email Address
gary.brinkley@arkadelphia.gov

From our database, the Cognizant Official are listed in the following

Cognizant Official First Name
Gary

Cognizant Official Last Name
Brinkley

Cognizant Official Title
City Manager

Did the Cognizant Official Change?
No

Please provide the Cognizant Official Email Address
gary.brinkley@arkadelphia.gov

Mailing Address
> 700 Clay Street
> Arkadelphia, AR 71923

Is the invoice address the same as the mailing address?
Yes

Attach Updated SWMP and Updated Storm Sewer System Map
> Stormwater Management Program_final.pdf - 05/15/2024 02:19 PM
> **Comment**
> NONE PROVIDED

Agreements and Signature(s)

SUBMISSION AGREEMENTS

- [x] I am the owner of the account used to perform the electronic submission and signature.
- [x] I have the authority to submit the data on behalf of the facility I am representing.
- [x] I agree that providing the account credentials to sign the submission document constitutes an electronic signature equivalent to my written signature.
- [x] I have reviewed the electronic form being submitted in its entirety, and agree to the validity and accuracy of the information contained within it to the best of my knowledge.

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

I certify that I have read and will comply with all the requirements of the Regulated Small Municipal Separate Storm Sewer Systems(MS4's) General Permit ARR040000.

Signed By Gary Brinkley on 05/17/2024 at 12:04 PM

STORMWATER MANAGEMENT PROGRAM

Table of Contents

I. PERMIT COVERAGE

The Arkansas Department of Environmental Quality (ADEQ) has issued General Permit ARR040000 which authorizes Regulated Small Municipal Separate Storm Sewer Systems (MS4s) located within the State of Arkansas to discharge stormwater to a receiving water. Arkansas cities with a population greater than 10,000 persons and with a population density greater than 1,000 persons per square mile that discharge to an Ecologically Sensitive Waterbody (ESW) are covered under this permit. Arkadelphia stormwater discharges to the Ouachita River which, according to ADEQ Regulation 2-Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas, is an ESW due to the presence of the flat floater, Ouachita rock pocketbook, and pink mucket mussels in the river.

General Permit ARR040000 is effective August 1, 2024, and it expires July 31, 2029. Arkadelphia is authorized to discharge stormwater and certain non-stormwater discharges, as defined in Section 1.2.2.2 of the permit, after it submits its Notice of Intent (NOI), application fee, and Stormwater Management Program (SWMP) to ADEQ.

NOI is submitted electronically through DEQ Portal.

II. STORMWATER MANAGEMENT PROGRAM (SWMP)

The SWMP is designed to reduce the discharge of pollutants from the MS4, to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act. The SWMP includes management practices, control techniques and system, design, and engineering methods to meet these goals.

The SWMP Table of Organization is included on the following page.

According to correspondence with the U.S. Fish and Wildlife Service, the mussels in the Ouachita River are sensitive to many contaminants including, but not limited to, metals, pesticides, herbicides, nutrients, organics, chlorine, and pharmaceuticals.

SWMP TABLE OF ORGANIZATION

ADEQ

Stormwater Permitting Agency

↓

City of Arkadelphia

Stormwater Permittee

↓

City Manager

Primary Point of Contact

870-246-9864

↓

Building Department Supervisor

SWMP Implementation

870-246-1818

The following are the control measures to be implemented as part of the SWMP.

A. Public Education and Outreach on Stormwater Impacts

1. The public education and outreach program consists of two mechanisms and numerous messages described as follows:
   a. Only Rain in the Drain!
      The “Only Rain in the Drain!” brochure is a storm drain art walk designed to build stormwater awareness on the streets of Arkadelphia through local artwork on storm drain inlets. This program element existed at the time of the development of this program.
      Messages include but are not limited to:
      - No used oil in storm drains
      - No leaves in storm drains
      - No construction debris in storm drains
      - No solid waste in storm drains
   b. Mussel Up Badgers – This public awareness theme, using the City’s high school mascot in combination with the ecologically sensitive mussel, will be used in public service spot opportunities to raise awareness of stormwater pollution prevention.
      Messages include but are not limited to:
      - Proper use of pesticides and herbicides
      - Proper disposal of herbicides and pesticides
      - Proper disposal of pharmaceuticals
      - Proper use of fertilizers

2. The target audiences for both elements will include commercial, industrial, educational and institutional entities, and the public.

3. The target pollutants include metals, pesticides, herbicides, nutrients, organics, chlorine, and pharmaceuticals.

4. Outreach strategy will include brochures, the City’s web page, and media outlets, reaching as many people as possible.

5. The Building Department Supervisor is responsible for public education and outreach.

6. The “Only Rain in the Drain!” is an ongoing element. At least 3 presentations of Mussel Up Badgers will be made over the permit term, with at least one message targeted to the land development community. The goal is to reach at least 50 percent of the population over the permit term.

7. Public education and outreach efforts shall be documented in the Annual Report.

B. Public Involvement/Participation

1. The stormwater program was developed and approved through the City's planning and approval process, culminating with City Board approval. To ensure public engagement in the development and improvement of the NOI and SWMP, the city has implemented the use of TextMyGov communications program.

2. Targeted audiences for presentations of the program include Henderson State University, Ouachita Baptist University, Arkadelphia public schools, city departments, contractors, civic organizations, garden clubs.

3. The city shall guide the emphasis of educational materials, educational programs, and public involvement efforts. The public involvement/participation program shall include at least 5 public involvement activities over the permit term. Examples may include storm drain marking, clean up days, rain barrel workshops, community events, and a community rain garden. Public participation activities will be documented.

4. The communications program, TextMyGov, will allow citizens to submit city-wide issues and provide opinions/suggestions regarding the SWMP, as well as other related topics (Serves as a water quality hotline). Several other communication channels will be used to engage with the public. Messages related to SWMP, and water quality are included in the city's water bills. Informational brochures are distributed at five strategically placed locations around town. Budget funds have been allocated for a message board, which will be implemented in 2024 to inform the public on updates and information on the SWMP.

5. The City of Arkadelphia Building Department will oversee all aspects of the SWMP. This includes monitoring public involvement and participation tracking, as well as the BMP's identified in this program.

6. TextMyGov is equipped with a comprehensive logging system to facilitate tracking and evaluation of public input received. The data collected will be regularly reviewed to assess the feedback and identify potential areas for improvement within the SWMP.

C. Illicit Discharge Detection and Elimination

1. A storm sewer system map is included in Appendix C and Appendix E.

2. The Building Inspections Officer will work to detect and eliminate non-stormwater discharges. The Building Inspections Officer will work with City water and sewer crews, Henderson State University, and Ouachita Baptist University personnel to define and eliminate non-stormwater discharges. The city of Arkadelphia ensures compliance with the Arkansas ICC building codes, which will be the best practice for managing and mitigating any MS4 concerns regarding the MS4.

3. The city to this point has not identified any non-storm water discharges as significant contributors of pollutants to the MS4.

4. The storm sewer map was developed as part of a stormwater management analysis. Arkadelphia's water and sewer company works directly with customers to ensure water and sewer connections remain adequate. The on-site employees will continue to diligently monitor any areas with a higher likelihood of illicit connections. Given that Arkadelphia has a significant number of underground springs, the necessity for ongoing and thorough inspections is a constant demand. If any water is found during inspections of drainage basins or if continuing water with no obvious source is discovered, then the staff with research until the point of origin. Water will continue to be tested for chlorine to ensure an illicit discharge has not occurred.

5. The city has adopted the ordinance included in Appendix D.2. Additionally, the city of Arkadelphia will display a message board in their lobby with vital information regarding the subject matter, as well as social media posts. The TextMyGov communication system will be in place as mentioned in section III.2B, along with another emergency texting medium called Rave.

6. The Building Inspections Officer will screen both the Maddox and Mill Creek drainages during dry weather at least once per year over the permit term.

7. The annual report will include the following:
   a. Number of dry weather outfalls screened
   b. Number of dry weather flows identified
   c. Number of illicit discharges identified
   d. Number of illicit discharges eliminated
   e. Schedules for elimination of illicit discharges identified but not eliminated
   f. Summary of storm sewer map updates

The city will continue monitoring to prevent any illicit discharges. If one is detected, it will immediately be addressed. Throughout the annual report, the city will be able to determine the success rate.

D. Construction Site Stormwater Runoff Control

1. To help lessen the impacts of construction activity stormwater, the city has adopted the ordinance included in Appendix D.1. The ordinance incorporates the “Stormwater Drainage Design Manual and Floodplain Compliance Guideline” by reference.

2. The Building Inspections Officer is responsible for implementing the ordinance. City staff also performs inspections before and after any significant rain events to ensure compliance with Erosion and Sediment control regulatory mechanisms. If non-compliance is observed, the city does issue stop work orders and/or impose fines.

3. The Building Inspections Officer shall conduct pre-construction site plan reviews (reviews of construction site Stormwater Pollution Prevention Plans) at 100 percent of projects from construction activities that result in a land disturbance of 1 acre or more. For more details on waste control on sites, reference Part III.2.F within this permit.

4. The annual report will include the following:
   a. Number of applicable construction sites in the MS4’s jurisdiction
   b. Number of pre-construction site plan reviews performed
   c. Number and frequency of site inspections
   d. Number of violation letter issued
   e. Number of enforcement actions taken
   f. Number of complaints received, and number followed up on

5. City staff contains and maintains a binder of all communications received from the public in the Building Department office. Annually, these are evaluated to ensure the concerns are being addressed.

6. To ensure compliance with the Construction Site Stormwater Runoff control, the city will maintain a log with all construction site visits. The log will include whether the sites meet requirements for stormwater runoff and if there were any issues (and how they were addressed).

E. Post Construction Stormwater Management in New Development and Redevelopment

1. The city has adopted a Stormwater Management Analysis (Appendix E) and Stormwater Drainage Design Manual and Floodplain Compliance Guideline (Appendix F).

2. These two items are implemented by the City and are overseen by the Building Inspector and Building Department Supervisor or designee.

3. The Building Inspections Officer shall conduct a pre-construction site plan review (for compliance with local requirements for post construction management of stormwater) of 100 percent of projects from construction activities that result in a land disturbance of 1 acre or more to help ensure that required controls are designed per requirements.

4. The annual report will document the following:
   a. Number of construction sites requiring post construction controls
   b. Number of pre-construction site plan reviews performed
   c. Number of inspections performed to ensure as built per requirements
   d. Compliance rates with MS4 requirements
   e. Number of long-term operation and maintenance plans developed and agreements in place

5. Low Impact Development – The MS4 will review its codes to evaluate the need to remove impediments to low impact development and green infrastructure. The City will include information on efforts to identify and remove impediments to low impact development in the post construction program element of the Annual Report in the fourth year of this renewal permit term.

6. To ensure the post construction sites have complied, the city will conduct in-house evaluation to verify that each of the construction sites stated has been reviewed. This shall be documented and logged for informational purposes and bookkeeping.

F. Pollution Prevention/Good Housekeeping for Municipal Operations

1. A pollution prevention/good housekeeping program for municipal operations will be developed to address the following potential pollutant sources associated with municipal operations: pesticides, herbicides, erosion control, nutrients, litter, fleet maintenance, building maintenance, and land disturbances.

2. The program will include annual employee training for the following departments: water and sewer, parks and recreation, street, and public school. The training will also be offered to Henderson and Ouachita.

3. This training program will be developed by the Building Department Supervisor. Annual employee training will be offered to the departments and entities listed above.

   i. Maintenance activities that the building inspectors could conduct to reduce floatables and other pollutants include but are not limited to:
      - Ensuring storm water catch basins are clear of debris.
      - Ensuring job sites follow regulations for excess trash.
      - Conducting inspections before and after rain events to ensure street drains are clear of debris.
      - Failing storm pipes are to be replaced, thus eliminating silt and debris.
      - Oversee street department on bi-monthly street sweeping to eliminate debris in storm water system (Sweeping streets and city parking lots).
      - Ensure the City provides pet waste disposal bags at parks and provide enough trash receptacles in such areas.

   ii. Bi-annually, the city participates in a household hazardous waste cleanup event in which residents can dispose of toxic materials free of charge to a certified disposable company.

   iii. The city of Arkadelphia uses a knowledgeable engineering firm that is proficient in storm water management system design and implementation to ensure the best practices are followed.

4. To ensure compliance with Pollution Prevention/Good Housekeeping for municipal operations, the city will maintain a log with all municipal operations site visits. The log will include whether the sites meet requirements and if there were any issues (and how they were addressed).

5. The annual report shall document the following:
   a. Summary of employee training programs presented and number of attendees
   b. Summary of activities and procedures implemented for the operation and maintenance program

G. Monitoring

1. The city does not discharge into a TMDL or 303(d) impaired system.

III. SHARING RESPONSIBILITY

Portions of this program will be offered to the Arkadelphia Public Schools, Henderson State University, and Ouachita Baptist University.

IV. REVIEWING AND UPDATING SWMP

The City shall review the SWMP in conjunction with the preparation of the Annual Report, as described in Section IV of this SWMP. The method to change the SWMP is described in part 3.4.2.1 of the General Permit. ADEQ may require changes to the SWMP.

V. EVALUATING, RECORD KEEPING AND REPORTING

The City shall evaluate the effectiveness of the SWMP on an ongoing basis. The City shall retain a record of this SWMP, NOI, Annual Reports, and related data for the term of this permit through July 2029. The city must retain a copy of the SWMP and its records at a location accessible to ADEQ and the public.

ADEQ
Office of Water Quality, General Permits
5301 Northshore Drive
North Little Rock, AR 72118

Or, to the following email address: water-permit-application@adeq.state.ar.us

VI. CERTIFICATION

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

______________________________ ____________________
City Manager Date

CITY OF ARKADELPHIA
MUNICIPAL SEPARATE STORM SEWER SYSTEM
STORMWATER MANAGEMENT PROGRAM

ARKANSAS DEPARTMENT OF
ENVIRONMENTAL QUALITY

NPDES REGULATED SMALL
MS4 STORMWATER
GENERAL PERMIT

ARR040000

Prepared for

City of Arkadelphia, Arkansas

Prepared by

May 2024

24003

CRIST ENGINEERS, INC.

www.cristengineers.com

1 Executive Center Court
Little Rock, Arkansas 72211

Telephone: 501.664.1552
Fax: 501.664.8579

STORMWATER MANAGEMENT PROGRAM

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NOI is submitted electronically through DEQ Portal.

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According to correspondence with the U.S. Fish and Wildlife Service, the mussels in the Ouachita River are sensitive to many contaminants including, but not limited to, metals, pesticides, herbicides, nutrients, organics, chlorine, and pharmaceuticals.

SWMP TABLE OF ORGANIZATION

ADEQ

Stormwater Permitting Agency

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City of Arkadelphia

Stormwater Permittee

↓

City Manager

Primary Point of Contact

870-246-9864

↓

Building Department Supervisor

SWMP Implementation

870-246-1818

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      Messages include but are not limited to:
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      - Proper disposal of herbicides and pesticides
      - Proper disposal of pharmaceuticals
      - Proper use of fertilizers

2. The target audiences for both of these elements will include commercial, industrial, educational and institutional entities, and the general public.

3. The target pollutants include metals, pesticides, herbicides, nutrients, organics, chlorine, and pharmaceuticals.

4. Outreach strategy will include brochures, the City's web page, and media outlets, reaching as many people as possible.

5. The Building Department Supervisor is responsible for public education and outreach.

6. The "Only Rain in the Drain!" is an ongoing element. At least 3 presentations of Mussel Up Badgers will be made over the permit term, with at least one message targeted to the land development community. The goal is to reach at least 50 percent of the population over the permit term.

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2. Targeted audiences for presentations of the program include Henderson State University, Ouachita Baptist University, Arkadelphia public schools, city departments, contractors, civic organizations, garden clubs.

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2. The Building Inspections Officer will work to detect and eliminate non-stormwater discharges. The Building Inspections Officer will work with City water and sewer crews, Henderson State University, and Ouachita Baptist University personnel to define and eliminate non-stormwater discharges.

3. The City to this point has not identified any non-storm water discharges as significant contributors of pollutants to the MS4.

4. The storm sewer map was developed as part of a stormwater management analysis.

5. Ordinance.

6. The Building Inspections Officer will screen both the Maddox and Mill Creek drainages during dry weather at least once per year over the permit term.

7. The annual report will include the following:
   a. Number of dry weather outfalls screened
   b. Number of dry weather flows identified
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D. Construction Site Stormwater Runoff Control

1. To help lessen the impacts of construction activity stormwater, the City has adopted the ordinance included in Appendix D. The ordinance incorporates the "Stormwater Drainage Design Manual and Floodplain Compliance Guideline" by reference.

2. The Building Inspections Officer is responsible for implementing the ordinance.

3. The Building Inspections Officer shall conduct pre-construction site plan reviews (reviews of construction site Stormwater Pollution Prevention Plans) at 100 percent of projects from construction activities that result in a land disturbance of 1 acre or more.

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   e. Number of long-term operation and maintenance plans developed and agreements in place

5. Low Impact Development – The MS4 will review its codes to evaluate the need to remove impediments to low impact development and green infrastructure. The City will include information on efforts to identify and remove impediments to low impact development in the post construction program element of the Annual Report in the fourth year of this renewal permit term.

F. Pollution Prevention/Good Housekeeping for Municipal Operations

1. A pollution prevention/good housekeeping program for municipal operations will be developed to address the following potential pollutant sources associated with municipal operations: pesticides, herbicides, erosion control, nutrients, litter, fleet maintenance, building maintenance, and land disturbances.

2. The program will include annual employee training for the following departments: water and sewer, parks and recreation, street, and public school. The training will also be offered to Henderson and Ouachita.

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ADEQ
Office of Water Quality, General Permits
5301 Northshore Drive
North Little Rock, AR 72118

Or, to the following email address: water-permit-application@adeq.state.ar.us

VI. CERTIFICATION

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

____________________ 5.14.24
City Manager Date

APPENDIX A
ANNUAL REPORTING FORM

ADEQ
ARKANSAS
Department of Environmental Quality

NPDES Small MS4 General Permit (ARR040000) Annual Reporting Form

Instructions for completing this form:

- ARR040000 requires that this form be used when submitting annual reports. You may request approval to use your own reporting format.
- Annual Reports are due annually on or before June 1st.
- Complete the form and sign and date the certification statement below.
- If more space is needed than is provided, identify within the provided space that Attachment A, B, C, etc. has been attached.
- If an item of the form is not applicable for your program (such as street sweeping), fill in N/A in the space provided.
- Don't include attachments such as brochures, newspaper clips, sign-in sheets, etc. related to your program with this form. You only need to summarize these within this report. These records must be filed and will be needed during program audits.
- Please attach results of monitoring required for TMDL or impaired streams separately from this form.
- When complete, submit this Annual Report form to the following address:
  ADEQ
  Water Division
  General Permits Section
  5301 Northshore Drive
  North Little Rock, AR 72118
  Water-permit-application@adeq.state.ar.us

Small MS4 Annual Report for Year:		
ADEQ Permit Tracking Number:		
Name of MS4:		
Primary Contact:	Title:	
Mailing Address:		
City:	Zip Code:	County:
Telephone Number:	Email Address:	

Include or attach a Table of Organization. Indicate who (name and contact information) is responsible for overall management and implementation of your program, and if different, each minimum control measure of your program. Identify how development and implementation across multiple positions, agencies and departments occur. Also, identify any Memorandum of Understandings (MOUs) or other such agreements that exist.

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

Print Name: ______________________

Print Title: ______________________

Signature: ______________________ Date: ______________

ADEQ
ARKANSAS
Department of Environmental Quality

SMALL MS4 ANNUAL REPORT FORM

PUBLIC EDUCATION & OUTREACH
Estimate Your Permit Area's Total Population: ________

BMP (mechanism) & Responsible Party	Measurable Goal	Theme or Message	Target Audience	% of Target Audience Reached & Total # of people reached	Summary of Results	Effective (Yes or No)

ADEQ
ARKANSAS
Department of Environmental Quality

SMALL MS4 ANNUAL REPORT FORM

PUBLIC INVOLVEMENT/PARTICIPATION

BMP (Activity) & Responsible Party	Measurable Goal	Theme or Message	Target Audience	Estimate of People Participated	Summary of Results	Effective (Yes or No)

ADEQ
ARKANSAS
Department of Environmental Quality

SMALL MS4 ANNUAL REPORT FORM

ILLICIT DISCHARGE DETECTION & ELIMINATION (IDDE)

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Cite Local Code(s) Being Used (If available, web link for code(s))	Summary of Results or Activities	Effective (Yes or No)
Ordinance or Other Regulatory Mechanism					

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Summary of Activities or Updates	Effective (Yes or No)
Storm Sewer System Map				

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Summary of Activities or Updates	Effective (Yes or No)
IDDE Plan				

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	# of Outfalls Screened	# of Dry-Weather Flows Identified	# Of Illicit Discharges:		Effective (Yes or No)
					Identified*	Eliminated	
Dry-Weather Screening of Outfalls **# of Outfalls Screened ______** **Total # of Outfalls _______**							

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Summary of Activities or Updates	Effective (Yes or No)
Identification of allowable non-stormwater discharges				

*Include an attachment which provides schedules for elimination of illicit connections that have been identified but have yet to be eliminated.

ARKANSAS Department of Environmental Quality

SMALL MS4 ANNUAL REPORT FORM

CONSTRUCTION SITE RUNOFF CONTROL

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Cite Local Code(s) Being Used (If available, web link for code(s))	Summary of Results or Activities	Effective (Yes or No)
Ordinance or Other Regulatory Mechanism					

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Standards Being Used	Summary of Results or Activities	Effective (Yes or No)
Sediment and Erosion Control Requirements					

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Complaints		Summary of Results or Activities	Effective (Yes or No)
			Received	Followed-Up On		
Complaint Process						

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	# of Applicable Sites Requiring Plans	# of Plans Reviewed	Summary of Results or Activities	Effective (Yes or No)
Site Plan Review Procedures						

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Site Inspections Performed			Summary of Results or Activities	Effective (Yes or No)
			# of Applicable Sites	# Performed	Avg. Frequency		
Site Inspection Procedures							

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Violations		Summary of Results or Activities	Effective (Yes or No)
			# of Violation Letters	# of Enforcement Actions		
Enforcement Procedures						

*Include an attachment which identifies applicable sites within your jurisdiction for this reporting period.

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Department of Environmental Quality

SMALL MS4 ANNUAL REPORT FORM

POST-CONSTRUCTION STORM WATER MANAGEMENT IN NEW DEVELOPMENT AND REDEVELOPMENT

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Cite Local Code(s) Being Used (If available, web link for code(s))		Summary of Results or Activities	Effective (Yes or No)
Ordinance or Other Regulatory Mechanism						
BMP & Responsible Party	**Measurable Goal**	**Completed (Yes or No)**	**Structural and/or Non-Structural Standards Being Used**		**Summary of Results or Activities/Compliance rates with MS4 requirements**	**Effective (Yes or No)**
Post-Construction Requirements						
BMP & Responsible Party	**Measurable Goal**	**Completed (Yes or No)**	**# of Applicable Sites Requiring Post-Const. BMPs**	**# of Plans Reviewed**	**Summary of Results or Activities**	**Effective (Yes or No)**
Site Plan Review Procedures						
BMP & Responsible Party	**Measurable Goal**	**Completed (Yes or No)**	**Site Inspections Performed**		**Summary of Results or Activities**	**Effective (Yes or No)**
			# Performed	**Avg. Frequency**		
Site Inspection Procedures						
BMP & Responsible Party	**Measurable Goal**	**Completed (Yes or No)**	**Violations**		**Summary of Results or Activities**	**Effective (Yes or No)**
			# of Violation Letters	**# of Enforcement Actions**		
Enforcement Procedures						
BMP & Responsible Party	**Measurable Goal**	**Completed (Yes or No)**	**# of Sites Requiring Plans/Agreements**	**# of Plans Developed/Agreements in Place**	**Summary of Results or Activities**	**Effective (Yes or No)**
Long-Term O&M Plans/Agreements						

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SMALL MS4 ANNUAL REPORT FORM

POLLUTION PREVENTION/GOOD HOUSEKEEPING FOR MUNICIPAL OPERATIONS

BMP & Responsible Party	Measurable Goal	Completed (Yes or No)	Topic(s)	Targeted Audience	# of Employees Attended	Summary of Activity	Effective (Yes or No)
Employee Training Program							

List of Municipal Facilities Subject to Program	O&M Procedures Developed for Facilities (Yes or No)	# of Facility Inspections Performed	Frequencies of Such Inspections

MS4 Maintenance	Summarize Maintenance Activities and Schedules		Summarize Activities Performed
Disposal of Wastes	Procedures Developed (Yes or No)	Document Amounts of Wastes Properly Disposed	
Road Salt	Covered (Yes or No)	Tons Used	Summarize Measures Taken to Minimize Usage
Pesticide & Herbicide Usage	Procedures Developed (Yes or No)	Gallons Used	Summarize Measures Taken to Minimize Usage
Fertilizer Usage	Procedures Developed (Yes or No)	Pounds Used	Summarize Measures Taken to Minimize Usage
Street Sweeping	Procedures Developed (Yes or No)	Document Amount of Material Collected and Properly Disposed	
Flood Management Projects	Summarize any New or Existing Flood Management Projects that were Assessed for Impacts on Water Quality		

SMALL MS4 ANNUAL REPORT FORM

PROPOSED CHANGES TO YOUR SWMP (IF ANY)

- Summarize any proposed changes to your SWMP, including changes to any BMPs or any identified measurable goals that apply to the program elements. If you fail to satisfy measurable goals for the reporting year, please explain why.

VARIANCES GRANTED (IF ANY)

- Identify and summarize any variances granted under your storm water program.

APPENDIX B
MS4 STORMWATER GENERAL PERMIT ARR040000

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM AND THE ARKANSAS WATER AND AIR POLLUTION CONTROL ACT

In accordance with the provisions of the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended, Ark. Code Ann. 8-4-101 et seq.), and the Clean Water Act (33 U.S.C. 1251 et seq.),

Regulated Small Municipal Separate Storm Sewer Systems (MS4s) Located within the State of Arkansas

are authorized to discharge, in accordance with the requirements and other conditions set forth in this permit, to all receiving waters except as stated in Part I.3 of this permit.

Only those operators of MS4s who submit the required Notice of Intent (NOI) in accordance with Part II and Stormwater Management Program (SWMP) in accordance with Part III of this permit, and receive a Notice of Coverage (NOC) are authorized to discharge stormwater under the provisions of this general permit.

For facilities that are eligible for coverage under a general permit, the Division sends a cover letter (Notice of Coverage with a permit tracking number starting with ARR04) and a copy of the general permit to the facility. The cover letter includes the Division's determination that a facility is covered under the general permit and may specify alternate requirements outlined in the permit, such as modified sampling frequencies for certain parameters or the inclusion of monitoring for parameters in addition to those requiring regular monitoring.

Effective Date: August 1, 2024

Expiration Date: July 31, 2029

September 15, 2023
Issue Date

Stacie Wassell
Interim Associate Director, Office of Water Quality
Arkansas Department of Energy and Environment
Division of Environmental Quality

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PART I
COVERAGE UNDER THIS PERMIT

NOTE: Only a select sub-set of small MS4s, referred to as ***regulated*** **small MS4s**, is covered by the Phase II requirements, either through automatic designation or designation on a case-by-case basis by the Division.

1. Permit Area

This permit covers the State of Arkansas.

2. Eligibility

A. All operators of small municipal separate storm sewer systems (MS4s) meeting the eligibility requirements of this permit are required to comply with permit terms unless the Director of the Division of Environmental Quality (DEQ) has given written notification to an MS4 that coverage under this general permit is inappropriate. The operators described in the section below must submit a Notice of Intent (NOI) and Stormwater Management Program (SWMP) to the DEQ for review and approval in accordance with Part II of this permit and will thereafter be authorized to discharge via a Notice of Coverage under the terms and conditions of this general permit.

a. **Operators of MS4s in urban areas (Automatic Designation)**: Pursuant to 40 C.F.R. § 122.32, all operators of small MS4s, including non-traditional MS4s, fully or partially located in an urban area with a population of 50,000 or more people as determined by the 2000 through the latest Decennial Census by the Bureau of the Census must apply for permit coverage. Coverage area for the purposes of this permit is the urban area meeting the population threshold at minimum, or as specified by the SWMP.

b. **Operators of designated municipal MS4s**: Pursuant to 40 C.F.R. § 122.32, the Division has made the decision to set designation criteria for municipalities outside of designated urban areas to be covered under this permit. MS4s designated under this part shall use the city limits as the coverage area or a boundary delineated on maps contained in the SWMP approved by the Division. Municipalities with a population, according to the latest decennial census, of at least 10,000 persons and with a population density of at least 1,000 persons per square mile meeting one (1) of following criteria are required to obtain permit authorization:

(1) The MS4 directly discharges to a 303(d) listed waterbody with pollutants of concern caused by stormwater, or a waterbody with a completed Total Maximum Daily Load (TMDL) citing stormwater as a cause of impairment; or

(2) The MS4 Directly discharges to an Extraordinary Resource Water (ERW), Ecologically Sensitive Waterbody (ESW), Natural and Scenic Waterway (NSW); or

(3) The MS4 has had a 50% population growth rate between the two (2) most recent decennial censuses.

c. **MS4s that are in an urban area with a population of 50,000 people or more as determined by the latest Decennial Census by the Bureau of the Census, and would otherwise qualify as a designated MS4 under the requirements of Part I.2.A.b:** shall use the city limits as the coverage area for purposes of this permit.

d. **MS4s Discharging to a Physically Interconnected Storm System:** Any small MS4 located outside of an urban area with a population of 50,000 people or more as determined by the latest Decennial Census by the Bureau of the Census, contributing substantially to the pollutant loadings of a physically interconnected MS4 regulated by the National Pollutant Discharge Elimination System (NPDES) stormwater program. Coverage area will be determined on a case-by-case basis based on area of MS4 control and potential to contribute contaminants and shall be established in the MS4's SWMP.

e. **Operators of previously permitted small MS4s:** Operators of small MS4s which have previously been covered under a permit for discharge from their MS4 based on the 2000 through the latest Censuses must reapply for permit coverage.

B. **The following are types of authorized discharges**:

a. *Stormwater discharges:* This permit authorizes uncontaminated stormwater discharges to surface waters of the State from the MS4s identified in Part I.2, except as excluded in Part I.3.

b. *Non-stormwater discharges*: The MS4s are authorized to discharge the following non-stormwater sources, provided that DEQ has not determined and notified the MS4 in writing that these sources are substantial contributors of pollutants to the MS4:

- uncontaminated waterline flushing;
- landscape irrigation provided all pesticides, herbicides, and fertilizers have been applied in accordance with the approved labeling;
- diverted stream flows;
- rising ground waters;
- uncontaminated ground water infiltration (infiltration is defined as water other than wastewater that enters a sewer system, including sewer service connections and foundation drains, from the ground through such means as defective pipes, pipe joints, connections, or manholes. Infiltration does not include, and is distinguished from, inflow.);
- uncontaminated pumped ground water;
- discharges from potable water sources;
- uncontaminated foundation drains;

- uncontaminated air conditioning condensate;
- irrigation water;
- springs;
- water from crawl space pumps;
- uncontaminated footing drains;
- lawn watering;
- individual residential car washing;
- flows from riparian habitats and wetlands;
- dechlorinated swimming pool discharges;
- uncontaminated street wash water;
- discharges or flows from emergency firefighting activities; and
- unless otherwise permitted or regulated by DEQ, discharges of gray water from municipal splash pads (also known as spray ponds or spray grounds), as defined in Part VI.35 of this permit, provided the discharges comply with all applicable municipal or county ordinances enacted or pursuant to law. Discharges from recirculating systems shall be de-chlorinated prior to discharge.

3. Limitations on Coverage

This permit does not authorize:

A. Discharges that are mixed with sources of non-stormwater unless such non-stormwater discharges are:

a. In compliance with a separate NPDES permit, or

b. Determined by the Division not to be a substantial contributor of pollutants to waters of the State.

B. Stormwater discharges associated with industrial activity as defined in 40 C.F.R. § 122.26(b)(14) that are not in compliance with a separate NPDES permit.

C. Stormwater discharges associated with construction activity as defined in 40 C.F.R. § 122.26(b)(14)(x) or 40 C.F.R. § 122.26(b)(15) that are not in compliance with a separate NPDES permit.

D. Concerning discharges that DEQ, prior to authorization under this permit, determines will cause, have the reasonable potential to cause, or contribute to an excursion above any applicable water quality standard: Where such a determination is made prior to authorization, the Division may notify an MS4 that an alternative general permit or an individual permit application is necessary in accordance with Part V.17. However, the Division may authorize coverage under this permit after the operator has included appropriate controls and implementation procedures in the SWMP designed to bring any discharges into compliance with water quality standards.

E. Concerning discharges into waters identified on the 303(d) list or waters with an approved TMDL: Discharge of any pollutant which may cause or contribute to the impairment of a waterbody identified on the current list of impaired waters under Section 303(d) of the Clean Water Act, and for which a TMDL has been approved, is prohibited, unless said discharge is consistent with that TMDL. If a Wasteload Allocation (WLA) has been assigned to the MS4, the operator must incorporate that WLA into the SWMP as a Measurable Goal to ensure discharges are consistent with the TMDL requirements. The specific methods outlining implementation of the TMDL and its assumptions shall be included in the approved SWMP for the purpose to demonstrate compliance with this permit during the term of coverage. For discharges that cannot comply with approved TMDL requirements under this permit, the Division may notify applicants that an alternative permit application is necessary in accordance with Part V.17.

   Discharge of any pollutant which may cause or contribute to the impairment of a waterbody identified on the current list of impaired waters under Section 303(d) of the Clean Water Act, and for which a TMDL has not been approved, is prohibited, unless the discharge is addressed by the SWMP to sufficiently contain the necessary pollutant monitoring and control mechanisms necessary to prevent discharge of a pollutant which may cause or contribute to the impairment. The specific pollutant monitoring and/or control mechanisms required shall be included in the approved SWMP for the purpose to demonstrate compliance with this permit during the term of coverage.

4. Waiver from coverage

The following exclusion may be obtained:

A. The Division may waive permit coverage if an MS4 serves a population of less than 1,000 within the urban area with a population of 50,000 people or more as determined by the latest Decennial Census by the Bureau of the Census, and if the MS4 is meeting the following criteria:

   a. The MS4 system is not contributing substantially to the pollutant loadings of a physically interconnected MS4 that is regulated by the NPDES stormwater program (see 40 C.F.R. § 123.35(b)(4));

   b. The MS4 does not discharge any pollutant(s) with reasonable potential to cause or contribute to an impairment of any waterbody to which it directly discharges; and

   c. Any pollutant that is discharged does not require additional controls based on WLAs that are part of an EPA approved or established TMDL.

B. Any waiver provided by the Division pursuant to Part I.4.A may be reopened if:

a. The MS4 no longer meets the criteria established in Part I.4.A; or

b. Upon the renewal of this general permit.

PART II
AUTHORIZATION UNDER THIS PERMIT

1. Obtaining Authorization

A. To be authorized to discharge stormwater from small MS4s, the MS4 shall submit a completed NOI form, application fee (if new permittee only), and SWMP in accordance with Part III and the deadlines presented in Part II.2 of this permit. MS4s with existing permit coverage shall submit a completed renewal NOI form and updated SWMP, but do not need to submit an application fee because they are already annually invoiced.

B. The NOI, to be completed on a form furnished by the Division, shall be signed and dated in accordance with Part V.7 of this permit. The NOI shall contain the legal name and address of the MS4, the type of MS4, and the receiving waterbody or waterbodies of discharges from the MS4.

C. Until notified in writing by the Division, dischargers who submit an NOI in accordance with the requirements of this permit are not covered by this permit. The Division may deny coverage under this permit and require submittal of an application for an individual NPDES permit or alternative general permit based on a review of the NOI or other information (see Part V.17).

D. Where an operator is added, removed or transferred after submittal of an NOI, a permit transfer form shall be submitted prior to the change.

2. Deadlines for Notification

A. *Renewal*. Existing MS4s must reapply for coverage no later than thirty (30) days prior to the effective date of this permit. To reapply, the MS4 shall submit a completed NOI form and SWMP to the Division. MS4s previously covered will receive notification of the renewal along with instructions for obtaining coverage under the renewal permit. MS4s previously covered will continue being covered by the previous permit until authorized by the Division to be covered by this renewed permit as long as they reapplied for coverage no later than thirty (30) days prior to the effective date of this permit.

B. *New designations.* If the MS4 is designated either by the latest census or meets the criteria of Part I after the census information has been reviewed, then the MS4 is required to submit an NOI, the SWMP and application fee to the Division within 180 days of notification from DEQ that permit coverage is required.

C. *Submitting a late NOI*. The MS4s are not prohibited from submitting an NOI after the dates provided in Part II.2.A or II.2.B of this permit. If a late NOI is submitted, the authorization is only for discharges that occur after permit coverage is granted. The Division reserves the right to take appropriate enforcement actions against MS4s that have not submitted a timely NOI.

3. Where to Submit

A. The permittee is to submit the NOI, permit fee (for new permittees only), and SWMP, signed in accordance with the signatory requirements of Part V.7 of this permit, to DEQ through ePortal (or any successor system), unless the operator receives a waiver from DEQ, at the following web address: https://eportal.adeq.state.ar.us/

B. In order to apply for a waiver from electronic reporting, the operator must submit the required information outlined in 40 C.F.R. §127.15(b)(2). Waivers from electronic reporting may be granted based on one of the following conditions:

a. If the operational headquarters is physically located in a geographic area (i.e. Zip code or census tract) that is identified as under-served for broadcast internet access in the most recent report from the Federal Communications Commission;

b. If available computer access or computer capability is limited; or

c. If the operator is a religious community that chooses not to use certain modern technologies pursuant to 40 C.F.R. §127.15(c)(1).

If DEQ grants a waiver approval to use a paper NOI and operator elects to use it, the operator must use the approved form developed by DEQ. Applicants may contact the Division regarding other available submission methods electronically via email: Water-permit-application@adeq.state.ar.us, or at the following address:

DEQ
Office of Water Quality, General Permits
5301 Northshore Drive
North Little Rock, AR 72118

4. Co-Permittees Under a Single NOI

The MS4 may partner with other MS4s to develop and implement the SWMP. The MS4 may also jointly submit an NOI with one (1) or more MS4s. Their SWMP shall clearly describe which permittees are responsible for implementing each of the control measures.

A. When a MS4 is added as a Co-Permittee, a Co-Permittee NOI shall be submitted in accordance with Part II.3.

B. When a MS4 separates from a permitted MS4 group, the separating MS4 shall submit a new NOI.

C. A determination to approve co-permittees under a single NOI shall be the sole discretion of the Administrator of the Division of Environmental Quality (Director).

5. Public Notification Requirements

After review of the application for permit coverage, the Division will give the public access to the NOI and SWMP for a minimum of thirty (30) days. A link will be provided at the Division's MS4 webpage:

https://www.adeq.state.ar.us/water/permits/npdes/stormwater/noi/ms4/

Public comments and requests for a public hearing will be accepted within a thirty (30) day public notice period. The end date for public comments, and methods for submitting comments and requests for a public hearing will be available on the DEQ's webpage.

On issues of public or DEQ comment, the operator of the MS4 must, prior to permit coverage issuance:

A. Provide the MS4's responses to any unresolved public comments on the NOI and SWMP received either by the MS4 during local participation and involvement efforts, or by the Division during the Division's public participation process, to DEQ within thirty (30) days of the Director's request. Responses provided by the MS4 will be considered as part of the Division's decision-making process.

B. Modify, or include a schedule to modify, the SWMP as necessary after consideration of the public comments on the NOI or as required by the Director in response to such comments.

6. Modification of the Permit

The permit may be reopened and modified, in accordance with 40 C.F.R. §§ 122.62, 122.63, and 124.5, during the life of the permit.

7. Terminating Coverage

To terminate permit coverage, the permittee must submit a written Notice of Termination (NOT) that contains facts or reasons supporting the request. The permittee is responsible for meeting the terms of this permit until the acceptance of the termination of authorization by the Division. A NOT shall be submitted if the permittee:

A. Undergoes a change in property ownership or responsibility to another MS4;

B. Ceases the operations and there are no stormwater discharges from the MS4; or

C. Has obtained coverage under an individual or alternative general permit for all discharges required to be covered by an NPDES permit.

PART III
STORMWATER MANAGEMENT PROGRAMS (SWMP)

NOTE: Existing permitted MS4 programs should already be in compliance with the majority of the following requirements unless the requirements were not covered under the previous permit. Permittees shall continue to implement the existing programs until the renewal is approved by the Division. The SWMP should be updated as necessary to comply with the new requirements of the permit. The SWMP is an integral and enforceable document. Permittees not meeting the requirements of the most currently approved SWMP will be considered in violation of this permit.

1. Requirements

The permittee shall develop, implement, and enforce a SWMP designed to reduce the discharge of pollutants from the regulated small MS4, to protect water quality, and to satisfy the water quality requirements and the Clean Water Act. Permittees may use contracts, interagency agreements, or inter-jurisdictional agreements with other permittees to implement the SWMP based on the requirements outlined in Part III.3. The SWMP should include management practices; control techniques and system, design, and engineering methods; and shall be modified as needed to include provisions as the Division determines necessary after its review of the program for the control of such pollutants. The SWMP shall include the following information for each of the six (6) minimum control measures (MCMs) described in Part III.2 of this permit:

A. The best management practices (BMPs) that the MS4 or another entity will or already implements for each of the stormwater MCMs;

B. The measurable goals for each of the BMPs, the ones the MS4 has the authority to implement, including, as appropriate, the months and years in which the MS4 will undertake required actions, including interim milestones and the frequency of the action. At a minimum, measurable goals shall be implemented to satisfy this general permit's performance standards;

C. The person(s), including position title(s), or just the position title and contact information responsible for implementing or coordinating the BMPs for the SWMP. The SWMP shall include a Table of Organization, including a primary point of contact, which identifies how implementation across multiple positions, agencies and departments will occur; and

D. The permittee shall provide a rationale for how and why the permittee selected each of the BMPs and measurable goals for the SWMP. The MS4 shall develop and implement the program within five (5) years of initially being granted regulated small MS4 general permit coverage. If an MS4 initially had coverage under a previous version of this permit, then the MS4 shall revise the program and its implementation to satisfy this general permit's performance standards within two (2) years of when the MS4 coverage under this general permit was granted.

E. BMPs shall be evaluated and updated if the receiving streams are impaired or have an approved TMDL where the MS4 is identified as a substantial contributor to the impairment, or the receiving waters are designated as ERW, ESW, or NSW. The enhanced BMPs shall be specifically addressed within the SWMP.

2. Minimum Control Measures

The six (6) MCMs that shall be included in the SWMP are:

A. Public Education and Outreach on Stormwater Impacts

a. The permittee shall implement a public education program to distribute educational materials to the community or conduct equivalent outreach activities about the impacts of stormwater discharges on water bodies and the steps that the public can take to reduce pollutants in stormwater runoff. In the case of non-traditional MS4s (e.g., Arkansas Department of Transportation (ARDOT), universities, hospitals, prisons, military bases, and other government complexes), the permittee is only required to provide educational materials and outreach to the MS4 employees, on-site contractors, and individuals using the MS4's facilities.

b. *Decision process.* The permittee shall document the decision process for the development of a stormwater public education and outreach program. The rationale statement shall address both the overall public education program and the individual BMPs, measurable goals and responsible persons for the program. The rationale statement shall include the following information, at a minimum:

(1) How the MS4 plans to inform individuals and households about the steps they can take to reduce stormwater pollution;

(2) How the MS4 plans to inform individuals and groups on how to become involved in the stormwater program (with activities such as local waterbody and swim beach restoration activities);

(3) The target audiences for the MS4's education program that are likely to have significant stormwater impacts (including commercial, industrial, and institutional entities) and why those target audiences were selected;

(4) The target pollutant sources the MS4 public education program is designed to address. Topics may include, but are not limited to, litter disposal, yard waste, pet waste, chlorinated pool discharges, household hazardous waste disposal, vehicle maintenance, used fluid and oil disposal, vehicle washing, pavement washing, external building washdown, proper use of fertilizer and pesticides, as well as maintenance of individual septic system, if applicable ;

(5) The outreach strategy, including the mechanisms (e.g., printed brochures, newspapers, media, social media, workshops, etc.) the MS4 will use to reach the target audiences, and how many people the MS4 expects to reach by the outreach strategy over the permit term;

(6) Who (person or entity) is responsible for overall management and implementation of the stormwater public education and outreach program and, if different, who is responsible for each of the BMPs identified for this program; and

(7) How the MS4 will evaluate the success of this minimum measure, including how the measurable goals were selected for each BMP.

c. *Performance Standards*. The stormwater public education and outreach program shall include:

(1) more than one (1) mechanism;

(2) at least five (5) different stormwater themes or messages over the permit term. At a minimum, at least one (1) theme or message shall be targeted to the land development community. For non-traditional MS4s, the land development community refers to landscaping and construction contractors working within its boundaries; and

(3) The stormwater public education and outreach program shall reach at least fifty (50) percent of the population over the permit term.

d. *Annual Reporting*. The annual report shall identify each mechanism used, including each stormwater theme, audience targeted, and an estimate of how many people were reached by each mechanism.

B. Public Involvement/Participation

a. The permittee shall at a minimum, comply with State and local public notice requirements when implementing a public involvement/participation program. In the case of non-traditional MS4s (e.g., ARDOT, universities, hospitals, prisons, military bases, and other government complexes), the MS4 is required to involve employees, on-site contractors, and individuals using the MS4 facilities.

b. *Decision process.* The permittee shall document the decision process for the development of a stormwater public involvement/participation program. The rationale statement shall address the overall public involvement/participation program and the individual BMPs, measurable goals, and responsible persons for the program. The rationale statement shall include the following information, at a minimum:

(1) Has the permittee involved the public in the development and submittal of the NOI and SWMP description;

(2) The MS4's plan to actively involve the public in the development and implementation of the program;

(3) The target audiences for the public involvement program, including a description of the types of ethnic and economic groups engaged. The MS4 is encouraged to actively involve all potentially affected stakeholder groups, including commercial and industrial businesses, trade associations, environmental groups, homeowners associations, and educational organizations, among others;

(4) The types of public involvement activities included in the program. Where appropriate, consider the following types of public involvement activities: a water quality hotline (report spills, dumping, construction sites of concern, etc.), citizen representatives on a stormwater management panel, public hearings, working with citizen volunteers willing to educate others about the program, stewardship activities (e.g., waterbody or swim beach cleanup, wetland restoration, volunteer water quality monitoring, etc.);

(5) Who (person or entity) is responsible for the overall management and implementation of the stormwater public involvement/participation program and, if different, who is responsible for each of the BMPs identified for this program; and

(6) How the MS4 will evaluate the success of this minimum measure, including how the MS4 selected the measurable goals for each of the BMPs.

c. *Performance Standards*. The stormwater public involvement/participation program shall include at least five (5) public involvement activities over the permit term.

d. *Annual Reporting*. The annual report shall identify each public involvement/participation activity conducted, including a brief description of each activity, estimate of how many people participated, and the volume or mass of trash and litter removed if applicable.

C. **Illicit Discharge Detection and Elimination**

a. The permittee shall develop, implement and enforce a program to detect and eliminate illicit discharges, as defined in Part VI of this permit, into the small MS4 (for illicit discharges to the MS4 via an adjacent, outside of the MS4's jurisdiction, interconnected MS4, the MS4 are only required to inform the neighboring MS4 and the Division in the annual report submission, of their existence).

b. New permittees shall develop a storm sewer system map, showing the location of all outfalls and the names and location of all surface waters of the State that receive discharges from those outfalls. Within five (5) years of when the coverage under this general permit was granted, the storm sewer system map shall also include the entire MS4 system, including catch basins, pipes, ditches, and public and private stormwater facilities. MS4s that are required to update storm sewer system maps due to Part I.2.A.c of the permit must update their storm sewer system maps within three (3) years of the effective date of this permit.

c. The permittee shall, to the extent allowable under State or local law, effectively prohibit, through ordinance or other regulatory mechanism, illicit discharges into the storm sewer system and implement appropriate enforcement procedures and actions.

d. The permittee shall develop and implement a plan to detect and eliminate non-stormwater discharges, including illegal dumping, to the system. See Part III.2.C.f for exceptions to this requirement.

e. The permittee shall inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste; and

f. The permittee shall address the following categories of non-stormwater discharges or flows (i.e., illicit discharges) only if the MS4 identifies them as significant contributors of pollutants to the small MS4: uncontaminated water line flushing, landscape irrigation, diverted stream flows, rising ground waters, uncontaminated ground water infiltration (as defined at 40 C.F.R. § 35.2005(20)), uncontaminated pumped ground water, discharges from potable water sources, uncontaminated foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, uncontaminated footing drains, lawn watering, individual residential car washing, flows from riparian habitats and wetlands, dechlorinated swimming pool discharges, uncontaminated street wash water, and discharges or flows from emergency firefighting activities (by definition, not an illicit discharge), and splash pads.

g. The permittee may also develop a list of other similar occasional incidental non-stormwater discharges (e.g., non-commercial or charity car washes, etc.) that will not be addressed as illicit discharges. These non-stormwater discharges must not be reasonably expected (based on information available to the permittees) to be significant sources of pollutants to the MS4, because of either the nature of the discharges or conditions the MS4 have established for allowing these discharges to the MS4 (e.g., a charity car wash with appropriate controls on frequency, proximity to waters such as impaired waters, waters with an applicable TMDL, ERWs, ESWs, or NSWs, BMPs on the wash water, etc.). The MS4 must document in the SWMP any local controls or conditions placed on the discharges. The MS4 must include a provision prohibiting any individual non-stormwater discharge that is determined to be contributing significant amounts of pollutants to the MS4.

h. *Decision process.* The permittee shall document the decision process for the development of a stormwater illicit discharge detection and elimination program. The rationale statement shall address both the overall illicit discharge detection and elimination program and the individual BMPs, measurable goals, and responsible persons for the program. The rationale statement shall include the following information, at a minimum:

(1) How the MS4 will develop a storm sewer system map showing the location of all outfalls and the names and location of all receiving waters. Describe the sources of information used for the storm sewer system maps and the plan to verify the outfall locations with field surveys. If already completed, describe how the map was developed. Also, describe how the storm sewer system map will be regularly updated;

(2) The mechanism (ordinance or other regulatory mechanism) the MS4 will use to effectively prohibit illicit discharges into the MS4 and why the MS4 chose that mechanism. If this mechanism needs to be developed, then describe in the plan and a schedule to do so. If an ordinance or regulatory mechanism is already developed, include a copy of the relevant sections with the program;

(3) The plan to ensure through appropriate enforcement procedures and actions that the illicit discharge ordinance (or other regulatory mechanism) is implemented; and

(4) The plan to detect and address illicit discharges to the MS4 system, including discharges from illegal dumping and spills. The plan shall include dry weather field screening for non-stormwater flows, and DEQ recommends field tests of selected chemical parameters as indicators of discharge sources. The description shall address the following, at a minimum:

i. Procedures for locating priority areas which include areas with higher likelihood of illicit connections (e.g., areas with older sanitary sewer lines) or ambient sampling to locate impacted reaches;

ii. Procedures for tracing the source of an illicit discharge, including the specific techniques that will be used to detect the location of the source;

iii. Procedures for removing the source of the illicit discharge; and

iv. Procedures for program evaluation and assessment.

(5) How the MS4 plans to inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of

waste. Include in the description how this plan will coordinate with the public education minimum measure and the pollution prevention/good housekeeping minimum measure programs;

(6) Who is responsible for overall management and implementation of the stormwater illicit discharge detection and elimination program and, if different, who is responsible for each of the BMPs identified for this program; and

(7) How the MS4 will evaluate the success of this minimum measure, including how the MS4 selected the measurable goals for each of the BMPs.

i. *Performance Standards*. The stormwater illicit discharge detection and elimination program shall include:

(1) Dry-weather screening of all stormwater outfalls located in the MS4's coverage area at the time of this permit coverage over the permit term. Only those outfalls draining undeveloped watersheds do not need to be screened for illicit discharges; and

(2) The storm sewer system map shall be updated annually as needed for changes occurring in the MS4's coverage area boundaries at the time of permit coverage.

j. *Annual Reporting*. The annual report shall document the following:

(1) number of outfalls dry-weather screened;

(2) number of dry-weather flows identified;

(3) number of illicit discharges identified;

(4) number of illicit discharges eliminated;

(5) provide schedules for elimination of illicit connections that have been identified but have yet to be eliminated; and

(6) a summary of any storm sewer system mapping updates.

D. **Construction Site Stormwater Runoff Control**

a. The permittee shall develop, implement, and enforce a program to reduce pollutants in any stormwater runoff to the small MS4 from construction activities that result in a land disturbance of greater than or equal to one (≥1) acre. Reduction of pollutants in stormwater discharges from construction activity disturbing less than one (<1) acre shall be included in the program if that construction activity is part of a larger common plan of development or sale that would disturb one (≥1) acre or more. If the Division waives requirements for stormwater discharges associated with small construction from a specific site(s), the permittee is not required to enforce the program to reduce pollutant discharges from such site(s). The program shall include the development and implementation of, at a minimum:

(1) An ordinance or other regulatory mechanism to require erosion and sediment controls, as well as sanctions to ensure compliance, to the extent allowable under State or local law. The ordinance or other regulatory mechanism shall be at least as stringent and not conflicting with the criteria set forth in the current DEQ NPDES General Stormwater Permit for Construction Activities applicable for the permit area. If the DEQ NPDES General Stormwater Permit for Construction Activities is renewed during the duration of this permit, the permittee shall update ordinances or other regulatory mechanisms as needed within two years of the renewal of the DEQ NPDES General Stormwater Permit for Construction Activities. If initial coverage for this permit was under a previous version of this permit, then the ordinance or other regulatory mechanism, if needed, shall be revised within two years of coverage under this general permit was granted;

(2) Requirements for construction site operators to implement appropriate erosion and sediment control BMPs;

(3) Requirements for construction site operators to control waste such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at the construction site that may cause adverse impacts to water quality;

(4) Procedures for site plan review which incorporate consideration of potential water quality impacts;

(5) Procedures for receipt and consideration of information submitted by the public; and

(6) Procedures for site inspection and enforcement of control measures.

b. *Decision process.* The permittee shall document the decision process for the development of a construction site stormwater control program. The rationale statement shall address both the overall construction site stormwater control program and the individual BMPs, measurable goals, and responsible persons for the program. The rationale statement shall include the following information, at a minimum:

(1) The mechanism (ordinance or other regulatory mechanism) that will be used to require erosion and sediment controls at construction sites and why the MS4 chose that mechanism. If it is needed to develop this mechanism, describe the plan and a schedule to do so. If the ordinance or regulatory mechanism is already developed, include a copy of the relevant sections with the SWMP description;

(2) The plan to ensure compliance with the erosion and sediment control regulatory mechanism, including the sanctions and enforcement mechanisms that will be used to ensure compliance. Describe the procedures for when certain sanctions will be used. Possible sanctions include non-monetary penalties (such as a stop work orders), fines, bonding requirements, and/or permit denials for non-compliance;

(3) The requirements for construction site operators to implement appropriate erosion and sediment control BMPs and control waste at construction sites that may cause adverse impacts to water quality. Such waste includes discarded building materials, concrete truck washouts, chemicals, litter, and sanitary waste;

(4) The procedures for site plan review, including the review of pre-construction site plans, which incorporate consideration of potential water quality impacts. Describe the procedures and the rationale for how certain sites will be identified for site plan review, if not all plans are reviewed. Describe the estimated number and percentage of sites that will have pre-construction site plans reviewed;

(5) The procedures for receipt and consideration of information submitted by the public. Consider coordinating this requirement with the public education program;

(6) The procedures for site inspection and enforcement of control measures, including how sites are prioritized for inspection;

(7) Who is responsible for overall management and implementation of the construction site stormwater control program and, if different, who is responsible for each of the BMPs identified for this program; and

(8) Describe how the MS4 will evaluate the success of this minimum measure, including how the measurable goals were selected for each of the BMPs.

c. *Performance Standards*. The construction site stormwater control program shall include pre-construction site plan reviews (reviews of construction site Stormwater Pollution Prevention Plans) of 100 percent of projects from construction activities that result in a land disturbance of greater than or equal to one (≥1) acre. These applicable sites shall be inspected at least on a monthly basis to ensure compliance.

d. *Annual Reporting*. The annual report shall document the following:

(1) number of applicable sites in the MS4's jurisdiction;

(2) number of pre-construction site plan reviews performed;

(3) number and frequency of site inspections;

(4) number of violation letters issued;

(5) number of enforcement actions taken; and

(6) number of complaints received and number followed up on.

E. **Post-Construction Stormwater Management in New Development and Redevelopment**

a. The permittee shall develop, implement, and enforce a program to address stormwater runoff from new development and redevelopment projects that disturb greater than or equal to one (≥1) acre, including projects less than one (<1) acre that are part of a larger common plan of development or sale, that discharge into a small MS4. The program shall ensure that controls are in place that will prevent or minimize water quality impacts;

b. The permittee shall develop and implement strategies which include a combination of structural and/or non-structural BMPs appropriate for the community;

c. The permittee shall use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State and local law. The ordinance or other regulatory mechanism shall be at least as stringent as the criteria set forth in the current, at time of issuance of this permit, DEQ NPDES General Stormwater Permit for Construction Activities applicable for a permitted area. Of specific note is that a goal of at least 80% removal of total suspended solids from these flows which exceed predevelopment levels should be used in designing and installing stormwater management controls. If initial coverage was under a previous version of this permit, then the ordinance or other regulatory mechanism, if needed, shall be revised within two years of when coverage under this general permit was granted; and

d. The permittee shall ensure adequate long-term operation and maintenance (O&M) of BMPs.

e. *Decision process.* The permittee shall document the decision process for the development of a post-construction SWMP. The rationale statement shall address both the overall post-construction SWMP and the individual BMPs, measurable goals, and responsible persons for the program. The rationale statement shall include the following information, at a minimum:

(1) A program to address stormwater runoff from new development and redevelopment projects. Include in this description any specific priority areas for this program;

(2) How the program will be specifically tailored for a local community, minimize water quality impacts, and attempt to maintain pre-development runoff conditions;

(3) Any non-structural BMPs in the program, including, as appropriate: policies and ordinances that provide requirements and standards to direct growth to identified areas, protect sensitive areas such as wetlands and riparian areas, maintain and/or increase open space (including a dedicated funding source for open space acquisition), provide buffers along impaired waters, waters with applicable TMDLs, and waterbodies designated as ERWs, ESWs, or NSWs, minimize impervious surfaces, and minimize disturbance of soils and vegetation; policies or ordinances that encourage infill development in higher density urban areas, and areas with existing storm sewer infrastructure; education programs for developers and the public about project designs that minimize water quality impacts; and other measures such as minimization of the percentage of impervious area after development, use of measures to minimize directly connected impervious areas, and source control measures often thought of as good housekeeping, preventive maintenance and spill prevention;

(4) Any structural BMPs in the program, including, as appropriate: storage practices such as wet ponds and extended-detention outlet structures; filtration practices such as grassed swales, bio-retention cells, sand filters and filter strips; and infiltration practices such as infiltration basins and infiltration trenches;

(5) The mechanisms (ordinance or other regulatory mechanisms) used to address post-construction runoff from new developments and redevelopments and why they were chosen. If a mechanism needs to be developed, then describe a plan and a schedule to do so. If an ordinance or regulatory mechanism is already developed, include a copy of the relevant sections with the program;

(6) How the permittee will ensure the long-term O&M of the selected BMPs. Options to help ensure that future O&M responsibilities are clearly identified include an agreement between the permittee and another party such as the post-development landowners or regional authorities;

(7) Who is responsible for overall management and implementation of the post-construction SWMP and, if different, who is responsible for each of the BMPs identified for this program; and

(8) How the MS4 will evaluate the success of this minimum measure, including how the MS4 selected the measurable goals for each of the BMPs.

f. *Performance Standards*. The post-construction SWMP shall include pre-construction site plan review (for compliance with local requirements for post-construction management of stormwater) of 100 percent of projects from construction activities that result in a land disturbance of greater than or equal to one (≥1) acre to ensure that required controls are designed per requirements. These applicable sites shall be inspected to ensure that controls are installed per requirements. The program shall also ensure that long-term O&M plans are developed and agreements are in place for all applicable sites.

g. *Annual Reporting*. The MS4 annual report shall document the following:

(1) number of applicable sites in the jurisdiction requiring post-construction controls;

(2) number of pre-construction site plan reviews performed;

(3) number of inspections performed to ensure as built per requirements;

(4) compliance rates with MS4 requirements; and

(5) number of long-term O&M plans developed and agreements in place.

h. *Low Impact Development (LID)*. The Division recommends that MS4s evaluate their existing codes and planning procedures to remove impediments to low impact development and green infrastructure. The Division also encourages municipalities to evaluate proposed developments using green infrastructure for waivers from local requirements in their community planning process. The operator must include information on efforts to identify and remove impediments to LID in the post-construction program element of the Annual Report covering the 4th year of this renewal permit term.

F. Pollution Prevention/Good Housekeeping for Municipal Operations

a. The permittee shall develop and implement an O&M program that includes a training component and has the ultimate goal of preventing or reducing pollutant runoff from municipal operations; and

b. Using training materials that are available from EPA, DEQ, other organizations, or developed in-house, the program shall include employee training to prevent and reduce stormwater pollution from activities such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and stormwater system maintenance; and

The permittee shall include a list of industrial facilities owned or operated by the MS4 that are subject to DEQ's Industrial Stormwater General Permit or individual NPDES permits for discharges of stormwater associated with industrial activity that ultimately discharge to the MS4. Include the DEQ permit number or a copy of the NOC for each facility.

c. *Decision process.* The permittee shall document the decision process for the development of a pollution prevention/good housekeeping program for municipal operations. The rationale statement shall address both the overall pollution prevention/good housekeeping program and the individual BMPs, measurable goals, and responsible persons for the program. The rationale statement shall include the following information, at a minimum:

(1) The O&M program to prevent or reduce pollutant runoff from the municipal operations. The program shall specifically list the municipal operations that are impacted by this operation and maintenance program;

(2) Any government employee training program that will be used to prevent and reduce stormwater pollution from activities such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and stormwater system maintenance. Describe any existing, available materials planned for use. Describe how this training program will be coordinated with the outreach programs developed for the public information minimum measure and the illicit discharge minimum measure;

(3) The program description shall specifically address the following areas:

i. Maintenance activities, maintenance schedules, and long-term inspection procedures for controls to reduce floatables and other pollutants to the MS4;

ii. Controls for reducing or eliminating the discharge of pollutants from streets, roads, highways, municipal parking lots, maintenance and storage yards, waste transfer stations, fleet or maintenance shops with outdoor storage areas, and salt/sand storage locations and snow disposal areas the permittee operates;

iii. Procedures for the proper disposal of waste removed from the MS4 and the municipal operations, including dredge spoil, accumulated sediments, floatables, and other debris; and

iv. Procedures to ensure that new flood management projects are assessed for impacts on water quality and existing projects are assessed for incorporation of additional water quality protection devices or practices.

(4) Who is responsible for overall management and implementation of the pollution prevention/good housekeeping program and, if different, who is responsible for each of the BMPs identified for this program; and

(5) How will the MS4 evaluate the success of this minimum measure, including how the MS4 selected the measurable goals for each of the BMPs.

d. *Performance Standards*. The pollution prevention/good housekeeping program shall include, at a minimum, an annual employee training for all eligible employees. An eligible employee is a new or veteran employee whose day-to-day work activities have the potential to impact stormwater quality. MS4s shall evaluate all current municipal-owned facilities to ensure that industrial general stormwater permit coverage (ARR000000), if needed, is obtained. This evaluation shall be included in the first annual report. For all municipal facilities not requiring industrial stormwater permit coverage, the inspections must be performed at least annually for municipal facilities performing maintenance activities on mechanical equipment, facilities with fueling stations, facilities involved in waste storage, transfer or recycling, facilities with material stockpiles, and facilities storing fertilizers or pesticides. The O&M program shall include appropriate procedures, controls, maintenance schedules and recordkeeping to address Part III.2.F.c.(3) of this permit.

e. *Annual Reporting*. The annual report shall document the following:

(1) a summary of employee training program(s) implemented with the number of employees that attended; and

(2) a summary of activities and procedures implemented for the operation and maintenance program.

3. Sharing Responsibility

Implementation of one (1) or more of the minimum measures may be shared with another entity, or the entity may fully take over the measure. The permittee may rely on another entity only if:

A. The other entity, in fact, implements all or part of the control measure;

B. The particular control measure, or component of that measure, is at least as stringent as the corresponding permit requirement; and

C. The other entity agrees to implement the control measure on the permittee's behalf. There shall be written acceptance of this obligation. This obligation shall be maintained as part of their SWMP. If the other entity agrees to report on the minimum measure, the permittee shall supply the other entity with the reporting requirements contained in Part IV.3 of this permit. If the other entity fails to implement the control measure, then the permittee remains responsible for failing to implement the control measure.

4. Reviewing and Updating Stormwater Management Programs

A. *SWMP Review:* The permittee shall do an annual review of the SWMP in conjunction with preparation of the annual report required under Part IV.3 of this permit.

B. *SWMP Update:* The permittee may change the SWMP during the life of the permit in accordance with the following procedures:

a. Changes adding (but not subtracting or replacing) components, controls, or requirements to the SWMP may be made at any time upon written notification to the Division. This includes any changes that affect the signatory authority of the permit. These changes will be considered a minor modification and are not subject to the public notice requirements in Part II.5. This does not include changes adding a new BMP based on a newly applicable condition, such as BMPs required by Part III.4.E due to a newly impaired waterbody designation. Such changes will be considered a major modification to the SWMP and are required to undergo the process under Part III.4.B.b.

b. Changes replacing an ineffective or infeasible BMP specifically identified in the SWMP with an alternate BMP may be requested at any time. These changes may be considered a major modification to the SWMP and be subject to the public notice process outlined in Part II.5. The Division will review and provide a written decision within sixty (60) days of the request. The Division may approve with additional specific additional requirements. The permittee shall implement the revised BMPs immediately upon approval or within the timeframe specified by the approval. If the request is denied, the Division will send a written response giving a reason for the decision. The modification requests shall include the following:

(1) An analysis of why the BMP is ineffective or infeasible (including cost prohibitive);

(2) Expectations on the effectiveness of the replacement BMP; and

(3) An analysis of why the replacement BMP is expected to achieve the goals of the BMP to be replaced.

c. Changes applicable to Parts III.1.C and III.1.D are considered minor modifications and do not require any notification to DEQ.

d. Change requests or notifications shall be made in writing and signed in accordance with Part V.7 of this permit.

C. *SWMP Updates Required by DEQ*: The Division may require changes to the SWMP as needed to:

a. Address impacts on receiving water quality caused, or contributed to, by discharges from the MS4;

b. Include more stringent requirements necessary to comply with new Federal statutory or regulatory requirements; or

c. Include such other conditions deemed necessary by the Division to comply with the goals of the Clean Water Act.

d. Changes requested by the Division will be made in writing, set forth the time schedule to develop the changes, offer the opportunity to propose alternative program changes to meet the objective of the requested modification, and discuss whether the changes are subject to the public notification requirements in Part II.5.

D. *Transfer of Ownership, Operational Authority, or Responsibility for SWMP Implementation:* The permittee shall implement the SWMP on all new areas added to a portion of the MS4 (or for which the permittee becomes responsible for implementation of stormwater quality controls) as expeditiously as practicable, but not later than one (1) year from the addition of the new areas. Implementation may be accomplished in a phased manner to allow additional time for controls that cannot be implemented immediately.

Within thirty (30) days of a transfer of ownership, operational authority, or responsibility for SWMP implementation, the permittee shall have a plan for implementing a SWMP on all affected areas. The plan may include schedules for implementation. Information on all new annexed areas and any resulting updates required to the SWMP shall be included in the annual report. DEQ must be notified of permit transfer within thirty (30) days of change of ownership, operational authority or responsibility for SWMP implementation.

E. Discharges to Waters Identified on the 303(d); Discharges to Waters with TMDL Requirements

Discharges of pollutant(s) of concern to water bodies for which there is an approved TMDL are not eligible for this general permit unless they are consistent with the approved TMDL.

The permittee shall control the discharges of pollutant(s) of concern to impaired waters and waterbodies with approved TMDLs as provided below, and shall assess the success in controlling those pollutants.

a. Discharges to Waters with an Approved TMDL

If the permittee discharges to an impaired water body with an approved TMDL or a water that is attaining Water Quality Standards but has an approved TMDL, the permittee must comply with the WLA in the final permit in accordance with 40 C.F.R. § 122.44(d)(1)(vii)(1)(B) and will have three (3) years to comply with the TMDL in accordance with Rule 2.104. However, until the effective date of the WLA, the permittee shall control the discharges of pollutant(s) of concern to impaired waters and waters with approved TMDLs and shall assess the success in controlling those pollutants. The MS4 must include the following items in the SWMP:

(1) Acknowledge the WLA assigned to the MS4 and develop BMPs appropriate to the local community that are expected to result in progress toward meeting the reduction goals established in the TMDL;

(2) List and map the outfall(s) to be measured and discuss how to measure the flow at each sampling location and calculate the loading of the pollutant(s) in the watershed;

(3) Provide the monitoring plan, sampling results, and progress on program implementation as part of the MS4's annual report each year;

(4) Evaluate and assess the effectiveness of the monitoring program and pollutant reduction plan to demonstrate compliance with the assigned WLA. The MS4 must continue to implement BMPs that are equivalent to those in effect at the time of compliance.

(5) The specific methods outlining implementation of the TMDL and its assumptions shall be included in the approved SWMP for the purpose to demonstrate compliance with this permit during the term of coverage.

The list of existing approved TMDLs at the time of permit issuance, affected by the MS4 stormwater discharge, can be found at Appendix A. This permit serves as notification to implement the TMDL requirements for the applicable MS4s. Any new or revised TMDL or watershed plans affected by MS4 stormwater discharge that are approved after the effective date of this permit will be identified in the next permit cycle or modification.

b. Discharges Directly to Waters Identified on the 303(d) List without an approved TMDL

If the MS4 may be a source of the pollutant(s) of concern, the operator must, at a minimum:

(1) Within one (1) year of the date of permit coverage or a new waterbody impairment listing for an existing MS4, identify potential significant sources of the pollutant of concern entering the MS4 and conduct inspections on those areas likely to have illicit discharge;

(2) Within two (2) years of the date of permit coverage or a new waterbody impairment listing for an existing MS4, review results to date from the Illicit Discharge Detection and Elimination program and develop (or modify an existing program as necessary) and implement a program, including focused BMPs and corresponding measurable goals, to reduce the discharge of the pollutant of concern in municipal storm water;

i. For nutrients (e.g. nitrogen, phosphorus, and ammonia), reduce the nutrient contribution from the use of fertilizer by residential, commercial, municipal operations (e.g., parks, roadways, municipal facilities), and golf courses within MS4 jurisdiction;

ii. For bacteria, prioritize the detection and elimination of the waste sources of bacteria from pets, recreational and exhibition livestock, zoos, and areas within the MS4 served by on-site wastewater treatment systems;

iii. For turbidity, reduce the turbidity in the stormwater runoff from construction activities, dewatering activities, bare ground, failing stream banks, areas within the MS4 served by on-site wastewater treatment systems, and other areas.

(3) Within three (3) years of the date of permit coverage or new impairment for an existing MS4, develop (or modify an existing program as necessary) and implement a program to reduce the discharge of the pollutant of concern in municipal storm water contributed by any other significant source identified in the source identification evaluation; and

(4) Evaluate and report the progress on program implementation, the reduction of the discharge of the pollutant of concern into impaired waters, and updates to measurable goals in the annual report.

(5) The timelines for the steps (1) – (3) above are not applicable for permittees that had coverage under the previous ARR040000 permit, and discharge into water bodies listed as impaired as of the latest 303(d) list of impaired waterbodies. Instead, these requirements should be completed by the effective date of this

permit.

(6) The specific pollutant monitoring and/or control mechanisms required shall be included in the approved SWMP for the purpose to demonstrate compliance with this permit during the term of coverage.

5. Monitoring

A. *Discharges into waters with an approved TMDL.* The permittee must evaluate program compliance, the appropriateness of identified best management practices, and progress toward achieving identified measurable goals. If the MS4 discharges to waters with an approved TMDL, the permittee must establish the monitoring plan to determine if the stormwater controls are adequate to maintain compliance with the MS4's WLA. The monitoring program should be designed to assess the impacts to receiving waters resulting from stormwater discharges, identify sources of specific pollutants addressed in the TMDL, detect and eliminate illicit discharges and illegal connections to the MS4, and evaluate the effectiveness of the permittee's SWMP. This monitoring must include quarterly sampling for the pollutant(s) listed in the TMDL.

B. *Discharges into waters identified on the 303(d) list.* For MS4s discharging into 303(d) listed waters with the source of the pollutant identified as surface erosion or urban runoff, monitoring must include quarterly sampling for the pollutant(s) listed. The permittee must develop a sampling plan which will help to identify those outfalls discharging the pollutant(s) of concern. The initial outfall(s) to be sampled shall be representative of the varying land uses within the MS4 designated area. Based upon initial results of sampling, the permittee may revise its sampling plan as appropriate. The sampling plan and any revisions must be submitted to the Division for review and approval. All sampling results must be submitted with the annual report.

C. When additional information is required in the determination of the cause or status of a waterbody impairment, in the development or implementation of a TMDL, or in the development or implementation of a watershed management plan, the Division may require an MS4 to provide a timeline to develop the sampling plan for the study of the pollutant(s) of concern from the MS4. The Division will notify the MS4 of the decision in writing regarding the proposed action items and schedule for deliverables. Upon notification, the MS4 will be required to develop a monitoring plan and submit it to the Division according to an agreed schedule, generally within ninety (90) days. Upon Division approval of a monitoring plan, the MS4 must take samples for the pollutant(s) in accordance with the approved plan. Based upon initial results of sampling, the MS4 may submit a revised sampling plan to the Division for approval. The monitoring plan and schedule shall be followed to maintain compliance as it is considered an integral part of the SWMP upon approval. All sampling results must be submitted with the MS4's annual report.

D. *Analytical Methods.* Analysis and collection of samples must be done in accordance with the methods specified at 40 C.F.R. §136. Where an approved 40 C.F.R. §136 method does not exist, alternative methods may be used upon the Division's approval, unless a particular method or criteria for method selection (such as sensitivity) has been specified in the permit. Screening level tests may utilize less expensive "field test kits" using test methods not approved by EPA under 40 C.F.R. § 136, provided the manufacturers published detection ranges are adequate for the illicit discharge detection purposes.

E. The addition of a new sampling plan, as required by Parts III.5.A, III.5.B, or III.5.C, will be considered a major modification to the SWMP and will be required to follow the public notice procedures laid out in Part II.5 of the permit. If the changes to the sampling plan are considered a major modification to the SWMP, the changes will have to undergo the public notice procedures laid out in Part II.5 of this permit.

PART IV
EVALUATING, RECORDKEEPING, AND REPORTING

1. Evaluating

The permittee shall evaluate program compliance with the terms and conditions of the permit and SWMP, the appropriateness of identified BMPs, and progress toward achieving identified measurable goals and satisfying performance standards.

2. Recordkeeping

A. The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart or other recordings for continuous monitoring instrumentation, copies of all reports required by this permit, a copy of the NPDES permit, and records of all data used to complete the application (NOI) for this permit, for a period of at least three (3) years from the date of the sample, measurement, report or application, or for the term of this permit, whichever is longer. This period may be extended by request of the permitting authority at any time.

B. The permittee shall submit any records to the permitting authority upon request. The permittee must retain the SWMP required by this permit (including a copy of the permit language) at a location accessible to the permitting authority. The permittee must make all records, including the notice of intent (NOI) and the description of the SWMP, available to the public if requested in writing.

3. Reporting

A. Prior to submitting annual reports to the Division, all permittees must make a good faith effort to allow their citizens an opportunity for involvement and input. All permittees shall include a copy of the annual report in electronic format on their websites and at local centers of information, i.e. public libraries, city halls, county courthouses, community centers, etc. New permittees must submit annual reports to the Division for each year of the permit term. The first report is due fifteen (15) months from the effective date of the permit, covering the activities of the permittee during the twelve (12) month period beginning on the effective date of the permit for the permittee. Subsequent annual reports are due on the same date for each of the following years during the remainder of the permit term (and continuing into any administrative continuance of the permit, should it not be reissued prior to expiration). Existing permittees must submit their annual reports, which covers the previous twelve (12) months from January 1st to December 31st of a calendar year, no later than March 31st of the following year (i.e. 2024 report would be due no later than March 31, 2025) through the DEQ's website at https://eportal.adeq.state.ar.us/. The report must include:

   a. The status of compliance with permit conditions, an assessment of the appropriateness of the identified best management practices, and the progress towards achieving the measurable goals for each of the MCMs;

b. Results of information collected and analyzed, if any, during the reporting period, including monitoring data used to assess the success of the program at reducing the discharge of pollutants;

c. A summary of the stormwater activities the permittee plans to undertake during the next reporting cycle (including an implementation schedule);

d. Proposed changes to the stormwater management program, including changes to any BMPs or any identified measurable goals that apply to the program elements;

e. Description and schedule for implementation of additional BMPs that may be necessary, based on monitoring results, to ensure compliance with applicable TMDLs and implementation plans; and

f. Notice that the permittee is relying on another government entity to satisfy some of the permit obligations (if applicable).

g. Reports must be submitted using the appropriate DEQ reporting forms.

B. Where to Submit.

The MS4 must submit the required documents, including all annual reports, using the online electronic reporting system available through the DEQ's website: https://eportal.adeq.state.ar.us/

If an electronic reporting waiver is granted by the DEQ, the MS4 may submit the required documents in electronic format (.pdf) at the following email address: Water-permit-application@adeq.state.ar.us;

or by mail at the following address:

DEQ
Office of Water Quality, General Permits
5301 Northshore Drive
North Little Rock, AR 72118

PART V
GENERAL CONDITIONS

1. Duty to Comply. The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Federal Clean Water Act and the Arkansas Water and Air Pollution Control Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application.

2. Continuation of the Expired General Permit. An expired general permit continues in force and effect until a renewal general permit is issued. If this permit is not re-issued or replaced prior to the expiration date, it will be administratively continued in accordance with the A.C.A. § 8-4-203(m) and remain in force and effect. If permit coverage is granted prior to the expiration date, the MS4 will automatically remain covered by the continued permit until the earliest of:

A. Re-issuance or replacement of this permit, at which time the permittee must comply with the conditions of the new permit and submit a renewal NOI and SWMP no later than thirty (30) days prior to the effective date of this renewal permit to maintain authorization to discharge; or

B. Submittal of a NOT and approval by the Division; or

C. Issuance of an individual permit for the MS4's discharges; or

D. When a formal permit decision by DEQ to not re-issue this general permit, and the permittee seeks and obtains an individual permit.

3. Need to Halt or Reduce Activity Not a Defense. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

4. Duty to Mitigate. The permittee must take all reasonable steps to minimize or prevent any discharge in violation of this permit that has a reasonable likelihood of adversely affecting human health or the environment.

5. Duty to Provide Information. The permittee must furnish to the permitting authority any information that is requested to determine compliance with this permit or other information.

6. Other Information. If the permittee becomes aware that the permittee has failed to submit any relevant facts or submitted incorrect information in the Notice of Intent, Stormwater Management Plan, annual reports, or in any other report to the permitting authority, the permittee must promptly submit such facts or information.

7. **Signatory Requirements.** All Notices of Intent, Notices of Termination, reports, certifications, or information submitted to the permitting authority, or that this permit requires be maintained by the permittee shall be signed and certified as follows:

A. All Notices of Intent must be signed and certified as follows:

a. For a corporation: By a responsible corporate officer. For the purpose of this Part, a responsible corporate officer means:

(1) A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision making functions for the corporation; or

(2) The manager of one (1) or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

b. For a partnership or sole proprietorship: By a general partner or the proprietor, respectively; or

c. For a Municipality, County, State, Federal, or other public agency: By either a principal executive officer or ranking elected official. For purposes of this Part, a principal executive officer of a Federal agency includes

(1) The chief executive officer of the agency, or

(2) A senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrator of EPA).

B. All reports, including the annual report, required by this permit can be signed by a person described in Part V.7.A above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

a. The authorization is made in writing by a person described in Part V.7.A;

b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position); and

c. The signed and dated written authorization is included in the SWMP. A copy must be submitted to the Division, if requested.

C. Changes to Authorization. If an authorization is no longer accurate because a different operator has the responsibility for the overall operation of the MS4, a new authorization satisfying the requirement of Part V.7.A above must be completed prior to or together with any reports, information, or notices of intent to be signed by an authorized representative.

D. Any person signing documents under the terms of this permit shall make the following certification:

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

E. Falsification

Arkansas law imposes penalties and fines for persons who knowingly make false statements or knowingly swear or affirm the truth of a false statement previously made.

8. Local, State, and Federal Laws. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable local, state, or federal law or regulation, or any applicable State law or regulation under authority preserved by section 510 of the Act.

No condition of this permit releases the permittee from any responsibility or requirements under other environmental statutes or regulations.

9. Property Rights. The issuance of this permit does not convey any property rights of any sort, nor any exclusive privilege, nor does it authorize any injury to private property nor any invasion of personal rights, nor any infringement of federal, state or local laws or regulations.

10. Proper Operation and Maintenance. The permittee must at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used to achieve compliance with the conditions of this permit and with the conditions of the permittee's stormwater management program. Proper O&M also includes adequate laboratory controls and appropriate quality assurance procedures. Proper O&M requires the operation of backup or auxiliary facilities or similar systems, installed only when the operation is necessary to achieve compliance with the conditions of the permit.

11. Inspection and Entry. The permittee shall allow the Division or an authorized representative upon the presentation of credentials and other documents as may be required by law, to do any of the following:

A. Enter the premises at reasonable times where a regulated facility or activity is located or conducted or where records must be kept under the conditions of this permit;

B. Have access to and copy at reasonable times, any records that must be kept under the conditions of this permit;

C. Inspect at reasonable times any facilities or equipment (including monitoring and control equipment) practices, or operations regulated or required under this permit; and

D. Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the CWA, any substances or parameters at any location.

12. Permit Actions. This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any permit condition.

13. Anticipated Noncompliance. The permittee shall give advance notice to the Division of any planned changes in the permitted small MS4 or activity which may result in noncompliance with this permit.

14. Reserved.

15. Severability. The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit shall not be affected thereby.

16. Procedures for Modification or Revocation. Permit modification or revocation will be conducted according to 40 C.F.R. §§ 122.62, 122.63, 122.64 and 124.5.

17. Requiring an Individual Permit or an Alternative General Permit

A. *Request by permitting authority:* The Division may require any person authorized by this permit to apply for and/or obtain either an individual NPDES permit or coverage under an alternative NPDES general permit. Any interested person may petition the Division to take action under this paragraph. Where the Division requires the permittee to apply for an individual NPDES permit or coverage under an alternative NPDES general permit, the Division will notify the permittee in writing that a permit application is required. This notification shall include a brief statement of the reasons for this decision, an application form, a statement setting a deadline for to file the application, and a statement that on the effective date of issuance or denial of the individual NPDES permit or the alternative NPDES general permit coverage as it applies to the individual permittee, coverage under this general permit shall automatically terminate. DEQ may grant additional time to submit the application upon request of the applicant. If the MS4 fails to submit in a timely manner an individual NPDES permit application or an NOI for coverage under an alternative NPDES general permit as required by the Division under this paragraph, then the applicability of this permit is terminated at the end of the day specified by the Division.

B. *Request by permittee:* Any discharger authorized by this permit may request to be excluded from the coverage of this permit by applying for an individual NPDES permit with reasons supporting the request. The request may be granted by issuance of any individual permit or an alternative general permit if the reasons cited by are adequate to support the request.

C. *General permit termination*. When an individual NPDES permit is issued to a discharger otherwise subject to this permit, or the permittee is authorized to discharge under an alternative NPDES general permit, the permittee is required to submit a NOT before the applicability of this permit to the MS4 can be terminated, no earlier than the effective date of the individual permit or the date of authorization of coverage under the alternative general permit, whichever the case may be. When an individual NPDES permit is denied to an operator otherwise subject to this permit, or the operator is denied for coverage under an alternative NPDES general permit, the applicability of this permit to the MS4 is automatically terminated on the date of such denial, unless otherwise specified by the Division.

18. Re-opener Clause. In accordance with 40 C.F.R. § 122.62(a)(2), the permit may be modified, or alternatively, revoked and reissued, if new information is received that was not available at the time of permit issuance that would have justified the application of different permit conditions at the time of permit issuance.

PART VI
DEFINITIONS

All definitions contained in Section 502 of the Act and 40 C.F.R. § 122 shall apply to this permit and are incorporated herein by reference. For convenience, simplified explanations of some regulatory/statutory definitions have been provided, but in the event of a conflict, the definition found in the Statute or Rule takes precedence.

1. **"Best Management Practices (BMPs)"** means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants to waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.
2. **"Control Measure"** as used in this permit, refers to any Best Management Practice or other method used to prevent or reduce the discharge of pollutants to waters of the United States.
3. **"Coverage area"** is the area for which the permittee must implement the requirements for this permit.
4. **"CWA"** means the Clean Water Act or the Federal Water Pollution Control Act, 33 U.S.C. 1251 et seq.
5. **"DEQ"** is referencing the Arkansas Department of Energy and Environment – Division of Environmental Quality. The Division is the governing authority for the National Pollutant Discharge Elimination System program in the state of Arkansas.
6. **"Director"** means the Chief Administrator, Division of Environmental Quality, or a designated representative.
7. **"Division"** is referencing the Division of Environmental Quality. The Division is the governing authority for the National Pollutant Discharge Elimination System program in the state of Arkansas.
8. **"Discharge"** when used without qualification means the "discharge of a pollutant."
9. **"Discharge of Stormwater Associated with Construction Activity"** as used in this permit, refers to a discharge of pollutants in stormwater runoff from areas where soil disturbing activities (e.g., clearing, grading, or excavation), construction materials or equipment storage or maintenance (e.g., fill piles, borrow area, concrete truck washout, fueling), or other industrial stormwater directly related to the construction process (e.g., concrete or asphalt batch plants) are located.
10. **"Discharge-related activities"** include: activities which cause, contribute to, or result in stormwater point source pollutant discharges; and measures to control stormwater discharges, including the siting, construction and operation of best management practices (BMPs) to control, reduce or prevent stormwater pollution.
11. **"Eligible"** means qualified for authorization to discharge stormwater under this general permit.
12. **"Facility" or "Activity"** means any NPDES "point source" or any other facility (including land or appurtenances thereto) that is subject to regulation under the NPDES program.
13. **"Illicit Connection"** means any man-made conveyance connecting an illicit discharge directly to a municipal separate storm sewer.
14. **"Illicit discharge"** means any discharge to a municipal separate storm sewer that is not composed entirely of stormwater except discharges pursuant to a NPDES permit (other than the NPDES

permit for discharges from the municipal separate storm sewer) and discharges resulting from emergency fire fighting activities.

15. "**Impaired waters**" are waters that have been identified pursuant to Section 303(d) of the Clean Water Act as not meeting applicable surface water quality standards. This may include both waters with approved Total Maximum Daily Loads (TMDLs) and those for which a TMDL has not yet been approved.

16. "**Large Municipal Separate Storm Sewer System**" means all municipal separate storm sewer systems that are either:

A. Located in an incorporated place with a population of 250,000 or more as determined by the latest Decennial Census by the Bureau of Census: or

B. Located in the counties with unincorporated urbanized populations of 250,000 or more, except municipal, separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

C. Owned or operated by a municipality other than those described in paragraphs VI.16.A or VI.16.B and that are designated by the Director as part of the large or medium municipal separate storm sewer system.

17. "**Measurable Goal**" means a quantitative measure of progress in implementing a component of a stormwater management program.

18. "**Medium Municipal Separate Storm Sewer System**" means all municipal separate storm sewer systems that are either:

A. Located in an incorporated place with a population of more than 100,000 but less than 250,000 as determined by the latest Decennial Census by the Bureau of Census: or

B. Located in the counties with unincorporated urbanized populations of more than 100,000 but less than 250,000, except municipal, separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

C. Owned or operated by a municipality other than those described in paragraphs VI.18.A or VI.18.B and that are designated by the Director as part of the large or medium municipal separate storm sewer system.

19. "**MS4**" means Municipal Separate Storm Sewer System.

20. "**Municipal Separate Storm Sewer**" means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, and storm drains):

A. Owned or operated by a state, city, town, county, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under state law such as a sewer district, flood control district or drainage district, or similar entity, or a designated and approved management agency under section 208 of the Clean Water Act (33 U.S.C. 1288) that discharges to waters of the United States;

B. Designed or used for collecting or conveying stormwater;

C. That is not a combined sewer; and

D. That is not part of a publicly owned treatment works.

21. "**NOI**" means Notice of Intent to be covered by this permit.

22. "**NOT**" means Notice of Termination.

23. "**Non-Traditional MS4**" means systems similar to separate storm sewer systems in municipalities, such as systems at military bases, hospitals, public universities or prison complexes, and highways and other thoroughfares. The term does not include separate storm sewer systems in very discrete areas such as individual buildings.

24. **"Off-Lot Home Sewage Treatment System (HSTS)"** means a system designed to treat home sewage on-site and discharges treated wastewater off-lot.

25. **"On-Lot Home Sewage Treatment System (HSTS)"** means a system designed to treat home sewage on-lot with no discharges leaving the lot.

26. **"Outfall"** means a point source as defined by 40 C.F.R. § 122.2 at the point where a municipal separate storm sewer discharges to waters of the State and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels or other conveyances which connect segments of the same stream or other waters of the United States and that are used to convey waters of the United States.

27. **"Owner or operator"** means the owner or operator of any "facility or activity" subject to regulation under the NPDES program.

28. **"Permitting Authority"** means the Division of Environmental Quality.

29. **"Physically Interconnected"** means that one municipal separate storm sewer system is connected to a second municipal separate storm sewer system in such a way that it allows for direct discharges into the second system.

30. **"Point Source"** means any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

31. **"Pollutant"** is defined at 40 C.F.R. § 122.2. A partial listing from this definition includes: dredged spoil, solid waste, sewage, garbage, sewage sludge, chemical wastes, biological materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial or municipal waste.

32. **"Qualified personnel"** means staff knowledgeable in the operation and maintenance of Municipal Separate Storm Sewer Systems (MS4) and possessing the skills necessary to gather and evaluate information regarding an MS4 program.

33. **"Significant contributors of pollutants"** means any discharge that causes or could cause or contribute to a violation of surface water quality standards.

34. **"Small MS4"** means any MS4 not already covered by the Phase I stormwater program.

35. **"Splash Pad"** refers to an outdoor recreational bathing area with sprinklers, fountains, nozzles, and other devices or structures that spray water.

36. **"Total Maximum Daily Load (TMDL)"** the sum of individual wasteload allocations (WLAs) for point sources, load allocations (LA's) for non-point sources, and natural background levels.

37. **"Uncontaminated"** means that the water will not exceed the water quality standards as set forth in APC&EC Rule 2; also not containing a harmful quantity of any substance.

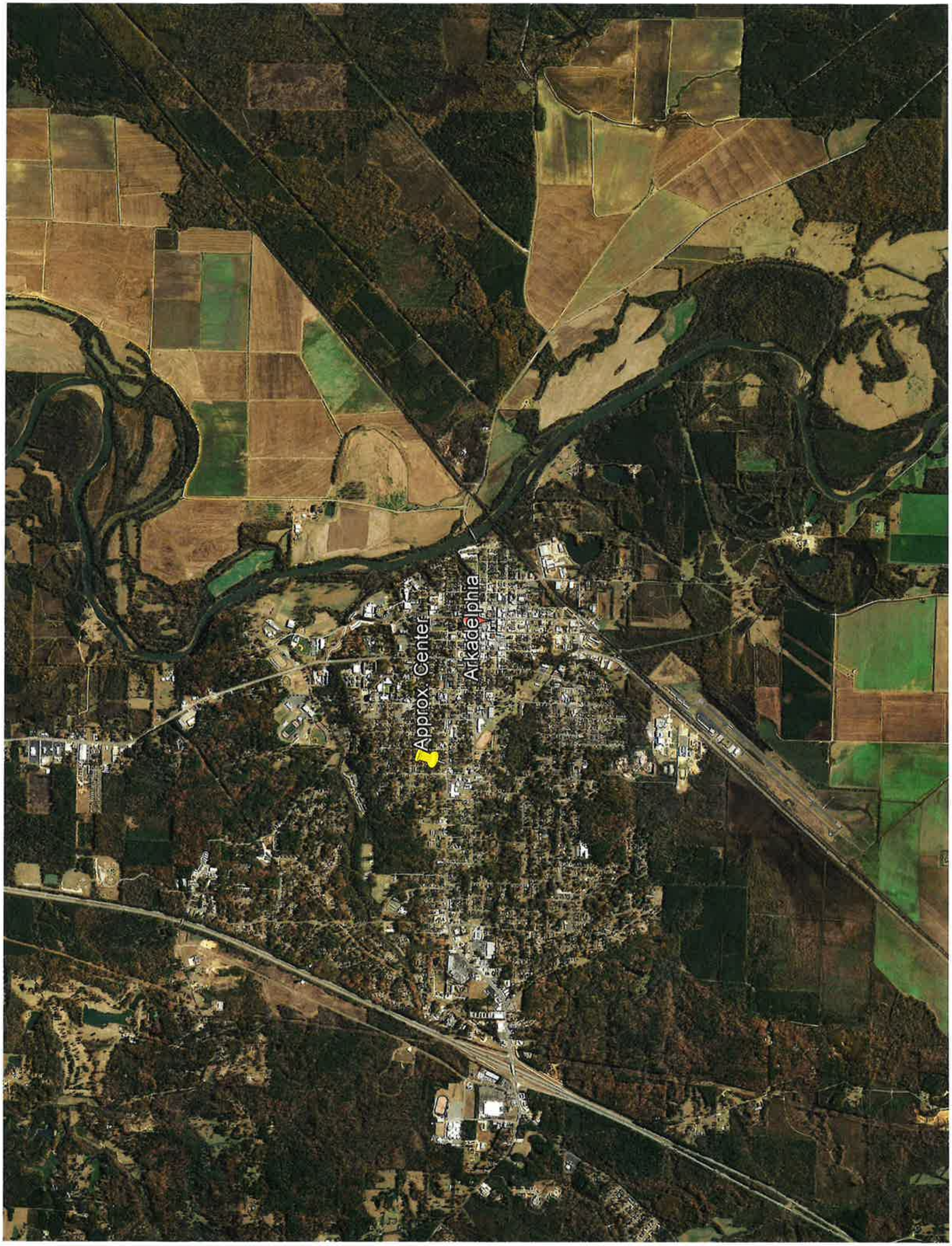
Appendix A

The following lists regulated MS4s that are identified in an EPA approved TMDL and the TMDL pollutant(s) for the MS4. Not included on this list are MS4s which become permitted after the effective date of this general permit.

If the MS4 is identified in Appendix A, the MS4 shall develop and implement the TMDL requirements within this permit for its discharge. Implementation shall occur, at a minimum, for the regulated MS4 discharges within each TMDL watershed identified.

NPDES ID	Regulated MS4	Water Body	Pollutant(s)
ARR040009	City of Bentonville	Town Branch	Total Phosphorus
ARR040010	City of Fayetteville	Clear Creek	Fecal Coliform and E. coli
ARR040012	Jefferson County	Saline River	Total Dissolved Solids
ARR040013	City of Cabot	Cypress Bayou	Fecal Coliform and E. coli
ARR040019	City of Springdale	Clear Creek	Fecal Coliform and E. coli
ARR040023	Washington County	Clear Creek	Fecal Coliform and E. coli
ARR040024	Pulaski County	Cypress Bayou	Fecal Coliform and E. coli
ARR040025	City of West Memphis	Blackfish Bayou	Total Suspended Solids
ARR040038	City of Johnson	Clear Creek	Fecal Coliform and E. coli
ARR040040	City of Marion	Blackfish Bayou	Total Suspended Solids
ARR040043	City of Benton	Saline River	Total Dissolved Solids

APPENDIX C
MS4 MAP


Approx. Center
Arkadelphia

APPENDIX D
STORMWATER ORDINANCE

ORDINANCE NO. O-04-10

A STORM WATER MANAGEMENT AND DRAINAGE ORDINANCE ADOPTING REGULATIONS DESIGN TO LESSEN AND AVOID HAZARDS TO PERSONS AND PROPERTY CAUSED BY OBSTRUCTION TO DRAINAGE AND TO OTHERWISE PROMOTE THE PUBLIC HEALTH; SAFETY AND GENERAL WELFARE, REPEALING ANY ORDINANCES IN CONFLICT HEREWITH AND FOR OTHER PURPOSES.

NOW THEREFORE BE IT ORDAINED BY THE BOARD OF DIRECTORS OF THE CITY OF ARKADELPHIA, ARKANSAS, THAT:

ARTICLE 1.

1.1 Title - These regulations shall hereafter be known, cited and referred to as the "Stormwater Management and Drainage Regulations" of the City of Arkadelphia, Arkansas.

1.2 Authority- These regulations are adopted pursuant to the power and authority vested through the applicable laws and statutes of the State of Arkansas.

1.3 Applicability- Any person, firm, corporation or business proposing to construct building or develop land within the Arkadelphia Planning jurisdiction shall submit drainage plans to the City Engineer for approval of a stormwater management and drainage plan before building permits are issued or subdivisions are approved. No land shall be developed except upon approval of the City Engineer.

1.4 Exemptions- All construction, subdivision approvals or remodeling activities shall have a stormwater management and drainage plan approved before a building permit is issued or subdivision is approved except for the following:

- One – new or existing single-family structure.
- One – new or existing duplex family structure.
- **One – new commercial or industrial structure located on less than one-acre individual lot.**
- One – existing commercial or industrial structure where additional structural improvements are less than **5000** square feet.

1.5 Purpose- In order to promote the public health, safety and general welfare of the citizens of Arkadelphia, the provisions of these regulations, as amended from time to time, are intended to: (1) reduce property damage and human suffering, and (2) to minimize the hazards of personal injury and loss of life due to flooding, to be accomplished through the approval of a storm water management and drainage plan pursuant to the provisions of these regulations, which: (a) establish the major and minor stormwater management systems, (b) define and establish stormwater management practices and use restrictions, and (c) establish guidelines for handling increases in volume and peak discharges of runoff.

1.6 Definitions – For the purpose of this Ordinance, certain terms and words shall be used, interpreted and defined as set forth in this section. Unless the context clearly indicates to the contrary, words used in the present tense include the future tense; words used in the singular shall include the plural, and vice-versa; and words, "these regulations," mean "this Ordinance;" the work, "person," includes corporation, partnership, and unincorporated association of persons; and the word, "shall," is always mandatory.

A. Base Flood – The flood that has a 1 percent chance of being equaled or exceeded in any given year, i.e., the 100-Year Flood.

B. Bond – Any form of security for the completion or performance of the stormwater management and drainage plan or the maintenance of drainage improvements, including surety bond, collateral, property or instrument of credit, or escrow deposit in an amount and form satisfactory to the City Engineer.

C. Building – Any structure built for the support, shelter or enclosures of persons, animals, or movable property of any kind.

D. Channel – Course of perceptible extent which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water, and which has a definite bed and banks.

E. Conduit – Any open or closed device for conveying flowing water.

F. Control – The hydraulic characteristic which determines the stage-discharge relationship in a conduit. The control is usually critical depth, tail water depth, or uniform depth.

G. Detention Basins – Any man-made area which serves as means of controlling and temporarily storing stormwater runoff. The facility normally drains completely between spaced runoff events, e.g., parking lots, rooftops, athletic fields, dry wells, oversized storm drain pipes.

H. Detention - The temporary detaining or storage of floodwater in reservoirs, on parking lots, on rooftops and other areas under predetermined and controlled conditions accompanied by controlled release of the stored water.

I. Detention Pond – A stormwater detention facility which maintains a fixed minimum water elevation between runoff events except for the lowering resulting from losses of water to infiltration or evaporation.

J. Development – any change of land use or improvements on any parcel land.

K. Differential Runoff – The volume and rate of flow of stormwater runoff discharged from a parcel of land or drainage area which is or will be greater than the volume and rate which pertained prior to proposed development or redevelopment existed.

L. Drainage Approval – a certificate of approval issued by the City Engineer based upon an approved final stormwater management and drainage plan. The final stormwater management and drainage plan must accompany the building permit application or be submitted with the proposed construction plans.

M. Drainage Easement – Authorization by a property owner for use by another party or parties for all or any portion of his/her land for a drainage and adjoining utility purposes. Easements shall be dedicated to the City when required or approved by the City Engineer.

N. Engineer of Record – A registered professional engineer in Arkansas. This engineer shall supervise the design and construction of the project and shall be acceptable by the City Engineer.

O. Floodplain – a land area adjoining a river, stream, watercourse, or lake which is likely to be flooded.

P. Floodway – The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without a cumulative increase of the water surface elevation more than a designated height.

Q. Freeboard – A factor of safety expressed as the difference in elevation between the top of the detention basin dam, levees, culvert entrances and other hydraulic structures, and the design flow elevation.

R. Frequency – The reciprocal of the exceedance probability.

S. Habitable Dwelling Unit – A dwelling unit intended and suitable for human habitation.

T. Major Storm Easements – Privately maintained areas designed to carry the 100-year storm with no obstructions allowed such as fill or fences that would impede floodwater flow. Properly designed landscaping that does not impede floodwater or endanger adjacent property may be allowed.

U. Minor Storm Easements – Public maintained areas designed to carry the storm other than the 100-year storm, provide access for maintenance; and prevent channel obstructions.

V. On-site Detention – Temporary storage of runoff on the same land development site where the runoff is generated.

W. On-Stream Detention – Temporary storage of runoff within a principal drainage system, i.e., in the receiving streams or conduits.

X. Off-Stream Detention – Temporary storage accomplished off-line, i.e., not within a principal drainage system.

Y. 100-Year Peak Flow – The peak rate of flow of water at given point in a channel, watercourse or conduit resulting from the base flood.

Z. 100-Year Storm – Rainstorms of a specified duration having a 1 percent chance of occurrence in a given year.

AA. Permittee- A person, partnership or corporation to whom a permit is granted.

BB. Plat – A legally recorded plat of a parcel of land subdivided into lots with streets, alleys, easements, and other land lines drawn to scale.

CC. Project- Any development involving the construction, reconstruction or improvement of structures and/or grounds.

DD. Rational Method – An empirical formula for calculating peak rates of runoff resulting from rainfall.

EE. Retention Facility – Any type of detention facility not provided with a positive outlet.

FF. Stormwater Drainage Design Manual and Floodplain Compliance Guidelines – The set of drainage policies, analysis methods, design charts, stormwater runoff methods, and design standards used by the City as the official design guidelines for drainage improvements consistent with the Ordinance. The City Engineer will make any mediation consistent with the stated policies and intent of the Ordinance.

GG. Stormwater Runoff – Water that results from precipitation which is not absorbed by the soil, evaporated into the atmosphere or entrapped by ground surface depressions and vegetation, which flows over the ground surface.

HH. Structure – Any object constructed above or below ground. Pipes, manholes and certain other utility structures which exist underground may be excluded from the definition.

II. Swale- A shallow waterway.

JJ. Time of Concentration – The estimated time in minutes required for runoff to flow from the most remote section of the drainage area to the point at which the flow is to be determined.

KK. Tributary Area – All of the area that contributes stormwater runoff to a given point.

LL. Uniform Channel – A channel with a constant cross section and roughness.

MM. Wet Bottom Basin – A detention basin intended to have a permanent pool.

NN. Watercourse – Any surface stream, creek, brook, branch, depression, reservoir, lake, pond or drainage way in or into which stormwater runoff flows.

ARTICLE 2.

STORMWATER MANAGEMENT AND DRAINAGE SYSTEM.

2.1 General – This article establishes the stormwater runoff management system of the City of Arkadelphia which shall be composed of a major system and minor system, management controls and management practices.

2.2 The Major System – The major system is the area of any drainage way within the limits of flow of a 100-year storm.

2.3 The Minor System – The minor systems will be composed of all water course and drainage structures, both public and private, that are not part of the major system, because of lower design storm frequencies.

2.4 Management Controls – Management controls are regulations applicable to the major systems under the provisions of this Ordinance. Such controls shall limit any activity which adversely effect hydraulic function of open channels, drainage swales, detention facilities, or enclosed stormwater conveyance systems. The City of Arkadelphia Stormwater Drainage Design Manual and Floodplain Compliance

Guidelines, shall be the official document used for designing stormwater management controls and drainage systems.

2.5 Management Practices – The following practices may be utilized on approval by the City Engineer.

A. Storage – Runoff may be stored in temporary or permanent detention basins, or through rooftop, parking lot ponding, or percolation storage, or by other means in accordance with the design criteria and performance standards set forth in these regulations.

B. Open Channels- Maximum feasible use shall be made of existing drainage ways, open channels and drainage swales that are designed and coordinated with the design of building lots and streets in accordance with the design of building lots and streets in accordance with the design criteria and performance standards set forth in the Drainage Manual.

C. Curbs – Streets, curbs and gutters shall be a part of the stormwater runoff management systems. To the maximum extent possible, drainage systems, street layout and grades, lotting patterns and the location of curbs, inlets and site drainage and overflow swales shall be concurrently designed in accordance with design criteria and performance standards set forth in the Drainage Manual.

D. Enclosed Conveyance Systems – Enclosed conveyance systems consisting of inlets, conduits, and manholes may be used to convey stormwater runoff. Where used, such systems must be designed and performance set forth in the Drainage Manual.

E. Other - The stormwater runoff management practices enumerated herein shall not constitute an exclusive listing of available management practices. Other generally accepted practices and methods may be approved by the City Engineer, if the purposes, design criteria and minimum performance standards of these regulations are complied with.

2.6 Public and Private Responsibilities Under the Stormwater Management System

A. Public Responsibilities:

1. Administration – Administration of these regulations shall be the responsibility of the City Engineer, who shall determine approval, disapproval, or modification of stormwater management plans as provided herein.

2. Operation and Maintenance of Publicly Owner Facilities – The City Public Works Department shall be responsible after construction for the operation and maintenance of all drainage structures and improved courses which are part of the stormwater runoff management system under public ownership and which are not constructed and maintained by or under the jurisdiction of any state or federal agency.

B. Private Responsibilities:

1. Each developer of land within the City has responsibility to provide on the developer's property all approved stormwater runoff management facilities to ensure the adequate drainage and control of stormwater on the developer's property both during and after construction of such facilities.
2. Each developer or owner has a responsibility and duty before and after construction to properly operate and maintain any on-site stormwater runoff control facility which has not been accepted for maintenance by the public. Such responsibility is to be transmitted to subsequent owners through appropriate covenants.

ARTICLE 3.

PROCEDURE FOR SUBMISSION, REVIEW AND APPROVAL OF STORMWATER MANAGEMENT AND DRAINAGE PLANS.

3.1 General – The stormwater management and drainage plan shall be prepared by the Engineer of Record, who is a licensed professional engineer of the State of Arkansas. No building permits or subdivision approvals shall be issued until and unless the stormwater management and drainage plan has been approved by the City Engineer.

3.2 Pre-Preliminary Drainage Plan Review – A pre-preliminary drainage plan review with the Engineering staff is suggested before preliminary platting for the purpose of overall general drainage concept review.

3.3 Review of Preliminary Stormwater and Drainage Plan – A preliminary stormwater and drainage plan, and accompanying information shall be submitted at the time of preliminary plat submittal. If needed, a review meeting will be scheduled by the City Engineer with representatives of the developer, including the Engineer of Record, to review the overall concepts included in the preliminary stormwater and drainage plan. The purpose of this review shall be to jointly agree upon an overall stormwater management concept for the proposed development and to review criteria and design parameters which shall apply to final design of this project.

3.4.Final Stormwater Management and Drainage Plan – Following the preliminary stormwater management and drainage plan review, the final stormwater management and drainage plan shall be prepared for each phase is developed. The final plan shall constitute a refinement of the concepts approved in the preliminary stormwater and drainage plan with preparation and submittal of detailed information as required in the Drainage Manual. This plan shall be submitted at the time construction drawings are submitted for approval. No final plat is approved until the drainage structures approved on the construction plans are in place and approved by the City Engineer.

3.5. Review and Approval of Final Stormwater Management and Drainage Plans – Final stormwater management and drainage plans shall be reviewed by the City Engineer. If it is determined according to present engineering practice that the proposed development will provide control of stormwater runoff in accordance with the purposes, design criteria, and performance standards of these regulations and will not be detrimental to the public health, safety and general welfare, the City Engineer shall approve the plan or conditionally approve the plan, setting forth the conditions thereof.

If it is determined that the proposed development will not control stormwater runoff in accordance with these regulations, the City Engineer shall disapprove the final stormwater management and drainage plan.

If disapproved, the application and data shall be returned to the applicant for resubmittal.

(Note: Time frames for filing, review and approval of stormwater management and drainage plans shall coincide with time periods applicable in existing subdivision regulations.)

ARTICLE 4

DESIGN CRITERIA AND PERFORMANCE STANDARDS

4.1 Design Criteria – The City of Arkadelphia's Stormwater Drainage Design Manual and Floodplain Compliance Guidelines shall be the accepted design document. Unless otherwise provided, the following rules shall govern the design and improvements with respect to managing stormwater runoff:

A. Method of Determining Stormwater Runoff – Developments where the upstream drainage area contributing runoff is less than 300 acres should be designed using the rational method of calculating runoff. Developments where the area contributing runoff is greater than 300 acres the Snyder's Unit Hydrograph Method shall be used for calculating runoff. The U.S. Army Corps of Engineers HEC-I or HEC-HMS program should be used to calculate flows or discharges. The applicant may also submit an alternative hydrograph method of evaluation for the calculation of runoff to the City Engineer for review and approval.

All such development proposals shall be prepared by a licensed professional engineer of the State of Arkansas.

B. Development Design – Streets, lot depths of lots, parks and other public grounds shall be located and laid out in such a manner as to minimize the velocity of overland flow, allow maximum opportunity for infiltration stormwater to the ground, and to preserve and utilize existing and planned streams, channels, extension basins, and include wherever possible, streams and floodplains within parks and other public grounds.

C. Enclosed Systems and Open Channels – Enclosed systems and open channels shall be designed using the City of Arkadelphia's Stormwater Drainage Design Manual and Floodplain Compliance Guidelines.

D. Evaluation of Downstream Flooding – The Engineer of Record should evaluate whether the proposed plan will cause or increase downstream flooding conditions. This evaluation should be made on the basis of existing downstream development and an analysis of stormwater runoff with and without the proposed development. When it is determined that the proposed development will cause or increase downstream flowing conditions, provisions to minimize such flooding conditions should be included in the design of storm management improvements. Such provisions may include downstream improvements and/or detention of stormwater runoff and its regulated discharge to the downstream storm drainage system.

E. Detention – Development also shall include temporary detention of stormwater runoff in order to minimize downstream flooding conditions. The following design criteria shall govern the design of temporary drainage facilities:

1. Storage Volume – The volume of storage provided in the detention basin shall be sufficient to control the differential runoff from the 25-year storm frequency of six-hour duration. The differential runoff is the volume and rate of flow of stormwater runoff discharged from a parcel of land or drainage area which is or will be greater than the volume and rate which pertained prior to proposed development for redevelopment.
2. Freeboard – Detention storage areas shall have adequate capacity to contain the storage volume of tributary stormwater runoff with at least 6 inches of freeboard above the water surface of flow and the emergency spillway in a 25-year storm. The entire

structure should be designed for discharging the major storm.

3. Outlet Control Works
   (a.) Outlet works shall be designed to limit peak out-flow rates from detention storage areas to or below peak flow rates for a 25-year storm that would have occurred prior to the proposed development.
   (b.) Outlet works shall not include any mechanical components or devices and shall function without requiring attendance or control during operation.
   (c.) Size and hydraulic characteristics shall be such that all water and detention storage is released to the downstream storm sewer systems within 24 hours after the end of the design rainfall. Normal time for discharge ranges from 3 to 24 hours.
4. Spillway – Emergency spillways shall be provided to permit the safe passage of runoff generated from a 100-year storm or greater, if appropriate because of downstream high hazard, such as loss of life or damage to high value property.
5. Design Data Submittal – In addition to complete plans, all design data shall be submitted as required in the detention design data submittal section of the Drainage Manual.
6. Detention Methods – Depending upon the detention alternative(s) selected by the Engineer of Record, the design criteria for detention ponds shall follow those given in the Drainage Manual.

F. Reduction in Coefficient of Runoff – If an existing site with an existing coefficient of runoff of 1.0 (totally impervious) is developed, no on-site detention or in-lieu fee for detention is required. Also, if an existing site is developed whereby the coefficient of runoff is reduced to a lesser value, no on-site detention or in-lieu fee is required.

G. Alternatives to On-site Detention

1. Alternative Methods – Where on-site detention is deemed inappropriate due to local topographical or other increases in stormwater runoff, shall be permitted. The methods may include:
   (a) Off-site detention or comparable improvements.

(b) In-lieu monetary contributions for channel improvements or off-site detention improvements by the City within the named watershed. Channel improvements shall only be used if they are an integral part of a detailed watershed study.

2. In-Lieu Contributions to Regional or Sub-Regional Detention – An owner may contribute to the construction of a regional or sub-regional detention site constructed or to be constructed in lieu of constructing on-site detention. However, no in-lieu contributions are allowed when existing flooding occurs downstream from development, or if the development will cause downstream flooding.

3. In-Lieu Contributions Fees – The in-lieu fee contribution shall be based upon an amount of **$100,000** per Acre-Foot of stormwater storage.

4. Excess Storm water Storage Credit - An owner may receive credit for excess storm water storage (in Acre-Feet) created on one site that may be applied to another site within the same watershed. The transfer of storage volume credit (in Acre-Feet) shall not be allowed if the site where the credited storage is proposed to be transferred has an existing flooding condition downstream of the proposed development or will produce downstream flooding.

5. Regional or Sub-Regional Detention Sites – The acquisition of regional or sub-regional detention sites and construction of facilities thereon will be financed by the City. Monies contributed by the owners as above provided shall be used for regional and sub-regional detention site studies, land acquisition and facility construction thereof in the watershed in which the development is located.

6. Watershed Boundaries - The boundaries of watersheds and priority of acquisition of regional and sub-regional detention sites in construction of detention facilities and location thereof shall be established by the City Engineer and approved by the Planning Commission.

4.2 Performance Standards

A. Stormwater Channel Location – Generally acceptable locations of stormwater runoff channels in the design of a subdivision may include but not be limited to the following:

1. In a depressed median of a double roadway, street or parkway provided the median is wide enough to permit maximum three (3) to one (1) side slopes,

2. Along the roadway, street or parkway,

3. Located along lot lines or entirely within the rear yards of a single row of lots or parcels.

4. In each of the foregoing cases, a drainage easement to facilitate maintenance and design flow shall be provided and shown on the plat. Drainage easement required dimensions are shown in the Drainage Manual and shall conform to the dimensions given. No structures shall be constructed within or across stormwater channels without the approval of the City Engineer.

B. Easements – Drainage easements required to facilitate maintenance, detention and conveyance of stormwater shall be provided and shown on the preliminary and final plat. There are two types of easements that are to be determined by the Engineer of Record and shown on the preliminary final plat. These are:

1. Minor Storm Easements – Easements designed to carry the minor storm (10-year design frequency). The minor storm easements are primarily for carrying flow from the 10-year storm, maintenance access, utility locations, and are to be kept clear of any obstructions.

2. Major Storm Easements – Privately maintained easements designed to carry the major storm (100-year design frequency). The major storm easements shall be kept free of obstructions, such as fill or fences, that would impede the flow of the 100 year design storm. Properly designed landscaping that does not impede the flow of floodwater or endanger adjacent property is acceptable.

C. Storm Sewer Outfall – The storm sewer outfall shall be designed so as to provide adequate protection against downstream erosion and scouring.

D. Lot Lines – Whenever the plans call for the passage and/or storage of floodwater, surface runoff or stormwater along lot lines involving the major storm system, grading of all such lots shall be prescribed and established for the passage and/or storage of waters, and no structure may be erected which will obstruct the flow of stormwater, no fences, shrubbery, or trees planted, or changes made to the prescribed grades and contours of the specified floodwater or stormwater runoff channels.

E. Manholes – All sanitary sewer manholes constructed in a floodplain or in an area designed for the storage or passage of flood or stormwater, shall be provided with either a watertight manhole cover or be constructed with rim elevation of minimum one (1) foot above the high water elevation of the base flood, whichever is applicable to the specific area.

ARTICLE 5

BONDS, MAINTENANCE ASSURRANCE, AND DRAINAGE APPROVALS

5.1 Maintenance Agreement – A maintenance agreement approved by the City Engineer, assuring perpetual maintenance of stormwater management improvements shall be agreed upon by the City and the applicant.

Maintenance of detention ponds (wet type) shall be the responsibility of the owner of record and/or the property owners' association.

Maintenance of detention basins (dry type) shall be the responsibility of the owner of record and/or property owners' association. The City shall have the primary right to remove sediment when the basin's function is impaired. The owner of record and/or property owners' association shall be responsible for all other maintenance, planting, reseeding, or resodding. The owner shall also be responsible for removing and replacing any landscaping, playground equipment, or other facilities within the basin.

5.2 **Performance Guarantee**– A one-year **guarantee** against defects in workmanship shall be required by the Engineer for any portion of the stormwater management improvements dedicated to the public.

5.3 Drainage Permits and/or Approvals – Upon approval of the final stormwater management and drainage plan, and acceptance and the applicant's assurances of performance maintenance as provided in these regulations, the City Engineer shall approve the plan. Project approval shall be issued in the name of the applicant who shall then be known and thereafter be referred to as the permitee. An approved permit shall set forth the terms and conditions of the approve stormwater management and drainage plan.

5.4 Engineer of Record – Should the original Engineer of Record be prevented from completing the project, the Permitee shall employ another qualified engineer and notify the City Engineer immediately.

ARTICLE 6

ENFORCEMENT

6.1 General – It shall be the duty of the City Engineer to bring to the attention of the City Attorney any violation or lack of compliance herewith.

6.2 Violations and Penalties – Any Permittee (person, firm or corporation) who fails to comply with or violates any these regulations shall be guilty of misdemeanor and upon conviction thereof shall be fined not less than $100 per day and not more than $500 per day.

6.3 Inspection – The City Engineer shall be responsible for determining whether the stormwater management and drainage plan is in conformance with the requirements specified by the City's Stormwater Drainage Design Manual and Floodplain Compliance Guidelines. Also, the City Engineer shall be responsible for determining whether the development plan is proceeding in accordance with the approved drainage plan. Periodic inspection of the development site shall be made by the City Engineer's office. Through such periodic inspections, the City Engineer's Office shall ensure that the stormwater management and drainage plan is properly implemented and that the improvements are maintained.

6.4 Remedial Work – If it is determined through inspection that the development is not proceeding in accordance with the approved stormwater management and drainage plan, and drainage and/or building permit, the City Engineer shall immediately issue written notice to the permittee and the surety of the nature and location of the alleged noncompliance, accompanied by documentary evidence demonstrating noncompliance and specifying what remedial work is necessary to bring the project into compliance. The permittee so notified shall immediately, unless weather conditions or other factors beyond the control of the permittee prevent immediate remedial action, commence the recommended remedial action and shall complete the remedial work within 72 hours or within a reasonable time as determined in advance by the City Engineer. Upon satisfactory completion of remedial work, the City Engineer shall issue a notice of compliance and the development may proceed.

6.5 Revocation of Permits or Approvals; Stop Orders – The City Engineer after giving five days written notice, may revoke the permit issued pursuant to the regulations for a project which is found upon inspection to be in violation of the provisions of these regulations, and for which the permittee has not agreed to undertake remedial work as provided in Section 6.4. Drainage and/or building permits may also be revoked if remedial work is not completed within the time allowed. Upon revocation of a permit or approval the City Engineer shall issue a stop work order. Such stop work order shall be directed to the permittee and he shall immediately notify persons owning the land, developer, and those persons or firms actually performing the physical work of clearing, grading, and developing the land. The stop work order shall direct the parties involved to cease and desist all or any portion of the work on the development a portion thereof which is not in compliance, except such remedial work necessary to bring the project into compliance.

ARTICLE 7

GENERAL PROVISIONS

7.1 Interpretation, Conflict and Severability Interpretations

A. Interpretation- In their interpretation and application, the provisions of these regulations shall be held to be the minimum requirements for the promotion of the public health, safety and general welfare.

B. Conflict with Public and Private Provisions- These regulations are not intended to interfere with, abrogate, or annul any other ordinance, rule or regulation statute or other provision of law. Where any provision of these regulations imposes restrictions different from those imposed by any other provision of these regulations or any other ordinance, rule or regulation, or other provision or law, whichever provisions are more restrictive or impose higher standards, shall control.

Private Provisions- These regulations are not intended to abrogate any easement, covenant or any other private agreement or restriction, provided that where the provision of these regulations are more restrictive or impose highest standards or regulations that such easement, covenant or other private agreement or restriction, the requirements these regulations shall govern. Where the provisions of easement, covenant or private agreement or restriction imposed duties and obligations more restrictive, or higher standards than the requirements of these regulations, and regulations or determinations there under, then such private provisions shall be operative and supplemental to these regulations and determinations made hereunder.

C. Severability – If any part of provision of these regulations or application thereof to any person or circumstances is adjudged invalid by any court or competent jurisdiction, such judgment shall be confined in its operation to that part, provision, or application directly involved in the controversy in which such judgment shall have rendered and shall not affect or impair the validity of the remainder of these regulations or the application hereof to other persons or circumstances. The governing body hereby declares that it would have enacted the remainder of these regulations even without any such part, provision or application found to be unlawful or invalid.

7.2 Saving Provision – These regulations shall not be construed as abating any action now pending under, or by virtue of, prior existing regulations, or as discontinuing, abating, modifying, or altering any penalty accruing or about to accrue, or as effecting the liability of any person, firm or corporation, or as waiving any right to the City under any section or provision existing at the time of adoption of these regulations, or as vacating or annulling any rights obtained by any person, firm, or corporation by lawful action of the City, except as shall be expressly provided for in these regulations.

7.3 Amendments – For the purpose of providing for the public health, safety and general welfare, the governing body may, from time to time, amend the provisions of these regulations. The Public works Department has the responsibility for updating on a continuing basis, the Drainage Manual.

7.4 Appeals – Any persons aggrieved by a decision of the City Engineer may appeal any order, requirement, decision, or determination to the Planning Commission and then to the City Board of Directors. The next step in the process would be to a court of competent jurisdiction in accordance with the laws of Clark County and the State of Arkansas.

ARTICLE 8

LIABILITY

8.1 Disclaimer of Liability – The performance standards and design criteria set forth herein and in the Drainage Manual establish minimum requirements which must be implemented with good engineering practice and workmanship. Use of the requirements contained herein shall not constitute a representation, guarantee, or warranty of any kind by the City, or its officers and employees of the adequacy or safety of any stormwater management and drainage plan imply that the land uses permitted will be free from damages caused by stormwater runoff. The degree of protection required by these regulations is considered reasonable for regulatory purposes and is based on historical records, engineering and scientific methods of study. Larger storms may occur or stormwater runoff heights may be increased by man-made or natural causes. These regulations, therefore, shall not create liability on the part of the City or any officer or employee with respect to any legislative or administrative decision lawfully made hereunder.

ARTICLE 9

REPEAL

9.1 Repeal - All ordinances and parts of ordinances in conflict herewith are hereby repealed.

PASSED this ____________, day of __________ 2003.

APPROVED: ________________________________
C.T. Hollingshead, Mayor

ATTEST: ___________________________________
Rendi Currey, City Clerk

APPENDIX E
STORMWATER MANAGEMENT ANALYSIS

STORM WATER MANAGEMENT ANALYSIS

Prepared for:

CITY OF ARKADELPHIA
CLARK COUNTY
ARKANSAS

ARKADELPHIA
It's a great place to call home!

Prepared by:

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Little Rock, Arkansas 72211
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August, 2002

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1.0 INTRODUCTION

The City of Arkadelphia, Arkansas, is located on the west bank of the Ouachita River in northeast Clark County, approximately 420 river miles above the mouth of the Black River and 75 miles southwest of Little Rock at a point where the foothills of the Ouachita Mountains meet the coastal plain. Maddox Branch and Mill Creek are the two major creeks in the City of Arkadelphia. Increasing growth in the City's that encompass watersheds of creeks and tributaries has led City leaders to seek solutions to the inevitable drainage problems that arise out of growth.

In September of 2001, the City of Arkadelphia selected Carter & Burgess to begin a storm water management study to evaluate the City's existing drainage system. The results of the study will determine the recommendations for improvements to the existing system to alleviate larger-scale flooding problems.

Once solutions to the problems are identified, the study will prioritize the recommended improvements and propose a Capital Improvement Program (CIP) for constructing the projects within the City's allotted budget for drainage budget. A more detailed description of the scope of work for the study is given in Section 2 of this report.

1.1 APPLICABLE FLOOD STUDIES

In order to prevent duplication of previous drainage study efforts and to make as much use of existing information as possible, several studies were reviewed as a part of this report. A list of these studies and a brief synopsis of each is given in the following paragraphs.

1. *Flood Insurance Study – City of Arkadelphia, Arkansas* - by Federal Emergency Management Agency, Revised February 19, 1986.

This study was performed by Garver & Garver, Inc., in 1978 and revised in 1985. This study was authorized by the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. The purpose of the original study was to convert the City of Arkadelphia to the regular program of flood insurance by the Federal Insurance Administration and to provide a basis for local and regional planners to promote sound floodplain management practices. This report illustrates flood profiles for the 10, 50, 100 and 500-year storms and maps the flood plain along selected sections of Maddox Branch, Mill Creek, and the Ouachita River.

2. *Flood-Hydrograph Analyses and Computations, General Report on Snyder's Synthetic Unit Hydrograph Relationships, Journal of the Hydraulics Division, Technical Report Number 2B on Unit Hydrographs for Southeastern Louisiana and Southwestern Mississippi*, all provided by United States Corps of Engineers

These hydrologic studies and analyses were requested in order to maintain consistency and the greatest amount of accuracy in the development of an existing and future hydrologic model for the City of Arkadelphia.

2.0 SCOPE OF WORK

2.1 General

Carter - Burgess was retained to provide professional engineering services related to conducting a storm water management analysis for the City of Arkadelphia. A brief description of the specific task items is given in the following paragraphs.

2.2 Drainage Basin Map

The consultant team was tasked to provide a map showing major drainage basins and sub watersheds. The map was to include the major streams. In addition, the map was to be produced at a scale of 1 in. to 1000 ft. and be printed in color. The final map is included at the end of this report as Exhibit 2.

2.3 Drainage Channel / Structure Improvements

For this series of tasks, the team was to obtain all pertinent hydraulic and hydrologic study information relating to the creeks and streams within the city. This information, in combination with the City zoning districts, was used to develop fully-urbanized flows in the creeks and tributaries. The fully-developed flows were used to determine sizes of the hydraulic structures required to lessen the flooding effects from a 25-year storm event for structures on Mill Creek and Maddox Branch. For structures located on un-named tributaries or structures within sub drainage networks a 10-year storm event was utilized.

2.4 Estimated Costs for Channel / Structure Improvements

The purpose of this task was to provide the City with an estimate of probable cost for constructing the proposed improvements developed from fully-urbanized conditions. Included in this task would be the development of an estimate of probable cost for constructing channel, culvert, and bridge and/or detention pond improvements.

This task also included prioritizing the recommended improvements to give the City an idea of the order in which the improvements should be constructed. Based upon that approved order of construction, a proposed Capital Improvements Plan will be developed to aid the City in budgeting an appropriate amount of construction funds to complete the improvements.

The last item in this task was to prepare a map showing the location of the proposed improvements within the city. This map is found in Exhibit 1 at the end of this report.

2.5 Drainage Strategies

The consultant team will recommend strategies the city could use to implement policies to limit the impact of future development on flooding problems within the city.

3.0 IDENTIFIED PROBLEM AREAS

During the initial stages of the project, the consultant team held meetings with City staff to determine the location of drainage problems that should be addressed as a part of this study. Two site visits occurred to generally assess the condition of existing structures throughout the City. Each crossing that was inspected was also rated based on the overall stability of the crossing. The results of these inspections can be seen in Appendix A.

As a result of these site visits, a list of drainage problems within the City were developed. The creeks, tributaries and hydraulic structures that were to be studied as a part of this study are shown in Table 1. Table 2 shows the type of existing study information that was available to begin an assessment of the particular stream or area to be studied.

In some cases, the deciding factor on whether or not to study a particular crossing depended on the ability to obtain information on the crossing. Some culverts were not studied due to the lack of information.

Since the information used in this study is based on available information within the scope of this study, any developer that proposes to make improvements along these creeks and tributaries will need to perform more detailed survey and analysis on the existing structures.

Table 1: City of Arkadelphia Drainage Study Areas

Stream	Location	Existing Structure	Proposed Structure
(1)	C Street & Hemphill	1-24" RCP	2-6'X5' RCB
(1)	Elaine Circle	1-36" CMP	1-48" CMP
(1)	Hartford Street	1-24" CMP	3-54" CMP
(1)	Wal Mart & Malone Street	1-42" RCP	2-48" CMP
(1)	2nd & Main Street	1-24" CMP	No Changes needed
(1)	10th & Haddock Street	1-4'X3' RCB	2-7'X3' RCB
(1)	8th & McNutt	1-60" CMP	2-60" CMP
(1)	University Drive	1-7'X4' RCB	1-10'X4' RCB
(1)	8th & Central Park	1-36" RCP	2-54" RCP
(1)	Carter Road	1-18" CMP	1-7'X3' Box
(1)	Cash Road	1-18" CMP	3-8'X4' Boxes
(1)	Caddo & 22nd Street	1-5'X4' Box	No changes needed
(1)	9th & Main Street	1-4'X3' Box	No changes needed
(1)	16th & Crawford	1-18" CMP	3-7'X3' Boxes
Maddox Branch	17th Street	5' CMP	71.6' Bridge
Maddox Branch	18th Street	6' CMP	4-6'X5' Boxes
Maddox Branch	19th Street	5' CMP	4-8'X8' Boxes
Maddox Branch	23rd Street	2-4' CMP	4-8'X6'
Maddox Branch Tributary	Caddo Street/ Main Street	4' RCP	12'X5' Box
Maddox Branch Tributary	Lower Pine Street	2-36" RCP	3-6'X4' Boxes
Maddox Branch Tributary	Upper Pine Street	2-24" CMP	1-8'X5' Box
Mill Creek Tributary	Druid Hills	2-5' CMP	39' Bridge
Mill Creek Tributary	Pinnacle Street	2-5.5' CMP	40' Bridge
Mill Creek Tributary	Forrest Park Road	1-6.5' CMP	40' Bridge
Mill Creek	26th Street	1-8'X6.5' RCP	2-7'X7' Boxes

Tributary			

(1) Structures located on unidentified tributaries or a part of subdrainage networks

Table 2: Existing Information Available for Study

Stream	Location	Survey	Site Visit	Aerial Topo
(1)	C Street & Hemphill		✓	✓
(1)	Elaine Circle		✓	✓
(1)	Hartford Street		✓	✓
(1)	Wal Mart & Malone Street		✓	✓
(1)	2^{nd} & Main Street		✓	✓
(1)	10^{th} & Haddock Street		✓	✓
(1)	8^{th} & McNutt		✓	✓
(1)	University Drive		✓	✓
(1)	8^{th} & Central Park		✓	✓
(1)	Carter Road		✓	✓
(1)	Cash Road			✓
(1)	Caddo & 22^{nd} Street		✓	✓
(1)	9^{th} & Main Street		✓	✓
(1)	16^{th} & Crawford		✓	✓
Maddox Branch	17^{th} Street	✓	✓	✓
Maddox Branch	18^{th} Street	✓	✓	✓
Maddox Branch	19^{th} Street	✓	✓	✓
Maddox Branch	23^{rd} Street	✓	✓	✓
Maddox Branch Tributary	Caddo Street/ Main Street	✓	✓	✓
Maddox Branch Tributary	Lower Pine Street	✓	✓	✓
Maddox Branch Tributary	Upper Pine Street	✓	✓	✓
Mill Creek Tributary	Druid Hills		✓	✓
Mill Creek Tributary	Pinnacle Street	✓	✓	✓
Mill Creek Tributary	Forrest Park Road	✓	✓	✓
Mill Creek Tributary	26^{th} Street	✓	✓	✓

(1) Structures located on unidentified tributaries or a part of subdrainage networks

4.0 HYDROLOGY

Hydrology can be defined as the science dealing with the occurrence, circulation, distribution, and properties of the waters of the earth and its atmosphere. By studying hydrology, engineers determine the amount of flow or discharge (Q) to a specific drainage point.

The best data source from which to base the design of storm drainage and flood control systems is continuous long-term records of rainfall and resulting storm runoff. Unfortunately though, it is not often possible to obtain such records in sufficient quantities as weather records do not often date back very far and land development alters the runoff volumes produced by similar storms. Therefore, the accepted practice that is used most often today is to relate storm runoff to the amount of rainfall over a particular watershed along with different parameters of the watershed. This relation provides a means of estimating the rates, timing and volume of runoff expected from watersheds at various rainfall recurrence intervals.

The 25-year storm was selected to analyze the structures along Mill Creek and Maddox Branch. Structures analyzed on tributaries not on the main creeks or selected areas within the storm drainage network of the city were analyzed utilizing the 10-year storm event.

4.1 Methodology

Two methods are used in Arkadelphia to compute the discharge runoff from a watershed. For watershed areas greater than 300 acres, the Snyder's Synthetic Unit Hydrograph is used. Snyder's Method was chosen because it was used in the previous study and is accepted by the United States Army Corps of Engineers.

Snyder studied watersheds located mainly in the Appalachian highlands of the United States and varying in size from 10 to 10,000 mi^2. He found synthetic relations for some characteristics of a standard unit hydrograph. From the relations, five characteristics of a required unit hydrograph for a given excess rainfall duration may be calculated and used to determine a unit hydrograph from which peak discharge for a watershed may be drawn.

The second method is the Rational Method, which applies to smaller drainage areas of usually less than 300 acres. A more detailed description of the Rational Method is explained in a later section.

4.2 Computer Modeling (HEC-HMS Hydrologic Modeling System Package)

HEC-HMS is a computer program created by the United States Army Corps of Engineers designed to simulate rainfall-runoff processes of dendritic watershed systems. The program works by creating a stream network model that simulates the runoff responses of a river basin to rainfall over that basin. The program combines hydrology and routing computations in its analysis.

4.3 Watershed

The watershed is the surface area that is drained by a stream or drainage system. The watersheds for the problem areas in this study were all determined by utilizing ortho-rectified aerial topography obtained on February 2, 2001. The "aerial topography" provided a 4 ft. contour interval. The aerial topography was provided by AMI Engineering, Inc, Little Rock, Arkansas, and complies with Class I ASPRS – 1990 Standards.

From the contours developed from the aerial topography, Carter & Burgess delineated the watersheds and sub-watersheds for the major creeks in Arkadelphia. The drainage areas were computed based on this delineation.

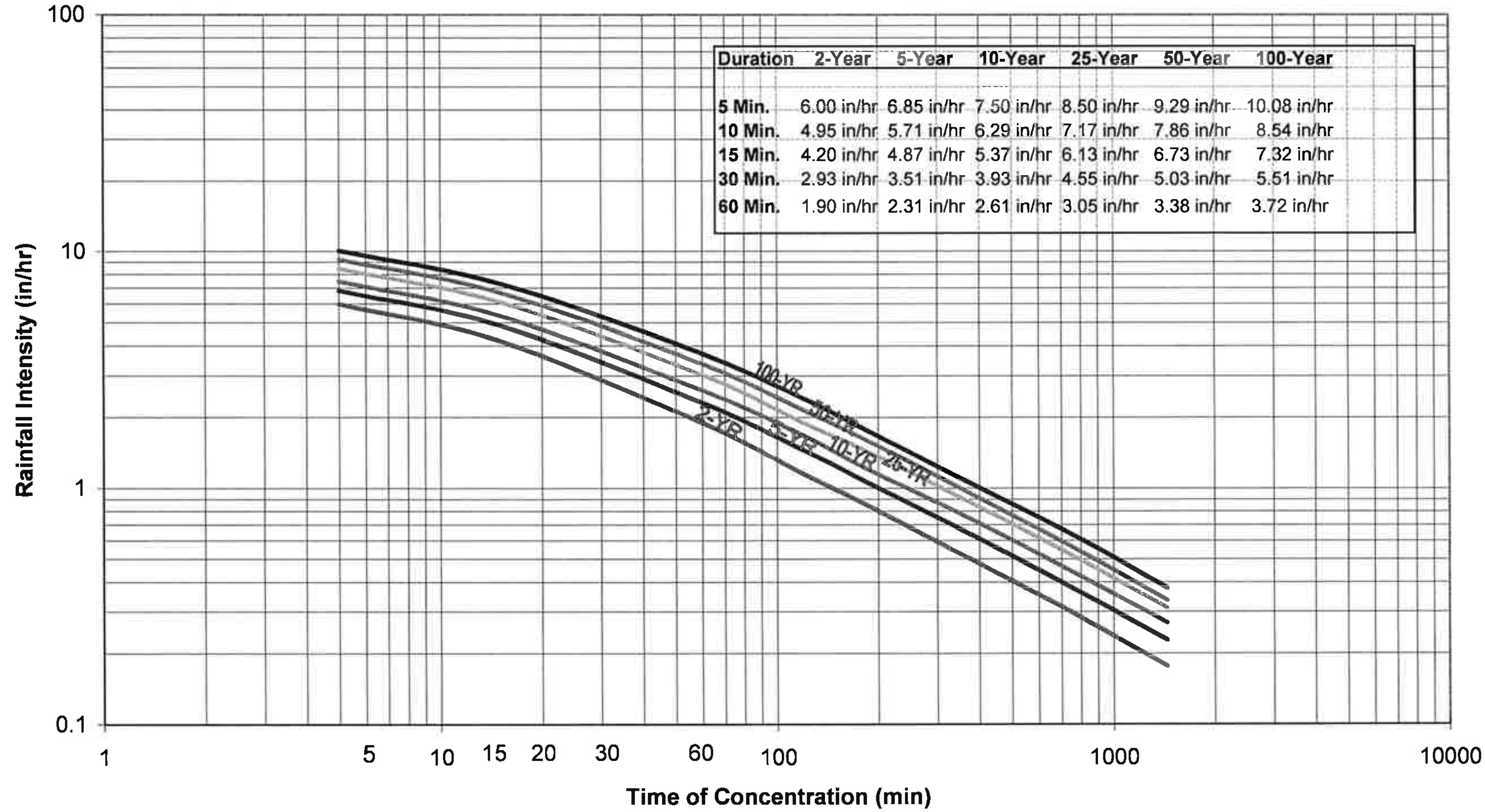
4.4 Rainfall

The rainfall depths for Clark County were determined from a combination of the Technical Paper 40 (TP-40), published by the National Weather Service, and the Technical Memorandum Hydro-35, published by the National Oceanic and Atmospheric Administration. TP40 was used to develop the rainfall depths for durations ranging from 2 hours to 24 hours. The Hydro-35 was used to develop depths for the 5-minute, 15-minute and 60-minute storms. These depths were tabulated in Table1 for the 2, 5, 10, 25, 50, and 100-year storm events. This information was input into the HEC-HMS hydrology models to create hypothetical 24-hour hydrographs. Figure 1 shows the Intensity-Duration-Frequency (IDF) curve for Clark County.

Table 3: Rainfall Depths for Clark County, Arkansas

COUNTY NAME : *CLARK*			DATE: *1/22/02*		
THESE NUMBERS ASSUME EVEN DISTRIBUTION FOR SMALL AREAS					
REFER TO FIGURE 15 IN TP-40 FOR LARGE AREAS (OVER 20 SQUARE MILES)					
TP-40 INPUT				HYDRO-35 INPUT	
FREQ.	DURATION	SOURCE	RAINFALL	DURATION	RAINFALL
			IN.ES	MINUTE	IN.ES
2	30MIN	*TP-40*	1.5	5	0.5
	1HR	*TP-40*	1.85	15	1.05
	2HR	*TP-40*	2.3	60	1.9
	3HR	*TP-40*	2.6		
	6HR	*TP-40*	3.1		
	12HR	*TP-40*	3.7		
	24HR	*TP-40*	4.25		
5	30MIN	*TP-40*	1.9	5	0.57052
	1HR	*TP-40*	2.35	15	1.21644
	2HR	*TP-40*	2.9	60	2.31476
	3HR	*TP-40*	3.25		
	6HR	*TP-40*	3.95		
	12HR	*TP-40*	4.7		
	24HR	*TP-40*	5.5		
10	30MIN	*TP-40*	2.12	5	0.62516
	1HR	*TP-40*	2.74	15	1.34247
	2HR	*TP-40*	3.35	60	2.61268
	3HR	*TP-40*	3.7		
	6HR	*TP-40*	4.6		
	12HR	*TP-40*	5.5		
	24HR	*TP-40*	6.5		
25	30MIN	*TP-40*	2.5	5	0.70846
	1HR	*TP-40*	3.1	15	1.53192
	2HR	*TP-40*	3.8	60	3.04538
	3HR	*TP-40*	4.4		
	6HR	*TP-40*	5.4		
	12HR	*TP-40*	6.45		
	24HR	*TP-40*	7.5		
50	30MIN	*TP-40*	2.7	5	0.7744
	1HR	*TP-40*	3.5	15	1.68135
	2HR	*TP-40*	4.3	60	3.3836
	3HR	*TP-40*	4.9		
	6HR	*TP-40*	5.9		
	12HR	*TP-40*	7		
	24HR	*TP-40*	8.1		
100	30MIN	*TP-40*	3.05	5	0.84
	1HR	*TP-40*	3.8	15	1.83
	2HR	*TP-40*	4.8	60	3.72
	3HR	*TP-40*	5.4		
	6HR	TP-40	6.5		
	12HR	*TP-40*	7.9		
	24HR	*TP-40*	9.1		

FIGURE 1
Rainfall Intensity and Duration Curves
for Clark County Arkansas



Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5 Min.	6.00 in/hr	6.85 in/hr	7.50 in/hr	8.50 in/hr	9.29 in/hr	10.08 in/hr
10 Min.	4.95 in/hr	5.71 in/hr	6.29 in/hr	7.17 in/hr	7.86 in/hr	8.54 in/hr
15 Min.	4.20 in/hr	4.87 in/hr	5.37 in/hr	6.13 in/hr	6.73 in/hr	7.32 in/hr
30 Min.	2.93 in/hr	3.51 in/hr	3.93 in/hr	4.55 in/hr	5.03 in/hr	5.51 in/hr
60 Min.	1.90 in/hr	2.31 in/hr	2.61 in/hr	3.05 in/hr	3.38 in/hr	3.72 in/hr

4.5 Estimated Parameters Used in Snyder's Method

The use of the Snyder's Method requires an estimation of several parameters. These parameters have been studied by the United States Corps of Engineers. Relationships that can be used to compute values for the parameters are published in the *General Report Snyder's Synthetic Unit Hydrograph Relationships* supplied by the United States Corps of Engineers. A mean square regression curve was developed for log C_t vs. log S_{st} and for log q vs. log t_p; where:

C_t = Snyder's Synthetic Unit Hydrograph Relationship
S_{st} = Weighted stream slope (ft/ft)
q_p = Peak of the Unit Hydrograph (cfs/mi^2)
t_p = Time to peak of the Unit Hydrograph (hrs)
L = Length of main stream from outlet to the divide
L_{ca} = Length along the main stream from the outlet to a point nearest the watershed centric.

The equations for the methodology are shown below:

$$C_t = 10^{(-0.6017(\log(S_{st})) - 1.4037)}$$

$$Q_p = 10^{(-1.0485(\log(t_p)) + 2.6047)}$$

$$T_p = C_t\,(L * L_{ca})^{0.3}$$

Carter - Burgess utilized the above equations, which are found in the *General Report Snyder's Synthetic Unit Hydrograph Relationships* furnished by the United States Corps of Engineers, Little Rock District office. These equations were based on unit hydrographs derived from gaged records obtained from the Little Rock District and the Vicksburg District. The calculated lag time, T_p, along with the Unit Hydrograph peaking coefficient, C_p, are then used in HEC-HMS to determine peak flow and total volume of flow for each storm event. This information was then used in HEC-RAS (see Section 5) for further analysis and to size drainage structures to adequately convey the design storm event.

4.6 Rational Equation

Most communities today use the widely known and accepted Rational Equation to calculate the amount of storm water runoff for small watersheds. For the purposes of this study, the rational method was used for watersheds with areas less than 300 acres. The Rational Equation is stated as follows:

Q=CIA

where
Q = the amount of runoff in cubic ft. per second
C = the runoff coefficient
I = the rainfall intensity in inches per hour
A = the watershed area in acres

The runoff coefficient varies according to soil type and land use. It is generally accepted that altering land use through urban development has a pronounced effect on the rate and volume of runoff from a given rainfall. Urbanization alters the hydrology of a watershed by improving its hydraulic efficiency, reducing its surface infiltration and reducing its storage capacity. The more impervious and densely developed an area, the higher the value of the runoff coefficient attributed to it and thus, the higher the calculated runoff.

Table 4 lists the runoff coefficients that were used in this analysis to compute flows for drainage areas less than 300 acres. Fully-developed land uses were considered in determining the runoff coefficients. Thus, the flows computed to size structures in this study are based on fully-urbanized conditions.

Table 4: Coefficient of Runoff and Minimum Inlet Times

Land Use	Runoff Coefficient C	Minimum Inlet Time (mins)
Residential	0.6	15
Commercial	0.9	10
Industrial	0.9	10
Multiple Unit Dwelling	0.8	10
Parks	0.4	15
Cemeteries	0.4	15
Pasture	0.4	15
Woods	0.3	15
Cultivated	0.6	20
Shopping Centers	0.9	10
Paved Areas	0.9	10
Schools	0.6	15
Patio Homes	0.6	15

The computed rainfall intensity, **I**, is the average rainfall rate in inches per hour over a watershed. The value is based on the chosen storm frequency and rainfall duration equal to the time of concentration, T_c. The storm frequency is a statistical variable based on the probable return interval in years of a particular size storm. For instance, a 100-year storm frequency has a $1/100^{th}$ (or 1%) chance of occurring in any given year while a 5-year storm has $1/5^{th}$ (or 20%) chance of occurring in any given year, based on past records of rainfall. The T_c is the time required for runoff to travel from the most hydraulically distant part of the watershed, to any point of interest along a drainage route. Runoff reaches its maximum value when the time of concentration has been reached at a particular point since at this time, all portions of the watershed are contributing runoff to that point.

The time of concentration, T_c and intensity value **I** have an inverse relationship for any given watershed. As the time of concentration decreases, or as runoff reaches an inlet faster, rainfall intensities increase. Rainfall intensities increase due to the natural phenomenon that very intense rainfalls last only a short amount of time while less intense rainfalls can last much longer. For instance, a heavy downpour of rain may last only about 15 minutes while a light steady drizzle may last for hours or even days. To drain effectively, storm drains need to carry just enough capacity at each point to drain the rainfall intensity that corresponds to the time of concentration for that drain at that point. For example, if it takes ten minutes for runoff to reach an inlet, then that portion of the drain needs to be designed for a rainfall intensity that corresponds to a ten-minute time of concentration. If it takes one hour for runoff to reach an inlet, then a smaller intensity is used that corresponds to a one-hour time of concentration.

Once the time of concentration is known, the corresponding rainfall intensity, **I**, may be determined from rainfall intensity-duration-frequency curves. These curves graphically relate rainfall durations to rainfall intensities in inches-per-hour over a particular region.

An average initial time of concentration, or that time required for runoff to reach the most upstream inlet for a developed portion of a city is usually between five and ten minutes. Beyond the initial time of concentration, the value may be incremented up to five minutes or more depending on the velocity and distance traveled along a drainage route. As most typical city storm drains are less than 2000 ft. in length and have velocities around 3 ft. per second, it is rare that the total accumulated time of concentration exceeds 30 minutes.

5.0 HYDRAULICS

The planning, design and construction of drainage facilities are not only based on the study of hydrology but also on the study of hydraulics. Hydraulics is used to determine what quantity of runoff a drainage system will convey and the resulting water surface elevation. This information is useful and necessary to design the most efficient sections for channels and storm drains and to predict flood elevations. This section discusses basic hydraulics and the two methods of hydraulic analysis used in this study.

The state of flow in a channel is at all times either uniform, gradually varied, or rapidly varied. Different methods for determining water surface profiles are applicable to each of these conditions of flow. A brief description of each type of flow is provided below.

5.1 Uniform Flow

When a section of channel is sufficiently long and unchanging such that the flow depth is not changing, i.e. the force of gravity and channel resistance can be considered balanced, then the flow profile can be analyzed assuming uniform flow. Under these circumstances, the depth remains constant and can be determined with Manning's equation. Manning's equation will be discussed in detail below.

5.2 Gradually Varied Flow

In the majority of channel flow situations, the state of flow is gradually varied. In other words, the depth is gradually changing with longitudinal distance along the channel due to an imbalance between the forces of gravity and channel resistance. Under these conditions, the recommended means for determining flow profiles is with the standard step method. The standard step method is an iterative process in which the one-dimensional energy equation is solved to find the water surface elevation at a cross-section. Manning's equation is utilized to determine channel losses due to friction. Losses due to channel non-uniformities are usually calculated with empirical coefficients. A widely accepted computer model for calculating gradually varied flow profiles is the United States Army Corps of Engineers' HEC-RAS computer program.

5.3 Manning's Equation

Manning's equation is an empirical equation that relates friction slope, flow depth, channel roughness, and channel cross-sectional shape to flow rate. The friction slope is a measure of the rate at which energy is being lost in the flow to channel resistance. When the channel slope and the friction slope are equal ($S_f = S_o$) the flow is uniform and Manning's equation may be used to determine the depth of the uniform flow. Uniform flow is also known as normal depth.

Manning's equation is stated as follows:

$$V = \frac{1.49}{n} R^{2/3} S_f^{1/2}$$

$$Q = \frac{1.49}{n} AR^{2/3} S_f^{1/2}$$

where Q = total discharge in cubic ft. per second (cfs)
V = velocity of flow (ft/sec)
n = Manning's coefficient of roughness
A = cross sectional are of the flow (ft^2)
R = hydraulic radius of the channel (ft) (flow area/wetted perimeter)
S_f = friction slope,(ft/ft)

Manning's "n" value is an experimentally derived constant that represents the effect of channel roughness in the Manning's equation. Considerable care must be given to the selection of an appropriate "n" value for a given channel due to its significant effect on a character of the flow. A well-maintained concrete channel will have a Manning coefficient of 0.013 where an earthen-channel with dense vegetation will have a Manning coefficient of 0.06-0.08. A list of "n" values used in this study is provided in Table 5. Much more extensive lists of "n" values are available in most hydraulic reference manuals.

Table 5: Manning's "n" Values

Conveyance	"n" value
Natural Channel	
Rock bottom	0.03
Light Vegetation	0.03
Moderate Vegetation	0.065
Heavy Vegetation	0.07
Concrete-Lined Channel	0.015
Floodplains	
Wooded areas	0.15
Residential	0.15
Marsh	0.08
Reinforced Concrete Pipe	0.013
Corrugated Metal Pipe	0.024

5.4 Computer Modeling

5.4.1 HEC-RAS Hydraulic Analysis Computer Program

HEC-RAS was utilized in this study to evaluate Maddox Branch, Mill Creek and their tributaries. Cross sectional data includes point elevations and stations, "n" values for the length of the cross section, and the distance between cross sections. Cross sections should be placed such that the channel configuration between them is largely uniform. In areas where channel properties are rapidly changing, the distances between cross-sections are appropriately less. The HEC-RAS cross sectional information used for the analysis in this report came from survey data, site visits, and aerial topography. The 100-year and 25-year fully urbanized floodplain maps are located in Exhibit 3 and 4 at the end of this report.

5.4.2. Culvert Design Program

The Culvert Master program is widely accepted by the US Federal Highway Administration (FHWA) for performing headwater computations for culverts. This study utilized Culvert Master to size drainage structures that were ancillary to the main creeks to carry the 10-year storm event.

For existing conditions, Culvert Master analyzed flow through the barrels as well as flow overtopping the road. The proposed analysis only considered flow through the barrels because water surface elevation was below the top of road. The drainage area pertinent to each structure was measured from the drainage area work map and measured in acres. Runoff coefficients were then determined from the city aerial map and zoning map obtained from the City of Arkadelphia. Intensities for use in the Rational Equation were taken off of the IDF curve discussed earlier. The rainfall intensity for a particular design was based on the time of concentration to that particular point of interest.

6.0 ANALYSIS OF IDENTIFIED PROBLEM DRAINAGE AREAS

After several meetings with the City of Arkadelphia, it was decided that a total of 25 structures would be analyzed in this study. Although other drainage problem areas exist, they were not included in this study due to the limitations set forth in this scope. The following section describes the individual drainage problem areas that were determined from those meetings. Only crossings with existing structures were included in the analysis. Fully-urbanized flows were used to size drainage structures. When available, survey data, field notes, and information from the aerial topography map were used to analyze existing conditions. All proposed conditions for Mill Creek Tributary, Maddox Branch, Maddox Branch Tributary and all other structures included in this study are based on the assumption that existing structures will be removed and replaced with proposed structures unless otherwise stated. The following sub-sections will describe the results of our analysis, determine improvements needed, and estimate of probable costs involved in drainage improvements.

6.1 Mill Creek Tributary

A major tributary of Mill Creek was analyzed in this study. The watershed area for Mill Creek Tributary is approximately 160 acres. The watershed area can be characterized as low to medium density residential. It was determined with the HEC-HMS hydrologic modeling program that the flow routed through the tributary for a 25-year storm event was 1,461 cfs.

A total of four crossings were studied for Mill Creek Tributary. Elevations inside the creek were surveyed and the elevations outside of the channel banks were obtained from aerial topography. Existing structure sizes and "n" values were measured from previous site visits and used to model existing conditions in HEC-RAS.

The crossings were designed to pass the 25-year storm event. The upstream limit of the tributary is located at 26th Street and the downstream section is located at Druid Hills. The following sub-sections will describe results of our analysis, determine improvements needed and estimate costs involved in drainage improvements.

6.1.1 Druid Hills Road

Existing

Druid Hills Road is the first downstream crossing on Mill Creek Tributary. Exhibit 1 shows Druid Hills as structure number 32, located north of Creekwood Road and west of Mill Creek Road. The existing structure consists of a double 60-in. corrugated metal pipes (CMP). We measured the slope and length of the pipe from the site visit. The slope and length of pipe were estimated to be 0.89 percent and 41 ft. long. These numbers were referenced with the aerial topography. An estimated 2.5 ft. of cover is present over the pipes.

Problem

The computed headwater elevation is over 2 ft. above the top of road for the existing structure at Druid Hills Road. The top of road elevation is measured to be 210.5 ft. and the 25-year water surface elevation is at 212.6 ft. From the hydraulic analysis, a larger structure is needed to prevent the road from being inundated by water.

Solution

A proposed bridge 39 ft. long by 21 ft. wide would lower the headwater elevation low enough to prevent flooding. The low chord is set to 209.5, exactly 1 ft. below the top of road. The existing slope and length is maintained for the bridge. The result is the water surface elevation lowered to 209.9 ft., safely beneath the top of the roadway.

Costs

Table 6: Estimate of Probable Construction Cost
Druid Hills Road – Structure 32

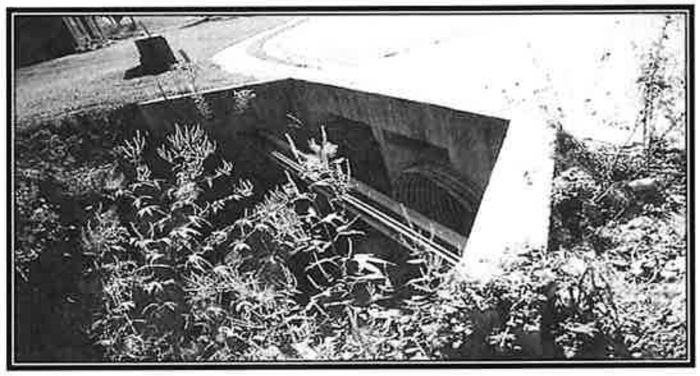
Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$3,400.00	$3,400.00
Maintenance of Traffic	LS	1	$2,000.00	$2,000.00
Remove and Dispose 60" CMP	EA	2	$500.00	$1,000.00
Unclassified Excavation for Str. (Bridge)	CY	160	$55.00	$8,800.00
Bridge	SF	860	$58.00	$49,880.00
Street Repair	SY	50	$50.00	$2,500.00
Final Stabilization	LS	1	$2,700.00	$2,700.00
			Raw Construction Cost	**$70,280.00**
Contigency (15% of Construction Cost)				$10,600.00
			Total Construction Cost	**$80,880.00**
Engineering (10% of Cost)				$8,100.00
Total Estimate of Probable Construction Cost- Druid Hill Road Structure 32				**$88,980.00**

6.1.2 Pinnacle Street

Existing

The next upstream crossing is located at Pinnacle Street. Exhibit 1 shows Pinnacle Street as structure number 31, approximately 915 ft. upstream from Druid Hills Road. There are two existing 66-in. corrugated metal pipes underneath the roadway. The pipe is sloped at 9.4 percent and the length is 42 ft. There is approximately 3 ft. of cover above the pipes. Survey data taken at this location puts the top of road elevation at 226.6 ft. The 25-year computed headwater elevation is 228.20 ft.

Problem



With a top of road elevation at 226.6 ft., the 25-year storm event cannot be contained underneath the roadway with the existing structure. The water surface overtops the road by 1.6 ft., causing the road to flood at this crossing. The structural integrity of this crossing appears adequate with little signs of wear; however, in order to pass the 25-year flood, the structure must be upgraded.

Solution

In order to lower the headwater, the existing structure is replaced with a 40-ft. spanned bridge. The width of the bridge is 28 ft. and the low chord at 225.6 ft. Maintaining the existing slope with the proposed bridge resulted in lowering the headwater elevation to 225.3 ft. This will prevent any future flooding to occur.

Table 7: Estimate of Probable Construction Cost Pinnacle Street – Structure 31

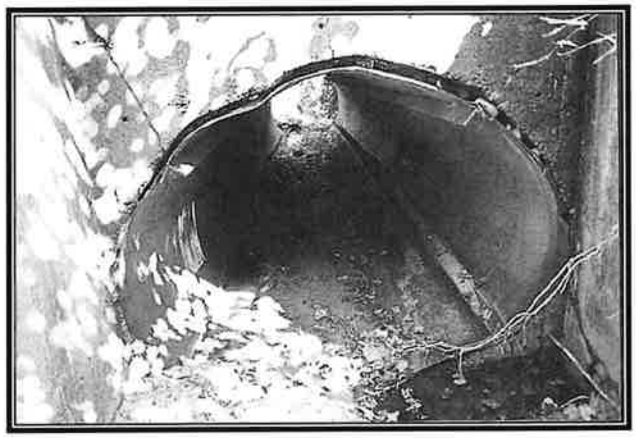
Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$6,300.00	$6,300.00
Maintenance of Traffic	LS	1	$3,800.00	$3,800.00
Remove and Dispose 66" CMP	EA	2	$550.00	$1,100.00
Unclassified Excavation for Str. Bridge)	CY	800	$55.00	$44,000.00
Precast Concrete Bridge	SF	1175	$58.00	$68,150.00
Street Repair	SY	50	$50.00	$2,500.00
Final Stabilization	LS	1	$5,000.00	$5,000.00
Raw Construction Cost				**$130,850.00**
Contingency (15% of Construction Cost)				$19,700.00
Total Construction Cost				**$150,550.00**
Engineering (15% of Cost)				$22,600.00
Total Estimate of Probable Construction Cost - Pinnacle Street Structure No. 31				**$173,150.00**

6.1.3. Forrest Park Road

Existing

Forrest Park Road crossing is approximately 1,230 ft. upstream of Pinnacle Street. It is structure number 30 on Exhibit 1, located north of North Ridge. There is an existing 78-in. CMP at this location. The pipe is 43 ft. long and the slope is at 4.84 percent. There is 1.5 ft. of cover over the pipe and according to survey information, the top of road is at 238.7 ft.

Problem



The headwater elevation computed for the existing structure is at elevation 240.8 ft., about 2 ft. above the top of road. A larger structure will be needed to prevent flooding of the road at this location. The condition of the pipe is presently in adequate condition but will continue to deteriorate if it is not replaced with a larger structure.

Solution

A proposed bridge at this location will alleviate potential flooding problems at this crossing. The dimensions of the proposed bridge is 40 ft. long and 28 ft. wide with the low chord set 1 ft. below the top of road at 237.7 ft. The existing slope is maintained. With the bridge, the water surface is lowered to 237.5 ft. and contained within the bridge section.

Costs

Table 8: Estimate of Probable Construction Cost
Forrest Park Road – Structure 30

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$6,300.00	$6,300.00
Maintenance of Traffic	LS	1	$3,900.00	$3,900.00
Remove and Dispose 78" CMP	EA	2	$650.00	$1,300.00
Unclassified Excavation for Str. (Bridge)	CY	780	$55.00	$42,900.00
Precast Concrete Bridge	SF	1200	$58.00	$69,600.00
Street Repair	SY	50	$50.00	$2,500.00
Final Stabilization	LS	1	$5,100.00	$5,100.00
Raw Construction Cost				**$131,600.00**
Contingency (15% of Construction Cost)				$19,800.00
Total Construction Cost				**$151,400.00**
Engineering (15% of Cost)				$22,700.00
Total Estimate of Probable Construction Cost – Forrest Park Road: Structure 30				**$174,100.00**

6.1.4 26th Street

Existing

The last crossing modeled on Mill Creek Tributary is about 700 ft. upstream from Forrest Park Road. Exhibit 1 shows this as crossing number 29. The existing structure underneath 26th Street is an 96-in. by 78-in. elliptical CMP. From our site visit, the measured pipe length is 50 ft. and the slope at 3.4 percent. There is 1.5 ft. of cover above the pipe and the top of road elevation from survey data is 253.6 ft.

Problem

The pipe is undersized and flooding does occur. The top of road is inundated by almost 1 ft. of water with the 25-year computed water surface elevation at 254.4 ft. There are silt and debris deposits which also contribute to drainage problems at this location. The condition of this crossing is presently in poor condition, with signs of wear and undermining evident.

Solution

Replacing the existing structure with a double 7-ft. by 7-ft. box culvert will lower the headwater elevation to 251.9 ft., which is below the top of road. The slope and length of the existing structure were maintained for the box culvert.

Costs

Table 9: Estimate of Probable Construction Cost
26th Street – Structure 29

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$7,100.00	$7,100.00
Maintenance of Traffic	LS	1	$4,400.00	$4,400.00
Remove and Dispose 8' X 6.5" RC Box	EA	1	$2,500.00	$2,500.00
Unclassified Excavation for Str. (Rdwy)	CY	1150	$45.00	$51,750.00
Embankment	CY	1100	$12.00	$13,200.00
Class S Concrete – Roadway	CY	90	$400.00	$36,000.00
Reinf. Steel – Roadway	LB	11000	$0.60	$6,600.00
Street Repair	SY	420	$50.00	$21,000.00
Final Stabilization	LS	1	$5,700.00	$5,700.00
Raw Construction Cost				**$148,250.00**
Contingency (15% of Construction Cost)				$22,300.00
Total Construction Cost				**$170,550.00**
Engineering (15% of Cost)				$25,600.00
Total Estimate of Probable Construction Cost Project Cost Structure No. 29				**$196,150.00**

6.2 Maddox Branch

Four crossings were studied on Maddox Branch. The watershed area for these crossings is approximately 462 acres. The watershed can be characterized as mostly low density residential homes. It was determined with the HEC-HMS hydrologic modeling program that the flow routed through the tributary for a 25-year event storm event is 611 cfs at 23rd Street crossing and 1,262.4 cfs for all other crossings included in this study for Maddox Branch.

A total of four cross sections were obtained along the tributary, with information for all the crossings taken from actual survey data. Elevations outside of the channel banks were measured from aerial topography and elevations inside the banks were surveyed. Existing structure sizes and "n" values were measured from previous site visits and used to model existing conditions in the hydraulic model, HEC-RAS.

The crossings were all designed to pass the 25-year storm event. The upstream limit of the tributary is located at 23rd Street and the downstream section is located at 17th Street. The following sub-section describes each crossing analyzed for Maddox Branch in greater detail.

6.2.1 17th Street

Existing

The first crossing on Maddox Branch included in this study is located at 17th Street, approximately 3 miles north of the mouth of the stream. Exhibit 1 lists this as structure number 8. There is an existing 60-in. CMP underneath the roadway. According to field notes from, the pipe is 36 ft. long and sloped at 9.75 percent. The top of road elevation, taken from survey data, is 215.5 ft.

Problem

The computed headwater elevation is above the road. The water surface elevation is at 217.3 ft., overtopping the roadway by almost 2 ft.

Solution

By replacing the existing structure with a 71.6 ft. bridge, the headwater elevation is lowered to 213.5 ft. and flooding would not occur. The bridge deck is 36 ft. wide and the low chord is set at 214.5 ft., 1 ft. below the top of road. The existing structure slope is used in modeling the bridge structure.

Costs

Table 10: Estimate of Probable Construction Cost 17th Street – Structure 8

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$5,900.00	$5,900.00
Maintenance of Traffic	LS	1	$3,600.00	$3,600.00
Remove and Dispose 60" CMP	EA	1	$500.00	$500.00
Unclassified Excavation for Str. (Bridge)	CY	550	$55.00	$30,250.00
Bridge	SF	1300	$58.00	$75,400.00
Street Repair	SY	50	$50.00	$2,500.00
Final Stabilization	LS	1	$4,800.00	$4,800.00
			Raw Construction Cost	**$122,950.00**
Contingency (15% of Construction Cost)				$18,500.00
			Total Construction Cost	**$141,450.00**
Engineering (15% of Cost)				$21,200.00
Total Estimate of Probable Construction Cost 17th Street Structure 8				**$162,650.00**

6.2.2 18th Street

Existing

18th Street crossing is located approximately 660 ft. upstream of 17th Street and is shown as structure number 13 in Exhibit 1. An existing 72-in. CMP is located underneath the road, with the surveyed top of road elevation at 223.3 ft. The pipe is 36 ft. long and is sloped at 8.30 percent.

Problem

The existing pipe is undersized for the 25-year flow. The headwater elevation overtops the road and floods the surrounding area. The water surface elevation is at 224.5 ft., nearly 1 ft. above the elevation of the top of road.

Solution

Replacing the existing structure with quadruple 6-ft. by 5-ft. box culvert will drop the surface water elevation to 221.50 ft., safely below the top of road. The existing lengths and slopes will remain the same for the proposed conditions.

Costs

Table 11: Estimate of Probable Construction Cost
18th Street – Structure 13

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$5,000.00	$5,000.00
Maintenance of Traffic	LS	1	$3,000.00	$3,000.00
Remove and Dispose 72" CMP	EA	1	$650.00	$650.00
Unclassified Excavation for Str. (Rdwy)	CY	590	$45.00	$26,550.00
Embankment	CY	340	$12.00	$4,080.00
Class S Concrete – Roadway	CY	90	$400.00	$36,000.00
Reinf. Steel – Roadway	LB	14400	$0.60	$8,640.00
Street Repair	SY	337	$50.00	$16,850.00
Final Stabilization	LS	1	$4,000.00	$4,000.00
Raw Construction Cost				**$104,770.00**
Contigency (15% of Construction Cost)				$15,700.00
Total Construction Cost				**$120,470.00**
Engineering (15% of Cost)				$18,000.00
Total Estimate of Probable Construction Cost – 18th Street Structure 13				**$138,470.00**

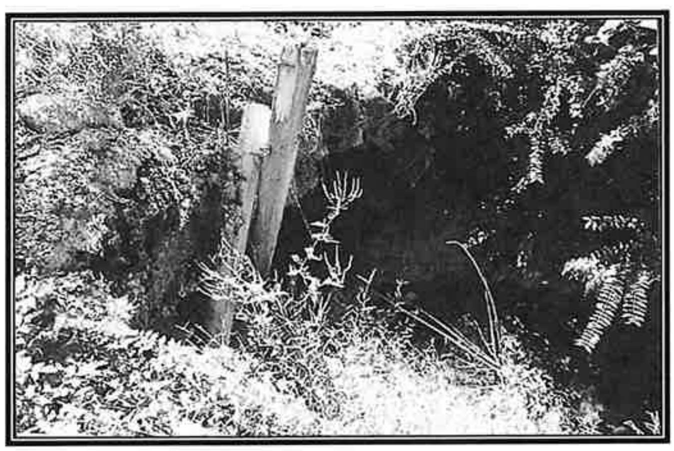
6.2.3 19th Street

Existing

Exhibit 1 shows 19th Street as structure number 9. This crossing is located 686 ft. upstream of 18th Street. There is an existing 60-in. CMP located at this crossing. The pipe is 48 ft. long and the slope is measured at 9.4 percent. The top of road was surveyed at an elevation of 227.2 ft.

Problem

The headwater elevation at 228.9 ft. is nearly 2 ft. above the top of road. The existing structure is inadequate in containing flow without causing some flooding. The existing asphalt is broken up and the integrity of the road is compromised due to the water overtopping the road.



Solution

By replacing the existing CMP with a quadruple 8-ft. by 6-ft. box culverts, the water surface elevation is lowered to 226.9 ft. The 25-year headwater elevation will remain below the top of road, thus eliminating potential damage to the roadway and surrounding area. The existing slope and length are maintained for the box culverts.

Costs

Table 12: Estimate of Probable Construction Cost
19th Street – Structure 9

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$6,700.00	$6,700.00
Maintenance of Traffic	LS	1	$4,100.00	$4,100.00
Remove and Dispose 60" CMP	EA	1	$500.00	$500.00
Unclassified Excavation for Str. (Rdwy)	CY	800	$45.00	$36,000.00
Embankment	CY	325	$12.00	$3,900.00
Class S Concrete – Roadway	CY	130	$400.00	$52,000.00
Reinf. Steel – Roadway	LB	19600	$0.60	$11,760.00
Street Repair	SY	393	$50.00	$19,650.00
Final Stabilization	LS	1	$5,400.00	$5,400.00
			Raw Construction Cost	**$140,010.00**
Contingency (15% of Construction Cost)				$21,000.00
			Total Construction Cost	**$161,010.00**
Engineering (15% of Cost)				$24,200.00
			Total Estimate of Probable Construction Cost – 19th Street Structure 9	**$185,210.00**

6.2.4 23rd Street

Existing

The last crossing for Maddox Branch in this study is located at 23rd Street, approximately 1,188 ft. upstream of 19th Street. 23rd Street is displayed as structure number 10 in Exhibit 1. The existing structure consists of two 48-in. CMP's. The pipes are 62 ft. long and sloped at 6.5 percent. The top of road is at 239.10 ft. This elevation was taken from survey data.

Problem

The existing pipe is severely undersized. Previous problems have occurred at this location. The 25-year computed water surface elevation is at 241.0 ft., nearly 2 ft. above the roadway.

Solution

By replacing the pipe with a double 8-ft. by 5-ft. box culvert and maintaining the same slope and length, the water surface is lowered 2 ft. to an elevation of 237.7 ft. This will prevent the roadway from being overtopped.

Costs

Table 13: Estimate of Probable Construction Cost 23rd Street – Structure 10

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$5,800.00	$5,800.00
Maintenance of Traffic	LS	1	$3,600.00	$3,600.00
Remove and Dispose 48" CMP	EA	2	$450.00	$900.00
Unclassified Excavation for Str. (Rdwy)	CY	730	$45.00	$32,850.00
Embankment	CY	450	$12.00	$5,400.00
Class S Concrete – Roadway	CY	95	$400.00	$38,000.00
Reinf. Steel – Roadway	LB	13900	$0.60	$8,340.00
Street Repair	SY	447	$50.00	$22,350.00
Final Stabilization	LS	1	$4,700.00	$4,700.00
Raw Construction Cost				**$121,940.00**
Contingency (15% of Construction Cost)				$18,300.00
Total Construction Cost				**$140,240.00**
Engineering (15% of Cost)				$21,000.00
Total Estimate of Probable Costs – 23rd Street Structure 10				**$161,240.00**

6.3 Maddox Branch Tributary

Maddox Branch tributary was analyzed in this study. The watershed area for Maddox Branch Tributary is approximately 109 acres. The watershed area can be characterized as mostly low to medium density residential homes. It was determined with the HEC-HMS hydrologic modeling program that the flow routed through the tributary for a 25-year event storm event is 516 cfs.

A total of four cross sections were obtained along the tributary, with information for all the crossings taken from actual survey data. Elevations outside of the channel banks were measured from aerial topography and elevations inside the stream banks were taken from survey data. Existing structure sizes and "n" values were measured from previous site visits and used to model existing conditions in the hydraulic model, HEC-RAS.

6.3.1 Caddo Street/Main Street

Existing

This is an underground structure over 900 ft. long. It is shown in Exhibit 1 as structure number 14. The downstream crossing is located at Main Street and the

upstream inlet is located on Caddo Street. From visual observation, the upstream pipe size was estimated to be a 36-in. pipe and the downstream is a 60-in. reinforced concrete pipe. For this study, we averaged the pipe size and used a 48-in. reinforced concrete pipe for the existing conditions. The slope of the pipe is 8 percent and the pipe is about 963 ft. long. The top of road elevation, taken from surveyed points, is 230.7 ft. on the upstream side.

Problem

This is a long drainage system that has encountered problems in the past. The culvert has been repaired at one time, but the pipes were not connected properly, thus contributing to drainage problems. The existing structure is undersized for the 25-year storm event. The computed headwater elevation is 231.7 ft., approximately 1 ft. above the top of road.

Solution

A 12-ft. by 5-ft. box culvert the same length and slope as the existing structure is proposed for this location. The box culvert will lower the water surface elevation to 230.5 ft. and keep the 25-year water storm event from flooding the road.

Costs

Table 14: Estimate of Probable Construction Cost Caddo Street/Main Street – Structure 14

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$49,200.00	$49,200.00
Maintenance of Traffic	LS	1	$30,100.00	$30,100.00
Remove and Dispose 48" CMP	EA	1	$450.00	$450.00
Unclassified Excavation for Str. (Rdwy)	CY	6000	$45.00	$270,000.00
Embankment	CY	1600	$12.00	$19,200.00
Class S Concrete – Roadway	CY	1260	$400.00	$504,000.00
Reinf. Steel – Roadway	LB	167000	$0.60	$100,200.00
Street Repair	SY	410	$50.00	$20,500.00
Final Stabilization	LS	1	$39,800.00	$39,800.00
Raw Construction Cost				**$1,033,450.00**
Contingency (15% of Construction Cost)				$155,000.00
Total Construction Cost				**$1,188,450.00**
Engineering (15% of Cost)				$178,300.00
Total Estimate of Probable Construction Cost – Caddo Street/Main Street Structure 14				**$1,366,750.00**

6.3.2 Lower Pine Street

Existing

At Lower Pine Street, the existing structures is a double 36-in. reinforced concrete pipes. This is structure number 15 shown in Exhibit 1. The existing structure is 64 ft. long and sloped at 4.6 percent. The surveyed top of road is at 235.9 ft.

Problem

The existing structure cannot accommodate flows from a 25-year storm event. The surface water elevation is above the road at 236.5 ft. An improvement is needed at this location to prevent drainage problems.

Solution

If the existing structure is replaced with triple 6-ft. by 4-ft. box culverts, the roadway will not be flooded. Maintaining the same slope and length as the existing conditions, the proposed structure will prevent water surface from reaching the top of road. Instead, the 25-year headwater elevation for the proposed structures is lowered to 235.7 ft.

Costs

Table 15: Estimate of Probable Construction Cost Lower Pine Street – Structure 15

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$5,600.00	$5,600.00
Maintenance of Traffic	LS	1	$3,400.00	$3,400.00
Remove and Dispose 36" CMP	EA	2	$325.00	$650.00
Unclassified Excavation for Str. (Rdwy)	CY	650	$45.00	$29,250.00
Embankment	CY	400	$12.00	$4,800.00
Class S Concrete – Roadway	CY	95	$400.00	$38,000.00
Reinf. Steel – Roadway	LB	16000	$0.60	$9,600.00
Street Repair	SY	440	$50.00	$22,000.00
Final Stabilization	LS	1	$4,500.00	$4,500.00
Raw Construction Cost				**$117,800.00**
Contingency (15% of Construction Cost)				$17,700.00
Total Construction Cost				**$135,500.00**
Engineering (15% of Cost)				$20,400.00
Total Estimate of Probable Construction Cost – Lower Pine Street Structure 15				**$155,900.00**

6.3.3 Upper Pine Street

Existing

The last crossing studied on Maddox Tributary is located at Upper Pine Street. This is structure number 16 shown in Exhibit 1. The existing structure consists of two 24-in. CMP's. The pipes are 31 ft. long and the slope is measured to be 11.5 percent. The surveyed top of road is 244.5 ft.

Problem

The existing structure is not large enough to carry the design storm runoff, thus causing the roadway and surrounding area to become flooded. The headwater elevation is at 245.1 ft., almost 1 ft. above the top of road.

Solution

Replacing the 24" pipes with a single 8-ft. by 5-ft. box culvert is recommended to lower the water surface elevation to 242.2 ft. This would eliminate any potential flooding problems at this crossing. The same length and slope is maintained for the proposed structure.

Costs

Table 16: Estimate of Probable Construction Cost Upper Pine Street – Structure 16

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$2,400.00	$2,400.00
Maintenance of Traffic	LS	1	$1,500.00	$1,500.00
Remove and Dispose 24" CMP	EA	2	$225.00	$450.00
Unclassified Excavation for Str. (Rdwy)	CY	330	$45.00	$14,850.00
Embankment	CY	205	$12.00	$2,460.00
Class S Concrete – Roadway	CY	35	$400.00	$14,000.00
Reinf. Steel – Roadway	LB	3500	$0.60	$2,100.00
Street Repair	SY	205	$50.00	$10,250.00
Final Stabilization	LS	1	$1,900.00	$1,900.00
Raw Construction Cost				**$49,910.00**
Contigency (15% of Construction Cost)				$7,500.00
Total Construction Cost				**$57,410.00**
Engineering (10% of Cost)				$5,700.00
Total Estimate of Probable Construction Cost – Upper Pine Street Structure 16				**$63,110.00**

6.4 Other Structures

Other structures included in this study are described in the section below. These structures are located on smaller tributaries and waterways scattered throughout the city. The drainage area for each structure is less than 300 acres and the Rational Method is used to calculate the flows. The 10-year flow was used to determine structure sizes and Culvert Master program was used for analyzing structures. The detailed description of each structure, the location, existing and proposed sizes, and flows computed for each drainage area are provided below.

6.4.1 C Street & Hemphill Road

Existing

C Street & Hemphill Road is shown as structure number 2 in Exhibit 1. The 10-year flow is 739 cfs and the existing structure is a 24-in. reinforced concrete pipe. The top of road was estimated at 184 ft. The estimated pipe length is 18 ft., which is the approximate width of the roadway.

Problem

Previous drainage issues have been observed. The existing pipe is undersized and causes the road to flood. The 10-year water surface elevation reaches 184.4 ft., 0.4 ft. above the existing top of road. A larger structure will be needed to reduce the headwater.

Solution

In order to prevent flooding at this location, the top of road should be raised 1 ft. to an elevation of 185. With the existing structures replaced with two 6-ft. by 5-ft. box culverts, the headwater elevation is lowered to 184 ft., 1 ft. below the top of road.

Costs

**Table 17: Estimate of Probable Construction Cost
C Street and Hemphill Road – Structure 2**

Item Name	Unit	Qty	Unit Price	Amount.
Mobilization	LS	1	$2,200.00	$2,200.00
Maintenance of Traffic	LS	1	$3,300.00	$3,300.00
Remove and Dispose 24" RCP	EA	1	$300.00	$300.00
Unclassified Excavation for Str. (Rdwy)	CY	200	$45.00	$9,000.00
Embankment	CY	150	$12.00	$1,800.00
Class S Concrete – Roadway	CY	30	$400.00	$12,000.00
Reinf. Steel – Roadway	LB	3500	$0.60	$2,100.00
Aggregate Base Course	CY	230	$30.00	$6,900.00
Asphalt Surface Course	SY	950	$6.00	$5,700.00
Final Stabilization	LS	1	$1,800.00	$1,800.00
			Raw Construction Cost	**$45,100.00**
Contingency (15% of Construction Cost)				$6,800.00
			Total Construction Cost	**$51,900.00**
Engineering (10% of Cost)				$5,200.00
Total Estimate of Probable Construction Cost – C Street and Hemphill Road Structure 2				**$57,100.00**

6.4.2 Elaine Circle

Existing

Elaine Circle is structure number 11 in Exhibit 1. There is an existing 36-in. CMP that is 48.5 ft. long. The top of road was estimated at 190 ft. The 10-year flow computed for this area is 122 cfs.

Problem

The roadway is overtopped by ½ -ft. of water with the water surface elevation reaching 190.5 ft. for the 10-year storm event. An improvement will be needed to alleviate the drainage problem at this location.

Solution

Increasing the pipe size to 48-in. will lower the headwater elevation to 189.54 ft. and prevent the road and surrounding properties from being flooded. The pipe length and slope will be the same as the existing structure.

Costs

Table 18: Estimate of Probable Construction Cost Elaine Circle – Structure 11

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$3,200.00	$3,200.00
Maintenance of Traffic	LS	1	$2,000.00	$2,000.00
Remove and Dispose 36" RCP	EA	1	$400.00	$400.00
48" Al. C.C. St. Pipe CLVT.	LF	50	$60.00	$3,000.00
F.E.S. for 48" C.St. Pipe	EA	2	$800.00	$1,600.00
Unclassified Excavation	CY	65	$10.00	$650.00
Embankment	CY	45	$12.00	$540.00
Street Repair	SY	45	$50.00	$2,250.00
Trenching & Safety Systems	LS	1	$200.00	$200.00
Final Stabilization	LS	1	$800.00	$800.00
Raw Construction Cost				**$14,640.00**
Contigency (15% of Construction Cost)				$2,200.00
Total Construction Cost				**$16,840.00**
Engineering (10% of Cost)				$1,700.00
Total Estimate of Probable Construction Cost – Elaine Circle Structure 11				**$18,540.00**

6.4.3 Hartford & Maddox Tributary

Existing

There is an existing 24-in. CMP at this location. It is structure number 12 in Exhibit 1. The 10-year flow is 169 cfs and the top of road is estimated at 228 ft. The headwater elevation is at 228.31 ft.

Problem

The structure's capacity is not large enough to capture the amount of flow. The road floods by at least ½ ft. of water. Increasing the structure size will help eliminate drainage problems from occurring at this crossing.

Solution

From the Culvert Master analysis, three 54-in. CMP's will reduce the headwater elevation enough to prevent flooding of the roadway for the 10-year event. With three 54-in. pipes, the water surface elevation is lowered to 227.96 ft. The existing pipe length of 25 ft. will remain the same as well as the slope.

Costs

Table 19: Estimate of Probable Construction Cost Hartford and Maddox Tributary – Structure 12

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$1,600.00	$1,600.00
Maintenance of Traffic	LS	1	$1,000.00	$1,000.00
Remove and Dispose 24" RCP	EA	1	$200.00	$200.00
54" Al. C.C. St. Pipe CLVT.	LF	150	$70.00	$10,500.00
F.E.S. for 54" C.St. Pipe	EA	6	$1,000.00	$6,000.00
Unclassified Excavation	CY	230	$10.00	$2,300.00
Embankment	CY	200	$12.00	$2,400.00
Street Repair	SY	150	$50.00	$7,500.00
Final Stabilization	LS	1	$1,300.00	$1,300.00
Trenching & Safety Systems	LS	1	$500.00	$500.00
Raw Construction Cost				**$33,300.00**
Contigency (15% of Construction Cost)				$5,100.00
Total Construction Cost				**$38,400.00**
Engineering (10% of Cost)				$4,000.00
Total Estimate of Probable Construction Cost – Hartford and Maddox Tributary - Structure 12				**$42,400.00**

6.4.4 Wal-Mart Parking Lot & Malone Street

Existing

This is structure number 19 located in Exhibit 1. The 10-year flow calculated for this drainage area is 378 cfs, which drains to a 42-in. CMP located just downstream of the Wal-Mart parking lot. The headwater is at elevation 291.3 ft. with the top of road estimated from the aerial topography at 290.4 ft. The pipe is approximately 28 ft. long.

Problem

There is some development underway on either side of the Interstate. This may contribute more flow to the existing structure downstream. A 10-year storm event already causes the roadway to be
inundated by almost 1 ft. of water. To prevent further problems at this location, a larger structure will be needed.

Solution

Replacing the existing structure with two 48-in. CMP's will allow the flow to pass underneath the roadway. The proposed headwater elevation is 286.1 ft. for a 10-year storm event, which is below the top of road. Existing slopes and lengths are maintained for the improved structure.

Costs

Table 20: Estimate of Probable Construction Cost
Wal-Mart Parking Lot & Malone Street – Structure 19

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$1,100.00	$1,100.00
Maintenance of Traffic	LS	1	$700.00	$700.00
Remove and Dispose 42" RCP	EA	1	$400.00	$400.00
48" Al. C.C. St. Pipe CLVT	LF	60	$60.00	$3,600.00
F.E.S. for 48" C.St. Pipe	EA	4	$800.00	$3,200.00
Unclassified Excavation	CY	210	$10.00	$2,100.00
Embankment	CY	200	$12.00	$2,400.00
Street Repair	SY	160	$50.00	$8,000.00
Final Stabilization	LS	1	$1,000.00	$1,000.00
Trenching & Safety Systems	LS	1	$300.00	$300.00
Raw Construction Cost				**$22,800.00**
Contingency (15% of Construction Cost)				$3,400.00
Total Construction Cost				**$26,200.00**
Engineering (10% of Cost)				$2,600.00
Total Estimate of Probable Construction Cost – Wal-Mart Parking Lot & Malone Street - Structure 19				**$28,800.00**

6.4.5. 2nd Street & Main

Existing

This location is structure number 20 in Exhibit 1. The existing structure consists of a 24-in. CMP underneath the roadway. The pipe is approximately 17 ft. long, which is estimated as the width of the road. Approximately 40 cfs is flowing through this structure for a 10-year storm event. This structure is adequately draining the runoff from a 10-year storm event. No improvements are needed for this location.

6.4.6 10th Street & Haddock

Existing

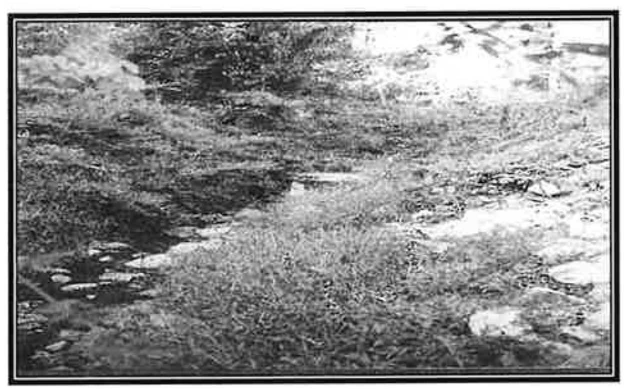
10th Street & Haddock is located as structure number 22 in Exhibit 1. The 10-year flow is 280 cfs. The existing headwater elevation is 233.9 ft. and the top of road elevation, taken from survey data, is at elevation 233.6 ft. The culvert is approximately 32 ft. long, estimated from the road width.

Problem

The existing 4-ft. by 3-ft. box culvert is severely inadequate. Although obvious signs of repair are evident, it is not enough to prevent the road and surrounding areas from being inundated by high water. There are also silt deposits present in the stream channel, further debilitating the ability of the structure to convey flow through. An improvement is greatly needed at this location.

Solution

The water surface profile can be reduced dramatically by replacing the existing structure with a double 7-ft. by 3-ft. box culvert. Existing slope and length are maintained for the proposed condition. In addition, the debris should be cleared with regular maintenance. The proposed structure will lower the headwater elevation to 233.2 ft. and prevent future flooding problems.



Costs

**Table 21: Estimate of Probable Construction Cost
10th Street & Haddock – Structure 22**

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$2,000.00	$2,000.00
Maintenance of Traffic	LS	1	$2,000.00	$2,000.00
Remove and Dispose 4'X3' Box	EA	1	$2,000.00	$2,000.00
Unclassified Excavation for Str. (Rdwy)	CY	150	$45.00	$6,750.00
Embankment	CY	100	$12.00	$1,200.00
Class S Concrete – Roadway	CY	45	$400.00	$18,000.00
Reinf. Steel – Roadway	LB	6000	$0.60	$3,600.00
Street Repair	SY	155	$30.00	$4,650.00
Final Stabilization	LS	1	$1,600.00	$1,600.00
Raw Construction Cost				**$41,800.00**
Contigency (15% of Construction Cost)				$6,300.00
Total Construction Cost				**$48,100.00**
Engineering (10% of Cost)				$4,800.00
Total Estimate of Probable Construction Cost – 10th & Haddock Structure 22				**$52,900.00**

6.4.7 8th & McNutt

Existing

Structure number 23 in Exhibit 1 is located at 8th Street and McNutt. There is an existing 60-in. CMP, 20 ft. long at this location. The 10-year flow for this drainage area is 326 cfs. The top of road elevation, 224.9 ft., is taken from survey data.

Problem

The roadway is overtopped with the computed headwater elevation at 225.1 ft. If improvements are not made, potentially more severe drainage problems may occur at this location.

Solution

For this particular location, the existing structure is not removed. Instead, an additional 60-in. CMP is added to help reduce flooding problems. The proposed water surface elevation is at 221.9 ft., well below the top of road. The same pipe length and slope are used for the additional CMP.

Costs

Table 22: Estimate of Probable Construction Cost
8^{th} & McNutt – Structure 23

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$1,400.00	$1,400.00
Maintenance of Traffic	LS	1	$900.00	$900.00
Remove and Dispose 60" RCP	EA	1	$500.00	$500.00
60" Al. C.C. St. Pipe CLVT.	LF	120	$75.00	$9,000.00
F.E.S. for 60" C.St. Pipe	EA	4	$1,500.00	$6,000.00
Unclassified Excavation	CY	160	$10.00	$1,600.00
Embankment	CY	140	$12.00	$1,680.00
Street Repair	SY	120	$50.00	$6,000.00
Final Stabilization	LS	1	$1,100.00	$1,100.00
Trenching & Safety Systems	LS	1	$300.00	$300.00
			Raw Construction Cost	**$27,080.00**
Contigency (15% of Construction Cost)				$4,000.00
			Total Construction Cost	**$31,080.00**
Engineering (10% of Cost)				$3,100.00
Total Estimate of Probable Construction Cost – 8^{th} & McNutt Structure 23				**$34,180.00**

6.4.8 University Drive

Existing

University Drive is structure number 24 in Exhibit 1. An existing 7-ft. by 4-ft. box culvert is in place at this crossing. The culvert is 35 ft. long and the top of road, taken from survey data, is at 226.8 ft. There is 535 cfs draining to this structure.

Problem

Flooding problems do occur for the 10-year storm event. The computed headwater elevation is at 227 ft., slightly higher than the existing roadway.

Solution

Replacing the existing structure with a 10-ft. by 4-ft. box culvert will eliminate flooding problems at this location. The headwater elevation will be lowered to 224.9 ft., thus eliminating the roadway from being flooded. The proposed structure will retain the same length as existing.

Costs

Table 23: Estimate of Probable Construction Cost University Drive – Structure 24

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$2,400.00	$2,400.00
Maintenance of Traffic	LS	1	$1,500.00	$1,500.00
Remove and Dispose 7'X4' Box	EA	1	$2,500.00	$2,500.00
Unclassified Excavation for Str. (Rdwy)	CY	270	$45.00	$12,150.00
Embankment	CY	215	$12.00	$2,580.00
Class S Concrete – Roadway	CY	46	$400.00	$18,400.00
Reinf. Steel – Roadway	LB	5000	$0.60	$3,000.00
Street Repair	SY	200	$30.00	$6,000.00
Final Stabilization	LS	1	$2,000.00	$2,000.00
Raw Construction Cost				**$50,530.00**
Contingency (15% of Construction Cost)				$7,600.00
Total Construction Cost				**$58,130.00**
Engineering (10% of Cost)				$5,800.00
Total Estimate of Probable Construction Cost – University Drive Structure 24				**$63,930.00**

6.4.9 8th & Central Park

Existing

An existing 36-in. reinforced concrete pipe is located underneath this crossing, which is structure number 25 in Exhibit 1. The pipe is approximately the width of the roadway, which is 55 ft. wide. The calculated 10-year flow for this drainage area is 354 cfs. The top of road elevation, estimated from aerial topography, is 191.6 ft.

Problem

The existing pipe cannot accommodate flows from a 10-year storm. The water surface elevation at 192.6 ft. exceeds the top of road and spreads across adjacent properties.

Solution

The recommended solution is to replace the existing structure with two 54-in. reinforced concrete pipes of the same length and slope as the existing structure. This will lower the headwater elevation to 190.4 ft. and eliminate potential flooding problems at this crossing.

Costs

Table 24: Estimate of Probable Construction Cost 8th & Central Park – Structure 25

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$2,200.00	$2,200.00
Maintenance of Traffic	LS	1	$1,400.00	$1,400.00
Remove and Dispose 36" RCP	EA	1	$500.00	$500.00
54" Al. C.C. St. Pipe CLVT.	LF	120	$75.00	$9,000.00
F.E.S. for 54" C.St. Pipe	EA	4	$1,000.00	$4,000.00
Unclassified Excavation	CY	470	$10.00	$4,700.00
Embankment	CY	410	$12.00	$4,920.00
Street Repair	SY	330	$50.00	$16,500.00
Trenching & Safety Systems	LS	1	$1,800.00	$1,800.00
Final Stabilization	LS	1	$500.00	$500.00
			Raw Construction Cost	**$43,320.00**
Contingency (15% of Construction Cost)				$6,500.00
			Total Construction Cost	**$49,820.00**
Engineering (10% of Cost)				$5,000.00
			Total Estimate of Probable Construction Cost – 8th & Central Park Structure 25	**$54,820.00**

6.4.10 Carter Road

Existing

Carter Road is shown in Exhibit 1 as structure number 27. There is an existing 18-in. CMP 36 ft. long at this location and 84 cfs flowing to the structure. From the aerial topography, the top of road is estimated to be 200 ft.

Problem

The computed headwater elevation is at 200.4 ft., slightly above the roadway. A larger structure will be needed to reduce the potential for flooding in this location.

Solution

The most effective solution is to raise the road by two ft. and replace the existing structure with a 7-ft. by 3-ft. box culvert.

The new water surface elevation is at 201.4 ft. and the proposed top of road is at 202 ft.

Costs

Table 25: Estimate of Probable Construction Cost Carter Road – Structure 27

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$1,900.00	$1,900.00
Maintenance of Traffic	LS	1	$1,200.00	$1,200.00
Remove and Dispose 18" CMP	EA	1	$200.00	$200.00
Unclassified Excavation for Str. (Rdwy)	CY	190	$45.00	$8,550.00
Embankment	CY	160	$12.00	$1,920.00
Class S Concrete – Roadway	CY	32	$400.00	$12,800.00
Reinf. Steel – Roadway	LB	3200	$0.60	$1,920.00
Street Repair	SY	170	$50.00	$8,500.00
Final Stabilization	LS	1	$1,500.00	$1,500.00
			Raw Construction Cost	**$38,490.00**
Contigency (15% of Construction Cost)				$5,800.00
			Total Construction Cost	**$44,290.00**
Engineering (10% of Cost)				$4,500.00
			Total Estimate of Probable Construction Cost – Carter Road Structure 27	**$48,790.00**

6.4.11 Cash Road

Existing

Structure number 28 in Exhibit 1 is located at Cash Road. This crossing is extremely undersized with an existing 18-in. CMP draining an area with a10-year flow of 718 cfs. The top of road is 205.6 ft., estimated from the aerial, and the headwater elevation is at 206.11 ft. The existing pipe is approximately 27 ft. long, estimated from the roadway width.

Problem

This structure is extremely undersized for such a large area draining to it. The existing pipe does not allow enough water to pass through, causing the road to flood.

Solution

By replacing the existing structure with a triple 8-ft. by 4-ft. box culvert, the headwater elevation will be lowered to 205.4 ft. The existing slope and length are kept the same for the box culverts. The box culvert will eliminate potential drainage problems at this crossing.

Costs

Table 26: Estimate of Probable Construction Cost
Cash Road – Structure 28

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$3,100.00	$3,100.00
Maintenance of Traffic	LS	1	$1,900.00	$1,900.00
Remove and Dispose 18" CMP	EA	1	$200.00	$200.00
Unclassified Excavation for Str. (Rdwy)	CY	300	$45.00	$13,500.00
Embankment	CY	285	$12.00	$3,420.00
Class S Concrete – Roadway	CY	60	$400.00	$24,000.00
Reinf. Steel – Roadway	LB	9200	$0.60	$5,520.00
Street Repair	SY	200	$50.00	$10,000.00
Final Stabilization	LS	1	$2,500.00	$2,500.00
			Raw Construction Cost	**$64,140.00**
Contigency (15% of Construction Cost)				$9,700.00
			Total Construction Cost	**$73,840.00**
Engineering (10% of Cost)				$7,500.00
			Total Project Cost Structure No. 28	**$81,340.00**

6.4.12 Caddo & 22nd Street

Existing

Exhibit 1 shows Caddo & 22nd Street as structure number 33. The 10-year flow is 40 cfs and the existing structure is a 5-ft. by 4-ft. box culvert that is 25 ft. long. From our analysis with Culvert Master, the computed headwater elevation is 246.4 ft., which is below the top of road estimated at 248 ft. No improvements are needed at this location.

6.4.13 19th & Main Street

Existing

At 9th & Main Street, indicated as structure number 34 in Exhibit 1, there is an existing 4-ft. by 3-ft. box culvert approximately 37 ft. long. The 10-year flow is 45 cfs. This flow is adequately conveyed through the existing structure without any potential flooding issues. The calculated headwater elevation is 228.7 ft. and the top of road is estimated at 232 ft. from the aerial topography. No improvements are needed at this location.

6.4.14 16th & Crawford

Existing

The last structure analyzed in this study is structure number 35 in Exhibit 1, located at 16th Street and Crawford. The discharge from the drainage area is about 401 cfs. The existing structure is an 18-in. CMP approximately 20 ft. long. The top of road is estimated at 208 ft.

Problem

The existing structure is severely undersized at this location. The areas upstream and downstream of this structure experience flooding problems and other drainage issues as a result of the inadequate conveyance of flow through the 18-in. pipe. The 10-year headwater elevation is at 209.95 ft., almost 2 ft. above the top of road. An improvement is greatly needed at this location.

Solution

The recommended solution for the area is to replace the existing structure with three 7-ft. by 3-ft. box culverts. In addition, the top of road elevation should be raised by 2 ft. This would significantly improve drainage at this crossing and eliminate future flooding problems. The proposed condition will set the top of road at 210 ft. and the headwater elevation at 209.5 ft.

Costs

**Table 27: Estimate of Probable Construction Cost
16th & Crawford – Structure 35**

Item Name	Unit	Qty	Unit Price	Amount
Mobilization	LS	1	$2,000.00	$2,000.00
Maintenance of Traffic	LS	1	$1,300.00	$1,300.00
Remove and Dispose 18" CMP	EA	1	$200.00	$200.00
Unclassified Excavation for Str. (Rdwy)	CY	170	$45.00	$7,650.00
Embankment	CY	155	$12.00	$1,860.00
Class S Concrete – Roadway	CY	45	$400.00	$18,000.00
Reinf. Steel – Roadway	LB	5900	$0.60	$3,540.00
Street Repair	SY	130	$50.00	$6,500.00
Final Stabilization	LS	1	$1,700.00	$1,700.00
Raw Construction Cost				**$42,750.00**
Contigency (15% of Construction Cost)				$6,500.00
Total Construction Cost				**$49,250.00**
Engineering (10% of Cost)				$5,000.00
Total Estimate of Probable Construction Cost – 16th & Crawford Structure 35				**$54,250.00**

APPENDIX F
STORMWATER DRAINAGE MANUAL
AND FLOODPLAIN COMPLIANCE GUIDELINE

STORM WATER DRAINAGE DESIGN MANUAL
AND
FLOODPLAIN COMPLIANCE GUIDELINE

Prepared for:

CITY OF ARKADELPHIA
CLARK COUNTY
ARKANSAS

ARKADELPHIA
It's a great place to call home!

Prepared by:

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August, 2002

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this manual is to establish standard principles and practices for the design and construction of storm water drainage facilities within Arkadelphia, Arkansas. In addition floodplain compliance guidelines will be presented to insure base flood elevations will not rise for the construction or modification of structures or land alteration within the floodplain. The design factors, formula, graphs, and procedures are intended for use as engineering guides in the solution of drainage problems involving determination of the quantity, rate of flow, and conveyance of storm water. The procedures defined herein shall be applied by experienced professional engineers licensed to practice in the state of Arkansas. Also, ultimate responsibility for the design of a storm drainage structures lies with the engineer of record. As such, prudent engineering judgment should be used in the design of any facility within Arkadelphia.

Methods of design other than those indicated herein may be considered in difficult cases where experience clearly indicates they are preferable. However, there should be no extensive variations from the practices established herein without express approval from the City of Arkadelphia.

1.2 Scope

This manual presents various applications of accepted principles of surface drainage engineering and is a working supplement to the information obtained from standard drainage handbooks and other publications on drainage. It is presented in a format that gives logical development of solutions to problems of storm water drainage design and floodplain management.

This manual is intended to be used by the City of Arkadelphia, consulting engineers contracted with the City, and for private development within the planning jurisdiction of the City. This manual applies to storm drainage conditions, which are generally relative to the City of Arkadelphia and the immediate geographical area. Accepted engineering principles, applied to the City of Arkadelphia's storm drainage requirements, are detailed within this manual.

1.3 Drainage Policy

The basic objective of the City of Arkadelphia is to construct and maintain facilities intended to minimize the threat of flooding to all areas of the City and comply with the requirements of the National Flood Insurance Program. The drainage facilities are defined as all public channels within dedicated right-of-way approved and accepted by the City and all other public flood control structures and facilities dedicated to, approved and accepted by the City. Additionally, it is the City's intent to insure that adequate facilities are constructed to accommodate new development such that existing property will not be subjected to additional flooding and so as not to increase the limits of the floodplains as shown on the flood insurance rate maps (FIRM's) for the City of Arkadelphia and other entities (County, Levee Improvement Districts, and Municipal Utility Districts).

It is not economically feasible to construct storm sewer facilities, which are large enough to keep the street systems from becoming inundated during severe storm events. The net effect of the City's policies will be of minimum depth and duration, and most importantly, that new structural building slab elevations are, at a minimum, set at least 12 inches above the maximum, anticipated, fully urbanized 100 year base flood elevations. The intent of this policy is that there should be any street ponding for minor storm events, minor street ponding for larger events, and major ponding for the 100-year event storms but without water inundating building structures. Every attempt will be made to design major thoroughfares so that they are passable during severe storm events.

The City has included in this manual criteria covering the design of storm water systems to serve both existing and new developments. The City of Arkadelphia has quantified the needed improvements for existing development in most of the watersheds in the City and is responsible for their approval. Upon the completion of all new design of drainage facilities, the City will accept, maintain, and operate said facilities for flood control purposes as an extension of the City. However, those drainage facilities, including detention facilities, which are planned and accepted for maintenance by some other perpetual special purpose district (such as a Levee Improvement District) will not be accepted by the City.

The criteria in this manual is considered a minimum for the City of Arkadelphia. Approval from other applicable agencies may be required. Ultimate approval for any variance of the criteria contained in this manual must be given by the City of Arkadelphia.

2.0 CONSTRUCTION PLAN PREPARATION

2.1 GENERAL

This section covers the preparation of drainage construction plans for the City of Arkadelphia.

2.2 Design Phase

Plans shall be submitted in accordance with the City of Arkadelphia's Checklist for Storm Drainage Plans. The first engineering plan set submission shall be complete, and in sufficient detail to allow review by the City of Arkadelphia. All topographic surveys should be furnished to allow establishment of alignment, grades, and right-of-way requirements. These may be accomplished by on-the-ground field surveys or aerial photogrametric methods.

The hydraulic design of the proposed facilities shall be accomplished based on the procedures and criteria outlined in this manual. Calculations shall be made on the appropriate forms and submitted as part of the plan set. These plans shall show the alignment, drainage areas, size of facilities, and grades.

Storm drainage plans shall include at a minimum, a drainage area map, plan-profile sheets, and channel cross-sections, if applicable. The proposed improvements shall be produced on 24" x 36" sheets.

Survey control performed for the project shall reference two reference marks established by the City of Arkadelphia. A copy of the reference marks can be obtained from the City Engineer.

Survey control for the project shall conform to the following requirements:

Vertical control will be NAVD 88, Second Order Vertical
Horizontal control will be NAD 83, First Order Horizontal, Arkansas State Plane South Zone

As builts of the project shall be provided to the City of Arkadelphia in a digital exchange format (DXF). Acceptance by the City of Arkadelphia will not be given until as-builts are provided to the City.

2.2.1 Drainage Area Map

The drainage area map shall have a minimum scale of 1" = 200', and show the street right-of-way. For large drainage areas, a map having a minimum scale of 1" = 2000' is usually sufficient.

The following items/information shall be included:

(1) Acres, coefficient, and intensity for each drainage sub-area;

(2) Inlets, their size and location, the flow bypass for each, the direction of flow as indicated by flow arrows, the station for the centerline;

(3) A chart including data shown shall be submitted with the first review, and included on the map with the final review;

(4) Existing and proposed storm sewers;

(5) Sub-areas for alleys, streets, and off-site areas;

(6) Points of concentration;

(7) Runoff to all inlets, dead-end streets, and alleys or to adjacent additions and/or lots;

(8) A table for runoff computations;

(9) Flow arrows to indicate all crests, sags and street and alley intersections;

(10) North arrow;

(11) Any off-site drainage shall be included;

(12) Street names shall be indicated;

When calculating runoff, the drainage area map shall show the boundary of the drainage area contributing runoff into the proposed system. This boundary should be determined from a map having a contour interval not exceeding two feet. The area shall be further divided into sub-areas, sequentially numbered, to determine flow concentration points or inlet locations. The centerline of all streets will normally be a boundary of a drainage area, to insure that inlets are sized and positioned to fill the need without depending on storm water crossing over the street crown for proper drainage.

In residential areas, the centerline of the street will only be used as a drainage area boundary if the flow in either gutter has not exceeded the street crown elevation.

Direction of flow within streets, alleys, natural and man-made drainage ways, and at all system intersections, shall be clearly shown on the drainage area map and/or paving plans. Existing and proposed drainage inlets, storm sewer pipe systems, and drainage channels shall also be clearly shown and identified on the drainage area map. Storm sewers shall show and mark station tic-marks at 100-foot intervals. Plan-profile storm sewer or drainage improvement sheet limits and match lines shall be shown with pipes and channels identified.

The drainage area map should show enough topology to easily determine its location within the City.

2.2.2 PLAN-PROFILE SHEETS

2.2.2.1 Inlets

Inlets shall be given the same number designation as the area or sub-area contributing runoff to the inlet. The inlet number designation shall be shown opposite the inlet. Inlets shall be located at or immediately downstream of drainage concentration points. At intersections, where possible, the end of the inlet shall be ten feet from the curb return P.T., and the inlet location shall also provide minimum interference with the use of adjacent property. Inlets in residential areas should be located in streets and alleys so that driveway access is not prohibited to the lots. Inlets located directly above storm sewer lines, as well as laterals passing through an inlet, shall be avoided. Drainage from abutting properties shall not be impaired, and shall be designed into the storm drainage system.

Data opposite each inlet shall include paving or storm sewer stationing at centerline of inlet, size and type of inlet, number or designation, top of curb elevation and flow line of inlet as shown on the construction plans.

2.2.2.2 Laterals

Inlet laterals leading to storm sewers, where possible, shall enter the inlet and the storm drain main at a 60-degree (60°) angle from the street side. Laterals shall be four feet from top of curb to flow line of inlet, unless utilities or storm sewer depth requires otherwise. Pipe soffits elevations should match at all junctions. Laterals shall not enter the corners or bottoms of inlets. Lateral profiles shall be drawn showing appropriate information including the hydraulic gradient and utility crossings.

2.2.2.3 Storm Sewer

In the plan view, the storm sewer designation, size of pipe, and length of each size pipe shall be shown adjacent to the storm sewer. The sewer plan shall be stationed at one hundred- (100) foot intervals, and each sheet shall begin and end with even or fifty- (50) foot stationing. All storm sewer components shall be stationed.

The profile portion of the storm sewer plan-profile sheet shall show the existing and proposed ground profile along the centerline of the proposed sewer, the hydraulic gradient of the sewer, the proposed storm sewer, and utilities which intersect the alignment of the proposed storm sewer. Also shown shall be the diameter of the proposed pipe in inches, and the physical grade in percent. Hydraulic data for each length of storm sewer between interception points shall be shown on the profile. This data shall consist of pipe diameter in inches, the design storm discharge in cubic feet per second, slope of hydraulic gradient in percent, Manning capacity of the pipe flowing full in cubic feet per second, velocity in feet per second, and $V^2/2g$. Also, the head loss at each interception point shall be shown.

Elevations of the flow line of the proposed storm sewer shall be shown at one hundred-(100) foot intervals on the profile. Stationing and flow line elevations shall also be shown at all pipe grade changes, pipe size changes, lateral connections, manholes, and wye connections. All soffit elevations shall match.

2.2.3 Miscellaneous

All plan sheets shall be drawn in ink on 24" x 36" material, to a standard engineering scale, and shall be clearly legible when sheets are reduced to half scale. All drawings shall be signed and sealed by a Professional Engineer registered in the State of Arkansas. After each review, all review comments shall be addressed, additional data incorporated, and drafting of plans completed. Each plan-profile sheet shall have a benchmark shown.

2.3 Check list for Storm Drainage Plans

2.3.1 Drainage Area Map

(1) Normally, use 1" = 200' scale for on-site, and 1" – 400' for off-site. Show match lines between any two (2) or more maps.

(2) Show existing sub-areas for alley, street, and off-site areas.

(3) Indicate sub-areas for alley, street, and off-site areas.

(4) Indicate contours on map for on- and off-site, not to exceed two (2) foot contour interval.

(5) Use design criteria as shown in design manual or as specified by the City Engineer.

(6) Indicate city zoning on drainage area.

(7) Show points of concentration and their designations.

(8) Indicate runoff at all inlets, dead-end streets and alleys, or to and from adjacent additions or acreage.

(9) Provide runoff calculations for all areas showing acreage, runoff coefficient, and inlet time.

(10) For cumulative runoff, show calculations.

(11) Indicate all crests, sags, and street and alley intersections with flow arrows.

(12) Identify direction of north to top page or to the left.

2.3.2 Storm Sewers

(1) Diversion of flow from one natural drainage area to another will not be allowed.

(2) Show plan and profile of all storm sewers.

(3) Pipe Material shall conform to the following minimum requirements:
Under Pavement or Roadway Crossings – RCP Class III
ASTM C-76
ASTM C-506
Mains and Laterals – Aluminized Steel Type 2 Corrugated Steel Pipe
ASTM A-929
ASTM A-760
Or Mains and Laterals – Smooth Interior Corrugated Polyethylene Pipe
AASHTO Type "S" (4"-42")
AASHTO Type "D" (48"-60")
ASTM D3350

(4) Use heavier than Class III RCP pipes were crossing railroads, areas of deep fill and areas subjected to heavy loads.

(5) Specify concrete strength for all structures. The minimum allowable is 3,000 psi.

(6) Provide inlets where street capacity is exceeded. Provide inlets where alley runoff exceeds intersection street capacity.

(7) Do not allow storm water flow from streets into alleys.

(8) Do not use high velocities in storm sewer design. A maximum discharge velocity of eight (8) fps at the outfall is required. Velocity dissipation may be necessary to reduce erosion.

(9) Flumes may not be allowed unless specifically designated by the City Engineer.

(10) Provide headwalls and aprons for all storm sewer outfalls. Provide riprap around headwalls where slopes exceed 3:1 or where the velocity out of the storm system exceeds erosive limits set by the City of Arkadelphia.

(11) Discharge flow lines of storm sewers to be two (2) feet above the natural flow line of the channel, unless channel lining is present. Energy dissipation shall be provided when specified by the City Engineer.

(12) Where fill is proposed for trench cut in creeks or outfall ditches, compaction shall be 95% of the maximum density as determined by ASTM D 698.

(13) Investigation shall be made by the engineer to validate the adequacy of the storm sewer outfall to a major stream.

(14) Engineer shall verify the existing outfall capacity to ensure safe and reliable discharge. Provide erosion control facilities with hydraulic data.

(15) Any off-site drainage work or discharge to downstream property will require an easement. Easement shall be sized such that the developed flows can be conveyed within the easement. Submit field notes for off-site easement that may be required (Private development only).

2.3.3 Plan and Profile

(1) Indicate property lines and lot lines along storm sewers, and show easements with dimensions.

(2) If necessary, provide separate plan and profile of storm sewers. The storm drainpipes should also be shown on paving plans with a dashed line, and on sanitary sewer profiles showing the full pipe section.

(3) Tie storm sewer system stationing with paving stations.

(4) Show pipe sizes in plan and profile.

(5) Show hydraulics on each segment of pipe profile to include: Q_{10} and Q_{25}, C , (Manning full flow capacity); S (Slope), V (Velocity), $V^2/2g$ (Velocity Head).

(6) Show curve data for all storm sewer system.

(7) Show all existing utilities in plan and profile. On storm sewer profiles, as a minimum, the sanitary sewer profile will be shown.

(8) Indicate existing and proposed ground line and improvements on all street, alley, and storm sewer profiles.

(9) Show future streets and grades where applicable.

(10) Where connections are made to existing storm sewer, show computations of existing system when available. HGL will be calculated from the outfall to the connection point including the designed flows of the added system. Six inches of freeboard will be provided between the HGL and the inlet curb opening.

(11) Indicate flow line elevations of storm sewers on profile, show pipe slope (percent grade). Match pipe soffits at all junction boxes or inlets.

(12) Intersect laterals at sixty (60) degrees with trunk line.

(13) Show details of all junction boxes, headwalls, storm sewers, flumes, and manholes, when more than one pipe intersects the drainage facility or any other item not a standard detail.

(14) Pipe deflections for directional changes shall be placed at the manufacturers recommendations. Deflections exceeding the manufactures' recommendation will not be tolerated.

(15) Bends in pipes may be used in unusual circumstances with approval by the City. No bend at one location may exceed thirty (30) degrees.

(16) Do not use 90-degree turns on storm sewer outfalls. Provide good alignment with junction structures, manholes, and downstream channels.

(17) Show all hydraulics, velocity head changes, gradients, and computations.

(18) Show water surface elevation of the outfall for Q_{25}.

(19) On all dead-end streets and alleys, show grade out to "daylight" for drainage on the profiles and provide erosion control. Show typical section and slope of "daylight" drainage.

(20) At sags in pavement, provide a positive overflow (paved sidewalk in a swale) to act as a safety path for failure of the storm drain system. Minimum finished floor elevations will be shown on the plat to protect building against flooding should the positive overflow be used.

(21) Where quantities of runoff are shown on plans or profiles, indicate storm frequency design.

(22) Provide sections for road, railroad, and other ditches with profiles and hydraulic computations. Show design water surface on profile.

2.3.4 Laterals

Laterals are defined as minor storm sewer lines that serve the purpose of connecting a single inlet to a larger storm sewer main line. The following is a list of requirements that apply to laterals.

(1) Show laterals on trunk profile with stations.

(2) Provide lateral profiles for laterals exceeding thirty (30) feet in length. Profile short laterals that pass over a sanitary sewer or other profiled utility.

(3) Where laterals tie into trunk lines, place at sixty-degree (60) angles with centerlines. Connect them so that the longitudinal centers intersect.

(4) Minimum pipe diameter shall be eighteen inches (18").

2.3.5 Inlets and Intakes

(1) Provide inlets where street capacity is exceeded. Provide inlets where runoff from alley causes the capacity of the intersecting street to be exceeded.

(2) Indicate runoff concentrating at all inlets and direction of flow. Show runoff for all stub cuts, pipes, and intakes.

(3) On plan view, indicate size of inlet, lateral size, flow line, top-of-curb elevations, paving station, and inlet designation number.

(4) Use standard curb inlets in streets. Use recessed inlets in divided streets. Use combination inlets in alleys when on a straight run. Do not use grate or combination inlet unless other solution is not available (special situations). These inlets can be seen in Figure 13 of Appendix 2.

(5) Use type "Y" or special "Y" inlets in ditches or swales. Intake structures for a concrete apron shall be constructed around "Y" inlets.

2.3.6 Paving

(1) Provide six (6) inch curb on alleys parallel to creek or channel on creek side of alley.

(2) For a proposed driveway turnout, curb return P.T. must be 10 feet upstream from any existing or proposed inlet or 5 feet downstream of a standard inlet.

(3) Check the need for curbing at all alley turns and "T" intersections. Flatten grades ahead of turns and intersections.

(4) Where inlets are placed in an alley, provide curbing for 10 feet on each side of combination inlet.

2.3.7 Detention

(1) Provide drainage area map and show all computations for runoff affecting the detention basin.

(2) Provide a plot plan with existing and proposed contours for the detention basin and plan for structural measures.

(3) Where earth embankment is proposed for impoundment, furnish a typical embankment section and specifications for fill include profile for the structural outflow structure and Geotechnical report.

(4) Provide structural details and calculations for any item that's not a standard detail.

(5) Provide detention basin volume calculations and elevation versus storage curve.

(6) Provide hydraulic calculations for outflow structure and elevation versus discharge curve.

(7) Provide routings or modified rational determination of storage requirements, (permitted for areas of 300 acres or less)

(8) Fencing may be required around detention area for public safety as determined by the City of Arkadelphia.

2.3.8 Bridges

(1) Clear the lowest member of the bridge by 2 feet above the design water surface, unless otherwise directed by the City Engineering Department.

(2) Show Geotechnical soil boring information on plans.

(3) Provide channel cross sections of the water surface elevations for the design storm immediately upstream and downstream of the structure.

(4) Provide hydraulic calculations on all sections.

(5) Provide structural details and calculations with dead load deflection diagram.

(6) Provide vertical and horizontal alignment.

(7) Show soil erosion protection measures.

(8) Hydraulic calculations for bridges constructed in a designated floodplain shall be performed in HEC RAS. The pre-construction and post construction 100 year floodplain shall be shown.

2.3.9 Open Channels

1) Plan view of channel showing existing and proposed alignment including creek centerline stationing, north arrow, and scale.

2) Profile of existing and proposed creek centerline.

3) Profile of the fully urbanized 100-year and 25-year water surface elevation.

4) Typical cross sections showing dimensions, and the station limits for which they apply.

5) Velocities and discharges for the 100-year and 25-year storms.

6) Limits of temporary erosion protection associated with the construction of the channel needs to be indicated in plan view.

7) Indicate property lines and lot lines along with existing utilities and show easements with dimensions.

8) Include on the construction plans or as a separate report the computations performed in developing the water surface profile.

3.0 HYDROLOGY

3.1 General

The planning, design and construction of drainage facilities are based on the determination of one or more aspects of storm runoff.

Continuous long-term records of rainfall and resulting storm runoff in an area provide the best data source from which to base the design of storm drainage and flood control systems in that area. However, it is not possible to obtain such records in sufficient quantities for all locations requiring storm runoff computations. Therefore, the accepted practice is to relate storm runoff to rainfall, thereby providing a means of estimating the rates, timing and volume of runoff expected within local watersheds at various recurrence intervals.

It is generally accepted that urban development has a pronounced effect on the rate and volume of runoff from a given rainfall. Urbanization generally alters the hydrology of a watershed by improving its hydraulic efficiency, reducing its surface infiltration, and reducing its storage capacity.

For certain small drainage areas (generally less than 300 acres in size), the widely used Rational Method provides a useful means of determining peak discharges. If the engineer wishes to use an alternative design technique, it is recommended that the City of Arkadelphia Engineer be consulted prior to design.

3.2 Rational Method

For smaller basins, less than 300 acres, the Rational Method is recommended for computing the runoff. The Rational formula is:

$$Q = C^{*}I^{*} A \qquad (3.1)$$

- Q = Discharge (cfs)
- I = Rainfall intensity (in/hr)
- A = Drainage area (acres)
- C = Runoff coefficient (dimensionless)

3.2.1 The Runoff Coefficient

The runoff coefficient, C-factor, varies according to soil type and land use. It is the ratio of rainfall to runoff. The more impervious and density developed an area is, the higher the value for the C-factor. In storm drain design, the C-factor should always be based on fully developed conditions. This helps to prevent future flooding due to increased development. Zoning ordinances can aid in choosing a C-factor. Table 1 of Appendix 1 shows typical values for the C-factor accepted by the City of Arkadelphia.

3.2.2 Rainfall Intensity

Rainfall intensity (I) is the average rainfall rate in inches per hour, which is considered for a particular basin or sub-basin and is selected on the basis of design rainfall duration and design frequency of occurrence. The design duration is equal to the time of concentration for all portions of the drainage area under consideration that contribute flow to the point of interest. The frequency of occurrence is a statistical variable, which is established by design standards or chosen by the engineer as a design parameter. The rainfall intensities for various frequencies have been compiled in graphical form on Figure 1 in Appendix 2. The graph plots the rainfall intensity versus time of concentration.

The time of concentration is defined as the longest time, without interruption of flow by detention devices that will be required for water to flow from the upper limit of a drainage area to the point of concentration. This time is a combination of the inlet time, which is the time for water to flow over the surface of the ground from the upper limit of the drainage area to the first storm sewer inlet, and the flow time in the conduit or channel to the point of concentration. The flow time in the conduit or channel is computed by dividing the length of the conduit by the average velocity in the conduit. Typical inlet times can be found in Table 1 of Appendix 1.

Although the basic principles of the Rational Method are applicable to all sizes of drainage areas, natural retention of flow and other interruptions cause an attenuation of the runoff hydrograph resulting in over-estimation of rates of flow for larger areas. For this reason, in development of runoff rates in larger drainage areas, use of the Unit Hydrograph Method is recommended.

3.3 Unit Hydrograph Method

For contributing drainage areas greater than 300 acres the Snyder's Unit Hydrograph Method must be used to calculate the runoff. To do this several parameters must be defined.

3.3.1 Definitions

The computation of runoff quantities utilizing the Unit Hydrograph Method is based on the following equations:

- "T_p" is the lag time, in hours, from the midpoint of the unit rainfall duration to the peak of the unit hydrograph;
- "C_t" and "C_p640" are coefficients related to drainage basin characteristics.
- "L" is the measured stream distance in miles from the point of design to the upper limit of the drainage area;
- "L_{ca}" is the measured stream distance in miles from the point of design to the centroid of the drainage area. This value may be obtained in the following manner:

  Trace the outline of the drainage basin on a piece of cardboard and trim to shape. Suspend the cardboard before a plumb bob by means of a pin near the edge of the cardboard and draw a vertical line. In a similar manner, draw a second line at approximately a 90 degree angle to the first line. The intersection of the two lines is the centroid of gravity of the area.

- "q_p" is the peak rate of discharge of the unit hydrograph for unit rainfall duration in cubic feet per second per square mile;
- "A" is the area in square miles that is draining to the point of design;
- "I" is the rainfall intensity at two hours, in inches per hour, for the appropriate design storm frequency;
- "S_D" is the design storm rainfall in inches for a two-hour period;
- "L_{is}" is the initial and subsequent losses;
- "R_T" is the total runoff in inches;
- "Q_u" is the design storm runoff in cubic feet per second.

3.3.2 Coefficients

Relationships for the lag time, Cp, and C_t were obtained from the Corps of Engineers, Vicksburg District Office. These relationships were published in a report prepared by Blaylock Threet and Associates, Inc. who performed an analysis of gaged data to develop relationships for computing the Snyder's Coefficients. The following relationships were obtained from the Corps of Engineers.

$$T_p = C_t (L\ L_{ca})0.3 \qquad (3.2)$$

$$q_p = \frac{C_p 640}{t_p} \qquad (3.3)$$

$$Q_p = q_p\ A \qquad (3.4)$$

$$S_D = I \times 2 \qquad (3.5)$$

$$R_T = S_D - L_{is} \qquad (3.6)$$

$$Q_u = R_T\ Q_p \qquad (3.7)$$

$$C_t = 10^{(-0.6017(\log(Sst))-1.4037)} \qquad (3.8)$$

$$q_p = 10^{(-1.0485(\log(Tp))+2.6047)} \qquad (3.9)$$

$$T_p = C_t (LL_{CA})^{0.3} \qquad (3.10)$$

$$Qp = 10^{(-1.0485(\log(tp))-2.6047)} \qquad (3.11)$$

$$C_p = \frac{Q_p t_p}{640} \quad \text{or} \quad Cp640 = Q_p{*}t_p \qquad (3.12)$$

Where:

S_{st} = weighted stream slope (ft/ft)

3.3.3 Initial and Subsequent Losses

Initial loss is defined as the maximum amount of precipitation that can occur under specific conditions without producing runoff. Initial loss values for basins in humid areas of the United States may range from a minimum value of a few tenths of an inch during relatively wet seasons to approximately 2 inches during dry summer and fall months. The initial loss for conditions usually preceding major floods in humid regions normally ranges from about 0.2 to 0.5 inch.

In view of the approximations involved in infiltration estimates, the average loss rate computed from rainfall-runoff data for natural drainage basins will be referred to herein as "infiltration index". Infiltration index is defined as an average rate of loss such that the volume of rainfall in excess of that rate will equal the volume of direct runoff. The infiltration index should range from 0.05 – 0.15 in/hr.

3.3.4 Rainfall

Rainfall data for the various storms can be determined from a combination of the TP-40 and the Hydro-35. Table 3 of Appendix 1 shows values for the rainfall data which has been obtained from the TP 40 and the Hydro-35.

3.3.5 Requirements

The amount of runoff can either computed by hand or by using the HEC-HMS computer program. HEC-HMS can be obtained from the Corps of Engineers. It can be downloaded from their website at www.hec.usace.army.mil\.

4.0 STORM DRAIN AND DRAINAGE APPURTENANCES

4.1 General

This section contains storm drainage design criteria and demonstrates the design procedures to be employed on drainage projects within the City of Arkadelphia. All drainage design shall be submitted both as required on the construction plans and on the forms in Appendix 3.

4.2 Design Frequencies

Table 7 of Appendix 2 shows the appropriate design frequencies to be used for fully developed watershed conditions in storm drain designs in the City of Arkadelphia.

4.3 Runoff Calculations

To begin design of a storm drainage system, it is necessary to compute the amount of runoff that accumulates upstream of the intake structures. To begin to quantify this accumulation the Rational Method can be employed to convert rainfall to runoff. The formula for the rational method is shown in Formula (4-1).

$$Q = C*I*A \qquad (4.1)$$

Q = Discharge (cfs)
I = Rainfall intensity (in/hr)
A = Area (acres)

The rainfall intensity is based on rainfall depths obtained from the *Technical Paper Number 40* (TP-40) and the Hydro-35 published by the *National Weather Service.* Figure 1 of Appendix 2 contains a graph of rainfall intensity versus time of concentration.

The time of concentration is the longest time water takes to travel from the upper boundary of the watershed to the design point. This includes both the time to the inlet and the travel time in the storm pipe. Table 1 of Appendix 1 contains the minimum inlet times to be used in the design of the storm drainage system. The time of concentration should be used to obtain an intensity from Figure 1 of Appendix 2. Table 1 also gives values for the runoff coefficient. The discharge for the appropriate frequency storm can then be calculated.

4.4 Street Flow

The next step in the design of the storm drain system is to calculate the flow within the streets.

4.4.1 Definitions

The following street classifications will provide clarity in discussing the requirements and methodology to calculate the flow in streets:

Principal Arterials: Serve the major centers of activity
Minor Arterials: Intended to provide land access
Collectors: Connect local streets in residential neighborhoods
Locals: Provide access to various public and private properties

The street classifications given above are adopted from the Arkadelphia Master Street 1995-2015, as amended.

Straight Crown – A constant slope from one gutter flow line across the street to the other gutter flow line.

Parabolic Crown – A pavement surface shaped in a parabolic from one gutter flow line to the other.

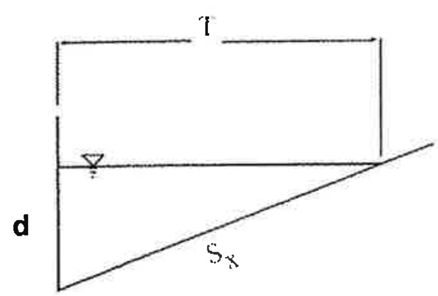
Vertical Displacement Between Gutter Flow Line: Due to topography, it will be necessary at times that the curbs on a street be placed at different elevations.

4.4.2 Calculation of Flow in Streets

The calculation of flow in streets is dependent on street width and shape. Generally, there are two shapes for streets; straight crown and parabolic crown. The straight crowned street can be further subdivided into two types of gutters; uniform and composite. The following discussion covers the methodology used to compute the flow in the street.

Table 7 in Appendix 1 shows the requirements for the design of the roadway drainage. These requirements are based on the *Federal Highway Administration* (FHWA) Circular Number 22.

4.4.3 Uniform Gutter Sections



Uniform Road Section

S_X = Pavement (road) cross-slope (ft/ft) = d/T
T = Total width of flow or spread
Q = Total discharge (cfs)
S_L = Longitudinal slope of road

The runoff in the gutter is generally treated as open channel flow. Therefore, Manning's Equation can be used to calculate the flow or spread in the road section. The following formula is a modified version of the Manning's Equation. It incorporates the geometry of the uniform roadway section.

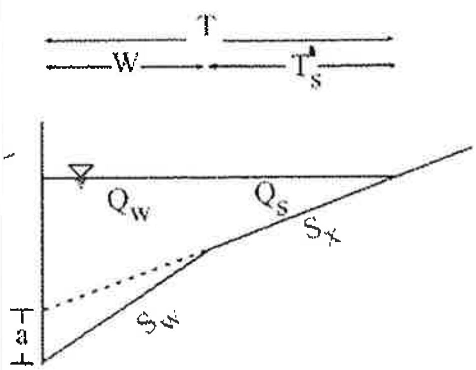
$$Q = \frac{K_C}{n} S_X^{1.67} S_L^{0.5} T^{2.67} \qquad (4.2)$$

Where $K_C = 0.56$
n = Manning's roughness coefficient (0.013 for concrete)
S_L = Longitudinal slope of road (ft/ft)

This equation assumes that the depth of flow, d, is small when compared to the overall topwidth and therefore the topwidth is assumed to be equal to the wetted perimeter. Also, the friction along the curb height is assumed to be negligible when compared to the friction along the spread.

The roadway should be designed such that the spread will be maximized just upstream of the inlet.

4.4.4 Composite Gutter Sections



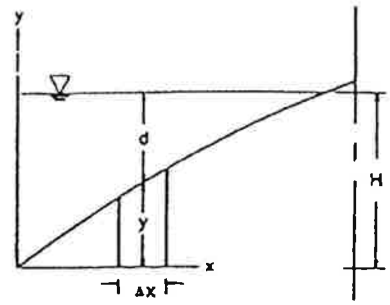
Composite Road Section

Q_W = Flow in depressed section (ft^3/s)
Q_S = Side flow (cfs)
S_W = Gutter Cross Slope (ft/ft)
S_X = Pavement (road) cross-slope (ft/ft)
W = Width of depressed gutter (ft)
T_S = Width of side flow (ft)
T = Total width of flow (ft)
a = Continuous gutter depression (in)

In order to calculate the flow in a composite section the ratio of frontal flow to total gutter flow, E_o, can be calculated using Formula (4.3) in conjunction with Formula (4.2).

$$E_O = 1 \Big/ \left\{ 1 + \frac{S_W}{S_X}\left[\left(1 + \frac{S_W / S_X}{(T/W) - 1}\right)^{2.67} - 1\right]^{-1} \right\} = \frac{Q_W}{QTOTAL} \qquad (4.3)$$

4.4.5 Parabolic Street Sections



For residential streets, parabolic sections are often used because they provide a flatter driving surface than uniform sections. However, the flow capacity is less for the parabolic section than the uniform section. The following formulas can be used to calculate the flows and associated spread in a parabolic section.

c. Parabolic

$$y = ((Q/S^{0.5})^{C2})\ /C1 \qquad (4.4)$$

$$Q = (y*C1)^{(1/C2)}*S^{0.5} \qquad (4.5)$$

$$T = B - (C3\text{-}C4y)^{0.5} \qquad (4.6)$$

$$A = (T \times y)\ /\ 3 \qquad (4.7)$$

$$V = Q/A \qquad (4.8)$$

Where:

y = Flow depth in gutter for one side of street (ft)

Q = Gutter discharge for one side of the street (cfs)

T = Spread for one side of the street (ft)

A = Cross sectional area of flow (ff^2)

V = Velocity of flow (ft/s)

B = 1/2 of the street width

Table 4,4: Parabolic Roadway Coefficients

	CROWN	C1	C2	C3	C4
	6"	9.2180	0.3405	169	338
26'	* 5"	9.9714	0.3404	169	405.6
	4"	10.9821	0.3404	169	507
	7"	9.1145	0.3418	225	385.7143
31'	6"	9.7396	0.3418	225	450
	* 5"	10.5346	0.3418	225	540
	8"	9.1888	0.3421	324	486
36'	7"	9.7317	0.3421	324	555.4286
	* 6"	10.4020	0.3422	324	648
44'	* 8"	9.9146	0.3433	484	726
	7"	10.4975	0.3433	484	829.7143
	6"	11.2173	0.3433	484	968
* These crown heights shall be used for new developments					
Note: These constants were derived for a Manning's n of 0.016.					

Alternatively, the nomagraphs included in Appendix 4 can be used as aids in designing parabolic roadway drainage.

4.5 Drainage Inlet Design

The hydraulic capacity of a storm drain inlet depends upon its geometry as well as the characteristics of the gutter flow. Inlet capacity governs both the rate of water removal from the gutter and the amount of water that can enter the storm drainage system. Inadequate inlet capacity or poor inlet location may cause flooding on the roadway resulting in a hazard to the traveling public.

In general inlets should be placed to meet the requirements summarized in Table 7 in Appendix 1. In addition, inlets should be spaced at a maximum distance of 600 feet apart.

4.5.1 Inlet Types

Storm drain inlets are used to collect runoff and discharge it to an underground storm drainage system. Inlets are typically located in gutter sections, paved medians, and roadside and median ditches. Inlets used for the drainage of highway surfaces can be divided into the following three classes:

1. Grate inlets
2. Curb-opening inlets
3. Combination inlets

Grate inlets consist of an opening in the gutter or ditch covered by a grate. Curb-opening inlets are vertical openings in the curb covered by a top slab. Combination inlets consist of both a curb-opening inlet and a grate inlet placed in a side-by-side configuration, but the curb opening may be located in part upstream of the grate.

4.5.2 Interception Capacity of Inlets on Grade

Inlet interception capacity, Q_j, is the flow intercepted by an inlet under a given set of conditions. The efficiency of an inlet, E, is the percent of total flow that the inlet will intercept for those conditions. The efficiency of an inlet changes with changes in cross slope, longitudinal slope, total gutter flow, and, to a lesser extent, pavement roughness. In mathematical form, efficiency, E, is defined by the following equation:

$$E = \frac{Q_j}{Q} \tag{4.9}$$

Where:

- E = Inlet Efficiency (ft^3/s)
- Q = Total Gutter Flow
- Q_j = Intercepted F=low, (ft^3/s)

Flow that is not intercepted by an inlet is termed carryover or bypass and is defined as follows:

$$Q_b = Q - Q_j \tag{4.15}$$

Where:

- Q_b = bypass flow, m^3/s (ft^3/s)

In Appendix 4, design charts for inlets on grade and procedures for using the charts are presented for the various inlet configurations. Remember that for locally depressed inlets, the quantity of flow reaching the inlet would be dependent on the upstream gutter section geometry and not the depressed section geometry.

Charts for grate inlet interception have been made and are applicable to all grate inlets tested for the Federal Highway Administration. The chart for frontal flow interception is based on test results which show that grates intercept all of the frontal flow until a velocity is reached at which water begins to splash over the grate. At velocities greater than "Splash-over" velocity, grate efficiency in intercepting frontal flow is diminished. Grates also intercept a portion of the flow along the length of the grate, or the side flow. A chart in Appendix 4 is provided to determine side-flow interception. Chart 5 in Appendix 4 determines the "splash" over velocity".

A procedure for determining the interception capacity of combination inlets is also presented.

4.5.2.1 Grate Inlets

Grate inlets as a class, perform satisfactory over a wide range of gutter grades. Grate inlets generally lose capacity with increase in grade, but to a lesser degree than curb opening inlets. The principal advantage of grate inlets is that they are installed along the roadway where the water is flowing. Their principal disadvantage is that they may be clogged by floating trash or debris. For this reason, it will be assumed that, on designing grate inlets, their capacity is reduced by fifty percent (50%). For safety reasons, preference should be given to grate inlets where out-of-control vehicles might be involved. Additionally, where bicycle traffic occurs, grates should be bicycle safe.

Grates are effective highway pavement drainage inlets where clogging with debris is not a problem. Where clogging may be a problem, see Table 4-5 where grates are ranked for susceptibility to clogging based on laboratory tests using simulated "leaves." This table should be used for relative comparisons only.

Table 4-5. Average Debris Handling Efficiencies of Grates Tested

Rank	Grate	Longitudinal Slope	
		0.005	0.04
1	Curbed Vane	46	61
2	30 - 85 Tilt Bar	44	55
3	45 - 85 Tilt Bar	43	48
4	P – 50	32	32
5	P – 50x100	18	28
6	45 - 60 Tilt Bar	16	23
7	Reticuline	12	16
8	P-30	9	20

When the velocity approaching the grate is less than the "splash-over" velocity, the grate will intercept essentially all of the frontal flow. Conversely, when the gutter flow velocity exceeds the "splash-over" velocity for the grate, only part of the flow will be intercepted. A part of the flow along the side of the grate will be intercepted, dependent on the cross slope of the pavement, the length of the grate, and flow velocity.

The ratio of frontal flow to total gutter flow, E_o for a uniform cross slope is expressed by equation 4-10:

$$E_o = \frac{Q_w}{Q} = 1 - \left(1 - \frac{W}{T}\right)^{2.67} \qquad (4.10)$$

Where:

- Q = total gutter flow, (ft^3/s)
- Q_w = flow in width W, (ft^3/s)
- W = width of depressed gutter or grate, (ft)
- T = total spread of water, (ft)

Chart 2 in Appendix 4 provides solutions of E_o for either uniform cross slopes or composite gutter sections.

The ratio of side flow, Q_s, to total gutter flow is:

$$\frac{Q_s}{Q} = 1 - \frac{Q_w}{Q} = 1 - E_o \qquad (4.11)$$

The ratio of frontal flow intercepted to total frontal flow, R_f, is expressed by equation 4.12:

$$R_f = 1 - K_u (V - V_o) \qquad (4.12)$$

Where:

- K_u = 0.09 in English Units
- V = velocity of flow in the gutter, ft/s
- V_o = gutter velocity where splash-over first occurs, ft/s (computed from Chart 5 in Appendix 4
- (Note: R_f cannot exceed 1.0)

This ratio is equivalent to frontal flow interception efficiency. Chart 5 in Appendix 4 provides a solution for equation 4.18 which takes into account grate length, bar configuration, and gutter velocity at which splash-over occurs. The average gutter velocity (total gutter flow divided by the area of flow) is needed to use Chart 5 in Appendix 4. This velocity can also be obtained from Chart 4 in Appendix 4.

The ratio of side flow intercepted to total side flow, R_s. is side flow interception efficiency, is expressed by equation 4.13. Chart 6 in Appendix 4 provides a solution to equation 4.13.

$$R_s = 1 \,/ \left(1 + \frac{K_u V^{1.8}}{S_x L^{2.3}}\right) \qquad (4.13)$$

Where:

- K_u = 0.15 in English Units
- L = length of grate along gutter, (ft)
- S_x = roadway cross slope
- V = velocity, (ft/s)

The efficiency, E, of a grate is expressed as provided in equation 4.14:

$$E = R_f E_o + R_s (1 - E_o) \qquad (4.14)$$

The first term on the right side of equation 4.14 is the ratio of intercepted frontal flow to total gutter flow, and the second term is the ratio of intercepted side flow to total side flow. The second term is insignificant with high velocities and short grates.

The interception capacity of a grate inlet on grade is equal to the efficiency of the grate multiplied by the total gutter flow as represented in equation 4.15.

$$Q_j = E\,Q = Q\,[R_f\,E_o + R_s\,(1 - E_o)] \qquad (4.15)$$

4.5.2.2. Opening Inlets

Curb-opening inlets are most effective on flatter slopes, in sags, and with flows which typically carry significant amounts of floating debris. The interception capacity of curb-opening inlets decreases as the gutter grade increases. Consequently, the use of curb-opening inlets is recommended in sags and on grades less than 3%. Of course, they are bicycle safe as well.

Curb-opening inlets are effective in the drainage of pavements where flow depth at the curb is sufficient for the inlet to perform efficiently. Curb openings are less susceptible to clogging and offer little interference to traffic operation. They are a viable alternative to grates on flatter grades where grates would be in traffic lanes or would be hazardous for pedestrians or bicyclists.

Curb opening heights vary in dimension; however, a typical maximum height is approximately 4 to 6 in. The length of the curb-opening inlet required for total interception of gutter flow on a pavement section with a uniform cross slope is expressed by equation 4.16:

$$L_T = K_u\,Q^{0.42}\,S_L^{\,0.3}\left(\frac{1}{nS_x}\right)^{0.6} \qquad (4.16)$$

Where:

- K_u = 0.6 in English Units
- L_T = curb opening length required to intercept 100 percent of the gutter flow, (ft)
- S_L = longitudinal slope
- Q = gutter flow, (ft^3/s)

The efficiency of curb-opening inlets shorter than the length required for total interception is expressed by equation 4.17:

$$E = 1 - \left(1 - \frac{L}{L_T}\right)^{1.8} \qquad (4.17)$$

Where:

- L = curb-opening length, (ft)
- L_t = curb opening length at 100% efficiency, (ft)

Chart 7 in Appendix 4 is a nomograph for the solution of equation 4.16 and Chart 8 provides a solution of equation 4.17.

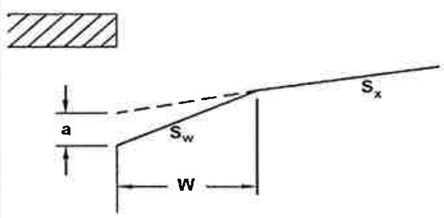
The length of inlet required for total interception by depressed curb-opening inlets or curb-openings in depressed gutter sections can be found by the use of an equivalent cross slope, S_e, in equation 4.16 in place of S_x. S_e can be computed using equation 4.18.

$$S_e = S_x + S'_w E_o \qquad (4.18)$$

Where:

- S_x = roadway cross slope, (ft/ft)
- S'_w = cross slope of the gutter measured from the cross slope of the pavement, S_x, (ft/ft)
- S'_w = (a/[12 W], for W in ft) or = $S_w - S_x$
- a = gutter depression, (in)
- E_o = ratio of flow in the depressed section to total gutter flow determined by the gutter
  configuration upstream of the inlet

The following diagram shows the depressed curb inlet for equation 4.24, E_o is the same ratio as used to compute the frontal flow interception of a grate inlet.



As seen from Chart 7 of Appendix 4, the length of curb opening required for total interception can be significantly reduced by increasing the cross slope or the equivalent cross slope. The equivalent cross slope can be increased by use of a continuously depressed gutter section or a locally depressed gutter section.

Using the equivalent cross slope, S_e, equation 4.16 becomes:

$$L_T = K_T Q^{0.42} S_L^{0.3} \left(\frac{1}{nS_e}\right)^{0.6} \qquad (4.19)$$

Where:

- K_T = 0.6 in English Units

Equation 4.17 is applicable with either straight cross slopes or composite cross slopes. Charts 7 and 8 in Appendix 4 are applicable to depressed curb-opening inlets using S_e.

4.5.2.2 Combination Inlets

Combination inlets provide the advantages of both curb opening and grate inlets. This combination results in a high capacity inlet which offers the advantages of both grate and curb-opening inlets. When the curb opening precedes the grate in a “Sweeper” configuration, the curb-opening inlet acts as a trash interceptor during the initial phases of a storm. Used in a sag configuration, the sweeper inlet can have a curb opening on both sides of the grate.

The interception capacity of a combination inlet consisting of a curb opening and grate placed side-by-side, is no greater than that of the grate alone. Capacity is computed by neglecting the curb opening. A combination inlet is sometimes used with a part of the curb opening placed upstream of the grate. The curb opening in such an installation intercepts debris which might otherwise clog the grate and is called a “sweeper” inlet. A sweeper combination inlet has an interception capacity equal to the sum of the curb opening upstream of the grate plus the grate capacity, except that the frontal flow and thus the interception capacity of the grate is reduced by interception by the curb opening.

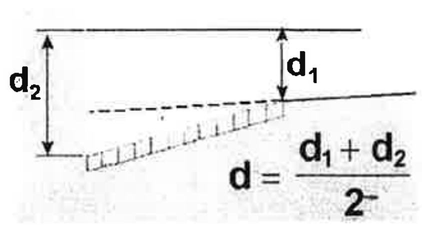
4.5.3 Interception Capacity of Inlets in Sag Locations

Inlets in sag locations operate as weirs under low head conditions and as orifices at greater depths. Orifice flow begins at depths dependent on the grate size, the curb opening height, or the slot width of the inlet. At depths between those at which weir flow definitely prevails and those at which orifice flow prevails, flow is in a transition stage. At these depths, control is ill-defined and flow may fluctuate between weir and orifice control. Design procedures presented here are based on a conservation approach to estimating the capacity of inlets in sump locations.

The efficiency of inlets in passing debris is critical in sag locations because all runoff which enters the sag must be passed through the inlet. Total or partial clogging of inlets in these locations can result in hazardous ponded conditions. Grate inlets alone are not recommended for use in sag locations because of the tendencies of grates to become clogged. Combination inlets or curb-opening inlets are recommended for use in these locations.

4.5.3.1 Grate Inlets in Sags

A grate inlet in a sag location operates as a weir to depths dependent on the size of the grate and as an orifice at greater depths. Grates of larger dimension will operate as weirs to greater depths than smaller grates.



The capacity of grate inlets operating as weirs is:

$$Q_j = C_w P d^{1.5} \qquad (4.20)$$

Where:

- P = perimeter of the grate in (ft) disregarding the side against the curb
- C_w= 3.0 in English Units
- d = average depth across the grate; 0.5 (d_1 + d_2), (ft)

The capacity of a grate inlet operating as an orifice is:

$$Q_i = C_o A_g (2 g d)^{0.5} \qquad (4.21)$$

Where:

- C_o = orifice coefficient = 0.67
- A_g =clear opening area of the grate, (ft^2)
- g = 32.2 ft/s^2

Use of equation 4.21 required the clear area of opening of the grate. Opening ratios for the grates are given on Chart 9 in Appendix 4.

Chart 9 in Appendix 4 is a plot of equation 4.20 and 4.21 for various grate sizes. The effects of grate size on the depth at which a grate operates as an orifice is apparent from the chart. Transition from weir to orifice flow results in interception capacity less than that computed by either the weir or the orifice equation. This capacity can be approximated by drawing in a curve between the lines representing the perimeter and net area of the grate to be used.

4.5.3.2 Curb-Opening Inlets

The capacity of a curb-opening inlet in a sag depends on water depth at the curb, the curb opening length, and the height of the curb opening. The inlet operates as a weir to depths equal to the curb opening height and as an orifice at depths greater than 1.4 times the opening height. At depths between 1.0 and 1.4 times the opening height, flow is in a transition stage.

Spread on the pavement is the usual criterion for judging the adequacy of a pavement drainage inlet design. It is also convenient and practical in the laboratory to measure depth at the curb upstream of the inlet at the point of maximum spread on the pavement. Therefore, depth at the curb measurements from experiments coincide with the depth at curb of interest to designers. The weir coefficient for a curb-opening inlet is less than the usual weir coefficient for several reasons, the most obvious of which is that depth measurements from experimental tests were not taken at the weir, and drawdown occurs between the point where measurement were made and the weir.

The weir location for a depressed curb-opening inlet is at the edge of the gutter, and the effective weir length is dependent on the width of the depressed gutter and the length of the curb opening. The weir location for a curb-opening inlet that is not depressed is at the lip of the curb opening, and its length is equal to that of the inlet, as shown in Chart 10 in Appendix 4.

The equation for the interception capacity of a depressed curb-opening inlet operating as a weir as:

$$Q_j = (L + 1.8\ W)d^{0.5} \qquad (4.22)$$

Where:

- $C_w = 2.3$
- L = length of curb opening, (ft)
- W = lateral width of depression, (ft)
- d = depth at curb measured from the normal cross slop, (ft), i.e., $d = T\ S_x$

The weir equation is applicable to depths at the curb approximately equal to the height of the opening plus the depth of the depression. Thus, the limitation on the use of equation 4.22 for a depressed curb-opening inlet is:

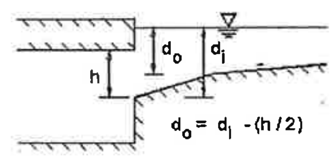
$$d \leq h + a/12, \text{ in English Units} \qquad (4.23)$$

Where:

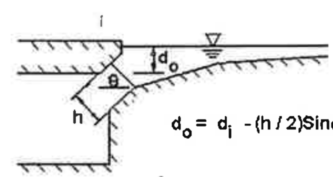
- h = height of curb-opening inlet, (ft)
- a = depth of depression, (in)

The weir equation for curb-opening inlets without depression becomes:

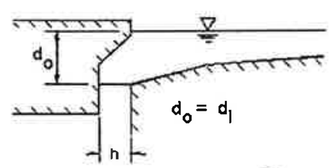
$$Q_j = C_w\ L\ d^{1.5} \qquad (4.24)$$



a. Horizontal Throat



b. Inclined Throat



Without depression of the gutter section, the weir coefficient, C_w, becomes 3.0, English system. The depth limitation for operation as a weir becomes $d \leq h$.

At curb-opening lengths greater than 12 ft, equation 4.24 for non-depressed inlet produces intercepted flows which exceed the values for depressed inlets computed using equation 4.24. Since depressed inlets will perform at least as well as non-depressed inlets of the same length, equation 4.24 should be used for all curb-opening inlets having lengths greater than 12 ft.

Curb-opening inlets operate as orifices at depths greater than approximately 1.4 times the opening height. The interception capacity can be computed by equation 4.25a and equation 4.25b. These equations are applicable to depressed and undepressed curb-opening inlets. The depth at the inlet includes any gutter depression.

$$Q_j = C_o\ h\ L\ (2\ g\ d_o)^{0.5} \qquad (4.25a)$$

Or

$$Q_j = C_o A_g \left[2g\left(d_i - \frac{h}{2}\right)\right]^{0.5} \qquad (4.25b)$$

Where:

- C_o = orifice coefficient (0.67)
- d_o = effective head on the center of the orifice throat, (ft)
- L = length of orifice opening, (ft)
- A_g = clear area of opening, (ft^2)
- d_i = depth at lip of curb-opening, (ft)
- h = height of curb-opening orifice, (ft)
- g = gravitational constant (32.2 ft/s^2)

The height of the orifice in equations 4.25a and 4.25b assumes a vertical orifice opening. As illustrated in the adjacent figure, other orifice throat locations can change the effective depth on the orifice and the dimension (d_j – h/2). A limited throat width could reduce the capacity of the curb-opening inlet by causing the inlet to go into orifice flow at depths less than the height of the opening.

For curb-opening inlets with other than vertical faces, equation 4.25a can be used with:

- h = orifice throat width, (ft)
- d_o = effective head on the center of the orifice throat, (ft)

Chart 10 in Appendix 4 provides solutions for equations 4.22 and 4.25 for depressed curb-opening inlets, and Chart 11 in Appendix 4 provides solutions for equations 4.24 and 4.25 for curb-opening inlets without depression. Chart 12 in Appendix 4 is provided for use for curb openings with other than vertical orifice openings.

4.5.3.3 Combination Inlets

Combination inlets consisting of a grate and a curb opening are considered advisable for use in sags where hazardous ponding can occur. Equal length inlets refer to a grate inlet placed along side a curb-opening inlet, both of which have the same length. A sweeper inlet refers to a grate inlet placed at the downstream end of a curb-opening inlet. The curb-opening inlet is longer than the grate inlet and intercepts the flow before the flow reaches the grate. The sweeper inlet is more efficient than the equal length combination inlet and the curb-opening has the ability to intercept any debris which may clog the grate inlet. The interception capacity of the equal length combination inlet is essentially equal to that of a grate alone in weir flow. In orifice flow, the capacity of the equal combination inlet is equal to the capacity of the grate plus the capacity of the curb-opening.

Equation 4.20 and Chart 9 in Appendix 4 can be used for grates in weir flow or combination inlets in sag locations. Assuming complete clogging of the grate, equations 4.22, 4.23, and 4.24 and Charts 10, 11, and 12 in Appendix 4 for curb-opening inlets are applicable.

Where depth at the curb is such that orifice flow occurs, the interception capacity of the inlet is computed by adding equations 4.21 and 4.24a as follows:

$$Q_j = 0.67\ A_g\ (2\ g\ d)^{0.5} + 0.67\ h\ L\ (2\ g\ d_o)^{0.5} \qquad (4.26)$$

Where:

- A_g = clear area of the grate, (ft^2)
- g = gravitational constant (ft/s^2)
- d = average depth over the grate, (ft)
- h = height of curb-opening orifice (ft)
- L = length of curb-opening, (ft)
- d_o = effective depth at the center of the curb opening orifice, (ft)

Trial and error solutions are necessary for determining the depth at the curb for a given flow rate using Charts 9, 10, and 11 in Appendix 4 for orifice flow. Different assumptions for clogging of the grate can also be examined using these charts.

4.5.4 Inlet Locations

4.5.4.1 Geometric Controls

There are a number of locations where inlets may be necessary with little regard to contributing drainage area. These locations should be marked on the plans prior to any computations regarding discharge, water spread, inlet capacity, or flow bypass. Examples of such locations follow.

- At all low points in the gutter grade
- Immediately upstream of median breaks, entrance/exit ramp gores, cross walks, and street intersections., i.e., at any location where water could flow onto the traveled way
- Immediately upgrade of bridges (to prevent pavement drainage from flowing onto bridge decks)
- Immediately downstream of bridges (to intercept bridge deck drainage)
- Immediately up grade of cross slope reversals
- Immediately up grade from pedestrian cross walks
- At the end of channels in cut sections
- On side streets immediately up grade from intersections
- Behind curbs, shoulders or sidewalks to drain low area

In addition to the areas identified above, runoff from areas draining towards the highway pavement should be intercepted by roadside channels or inlets before it reaches the roadway. This applies to drainage from cut slopes, side streets, and other areas alongside the pavement. Curbed pavement sections and pavement drainage inlets are inefficient means for handling extraneous drainage.

4.5.4.2 Inlet Spacing on Continuous Grades

Design spread is the criterion used for locating storm drain inlets between those required by geometric or other controls. The interception capacity of the upstream inlet will define the initial spread. As flow is contributed to the gutter section in the downstream direction, spread increases. The next downstream inlet is located at the point where the spread in the gutter reaches the design spread. Therefore, the spacing of inlets on a continuous grade is a function of the amount of upstream bypass flow, the tributary drainage area, and the gutter geometry. However, the inlets shall not be spaced any more than 600 feet apart.

For a continuous slope, the designer may establish the uniform design spacing between inlets of a given design if the drainage area consists of pavement only or has reasonably uniform runoff characteristics and is rectangular in shape. In this case, the time of concentration is assumed to be the same for all inlets.

4.6 HYDRAULIC DESIGN OF CLOSED CONDUITS

All closed conduits shall be hydraulically designed through the application of Manning's Equation, (non critical flows) expressed as follows:

$$Q = A\ V \tag{4.27}$$

$$Q = \frac{1.486}{n}\ AR^{2/3}\ \ S_f^{1/2} \tag{4.28}$$

$$R = \frac{A}{P} \tag{4.29}$$

- "Q" is the flow (ft^3/s);
- "A" is the cross sectional area, (ft^2);
- "V" is the velocity of flow in the conduit, (ft/s);
- "n" is the roughness coefficient of the conduit (see Table 2, Appendix 1);
- "R" is the hydraulic radius which is the area of flow divided by the wetted perimeter, (ft);
- "S_f" is the channel slope of the conduit in (ft/ft);
- "P" is the wetted perimeter, (ft).

4.6.1 Velocity in Closed Conduits

Storm sewers should operate within certain velocity limits to prevent excessive deposition of solids due to low velocities, and to prevent invert erosion and undesirable and hazardous outlet conditions due to excessively high velocity. A minimum velocity of 2.5 feet per second and a maximum velocity of 15 feet per second shall be observed. In extreme conditions where the maximum velocity must be exceeded, prior approval must be obtained from the City Engineer.

4.6.2 Roughness Coefficients for Closed Conduits

Roughness coefficients are directly related to construction procedures. When alignment is poor and joints have not been properly assembled, extreme head losses will occur.

Coefficients used in this matter are related to construction procedures, and assume that the pipe will be manufactured with a consistently smooth surface. The minimum roughness coefficient allowed for closed conduit shall be 0.013 regardless of material composition

Minor Head Losses in Closed Conduits

Head losses at structures shall be determined for manholes, junction boxes, wye branches, bends, curves and changes in pipe sizes in the design of closed conduits. Minimum head loss used at any structure shall be 0.10 foot. Properly designed curves may have zero losses.

A. Head losses and gains for wyes and pipe size changes will be calculated by the following formulas:

Where $V_1 < V_2$:

$$\frac{V_2^2}{2g} - \frac{V_1^2}{2g} = HL$$

Where $V_1 > V_2$:

$$\frac{V_2^2}{4g} - \frac{V_1^2}{4g} = HL \qquad (4.30)$$

and V_1 is upstream velocity and V_2 is downstream velocity. It should be noted that new storm sewer design shall be designed where the receiving pipe velocity increases going downstream. Otherwise a hydraulic jump may occur. Deviations to this requirement shall be handled on a case by case basis by the City Engineer.

B. Head losses and gains for manholes, bends, curves and junction boxes will be calculated as shown in Table 5A and Table 5B in Appendix 1.

1) The basic equation for most cases where there is both upstream and downstream velocity, takes the form as set forth below with the various conditions of the coefficient "Kj" shown in Table 5A in Appendix 1..

$$hj = \frac{V_2^2}{2g} - Kj \frac{V_1^2}{2g} \qquad (4.31)$$

- "hj" is the junction or structure head loss, (ft);
- "V_1" is the velocity in upstream pipe, (ft/s);
- "V_2" is the velocity in downstream pipe, (ft/s);
- "Kj" is the junction or structure coefficient of loss (Table 5A, Appendix 1)

2) In the case where the inlet is at the very beginning of a line, or the line is laid with bends or obstructions, the equation is revised as follows, without any approach velocity.

$$hj = Kj \frac{V_2^{\,2}}{2g} \tag{4.32}$$

5.0 OPEN CHANNELS

5.1 General

Channel design involves the determination of a channel cross-section required to convey a given design flow. The method outlined in the section 9 titled "Floodplain Guidelines" of this manual explains the guidelines for the analysis of an existing channel. This section describes the criteria for the design of proposed channels. The minimum slope for all proposed channels shall be 0.5% unless otherwise indicated by the City of Arkadelphia.

The hydraulic characteristics of improved channels are to be determined through the application of Manning's Equation. In lieu of Manning's Equation, HEC-RAS can be used to determine the water surface profile. The City, at its option, can require the use of the HEC-RAS Computer Program. The HEC-RAS Computer Program is available from the U.S. Army Corps of Engineers, Hydrologic Engineering Center, 609 Second Street, Davis, California 95616; or it can be downloaded from their website at www.hec.usace.army.mil/.

The proposed channel shall be designed to carry the 25-year fully urbanized flows plus one foot of freeboard.

A dedicated drainage easement shall be provided to the city for open channels. The easement width shall be the width of the channel from bank edge to bank edge plus an additional fifteen foot access easement on one side of the channel for maintenance access, minimum 20 feet.

5.2 Cross Sections

Figure 2 in Appendix 2 contains typical sections that are to be used in the design of open channels. Due to recent changes in the environmental permitting process, few if any concrete lined channels are being constructed. Although concrete lined channels are hydraulically quite efficient, the Design Engineer is reminded that it may be extremely difficult to obtain the proper permits from the State and Federal authorities. Also, developers are responsible for acquisition of all regulatory agency permits. The developer shall also be responsible for the initial (one time) channel modifications, to include the replacement of trees at the direction of the City of Arkadelphia, and as required by State and Federal agencies. Initial (one time) clearing of debris, small trees, brush, vines, etc. from floodways and floodplains of channels shall be the responsibility of the developer as allowed by the current permitting requirements. In addition, the developer may dedicate the floodway and/or floodplain as a deed-restricted greenbelt area.

All improved channels shall be designed to carry the 25-year flow plus one foot of freeboard, based on the fully urbanized development for each watershed. Adjacent building structures finish floor elevations shall be at least one foot above the 100-year water surface elevation.

Unlined improved channels that contain bends shall be designed such that erosion at the bends is minimized. Erosion protection at bends shall be determined based on the velocity along the outside of the channel bend. Unlined improved channels shall have side slopes no steeper than 4:1 and lined channels shall have side slopes no steeper than 2:1, unless authorized by the City Engineer. A soil analysis shall be performed to determine maximum slope that the soil at the channel improvement site will sustain without failure.

Roadside ditches shall be designed to carry the 25-year frequency runoff below the roadway elevation. The 100-year flood runoff shall remain within the right-of-way.

5.3 Roughness Coefficients

The roughness coefficients that are to be used are shown in Table 4A and Table 4B in Appendix 1. Variations from that which is shown must be approved by the City Engineer.

5.4 Velocity Requirements

Likewise the velocity limits for open-channel flow are given in Table 4A and Table 4B in Appendix 1. The creeks for which the velocity exceeds these limits will have to be protected by some sort of erosion protection or energy dissipater. Otherwise, variations will have to be approved by the City Engineer.

5.5 Channel Drop Structures

The function of a drop structure is to reduce channel velocities by allowing flatter upstream and downstream channel slopes. Sloping channel drops and vertical channel drops are two commonly used drop structures.

The flow velocities in the channel upstream and downstream of the drop structure need to satisfy the permissible velocities allowed for channels (Table 4). The velocities shall be checked for flows produced by the 10-, 50- and 100-year frequency events.

An apron shall be constructed immediately upstream of the chute or stilling basin to protect against the increasing velocities and turbulence which result as the water approaches the drop structure. The apron shall extend at least five (5') feet upstream of the point where flow becomes supercritical. In no case shall the length of the upstream apron be less than ten (10') feet.

An apron shall be constructed immediately downstream of the chute or stilling basin to protect against erosion due to the occurrence of the hydraulic jump. The apron shall extend a minimum of ten (10) feet beyond the anticipated location of the hydraulic jump.

The design of drop structures is based on the height of the drop, the normal depths upstream and downstream of the drop structure and discharge.

When used, channel drop structures shall be located near bridges or culverts, as directed by the City Engineer.

5.5.1 Vertical Drop Structures

The approximate height of the drop required to stabilize the hydraulic jump should be determined.

The drop length and the hydraulic jump length of the drop structure should be calculated to determine the length of the downstream apron required to prevent erosion.

5.5.2 Sloping Drop Structures

The location of the hydraulic jump should be determined based on the upstream and downstream flow depths and channel slopes.

The length of the hydraulic jump should be calculated to determine the length of the downstream apron required to prevent erosion.

5.6 Maintenance Access

Access roads shall be provided for the city to all channels to allow for maintenance. The developer shall provide a point of access from the improvement to the channel. Access roads shall have a width of at least ten (10) feet, cross slope no greater 0.02 ft/ft, and longitudinal slope not exceeding 0.12 ft/ft. The access road shall be constructed of six inches of Class 7 Base Course in accordance with Section 303 of the Arkansas State Highway and Transportation Department Standard Specifications for Highway Construction,

The improvement shall contain an access ramps into the channel. The access ramp shall be at least ten (10) feet wide and shall have a vertical grade no steeper than 6:1. The access ramps shall be placed at a minimum of every ¼ mile per development and should be located within a dedicated drainage easement.

For all channels within a floodplain, designated by FEMA, an access road shall be provided along the entire channel length. If the channel depth exceeds four (4) feet an access road will be required on both sides of the channel.

Specific guidelines on the computation of the water surface profile for the existing or proposed channels can be found in the "Floodplain Guidelines" section of this report.

6.0 CULVERTS

6.1 General

The design theory outlined herein is a modification of the method used in the hydraulic design of concrete box and pipe culverts, as discussed in the Federal Highway Administration's Hydraulic Design Series Number 5 titled "Hydraulic Design of Highway Culverts".

The hydraulic capacity of culverts is computed using various factors and formulas. Laboratory tests and field observations indicate that culvert flow may be controlled either at the inlet or outlet. Inlet control involves the culvert cross-sectional area, the ponding of headwater at the entrance, and the inlet geometry. Outlet control involves the tailwater elevation in the outlet channel, the slope of the culvert, the roughness of the surface and length of the culvert barrel.

Channel modifications must comply with Section 5 and Section 9 of this manual and meet FEMA requirements.

Provide one foot of freeboard between the headwater and tailwater surface elevation and the roadway.

6.2 Culverts Flowing with Inlet Control

Inlet control means that the discharge capacity of a culvert is controlled at the culvert entrance by the depth of the headwater and entrance geometry, including the barrel shape and cross- sectional area, and the type of inlet edge.

Nomographs for determining culvert capacity for inlet control are shown in Appendix 5. These nomographs were developed by the Division of Hydraulic Research, Bureau of Public Roads, from analysis of laboratory research reported in the National Bureau of Standards Report No. 444, entitled "*Hydraulic Characteristics of Commonly Used Pipe Entrances*", by John L. French, and "*Hydraulics of Conventional Highway Culverts*" by H. G. Bossy. Experimental data for box culverts with headwalls and wingwalls were obtained from an unpublished report of the U.S. Geological Survey.

6.3 Culverts Flowing with Outlet Control

The culvert is designed so that the depth of headwater, which is the vertical distance from the upstream culvert flow line to the elevation of the ponded water surface, does not encroach on the allowable freeboard during the design storm.

Headwater depth, HW, can be expressed by a common equation for all outlet control conditions:

$$HW = H + h_O - L\,(S_O) \qquad (6.1)$$

- "HW" headwater depth in feet from the flow line of the culvet, (ft);
- "H" head or energy required to pass a given discharge through a culvert, (ft);

- "h_O" vertical distance from the downstream culvert flow line to the elevation from which H is measured, (ft)
- "L" length of culvert, (ft);
- "S_O" culvert barrel slope, (ft).

The head, H, is made up of three parts, including the velocity head, exist loss (H_V) and entrance loss (H_e), and a friction loss (H_f). This energy is obtained from the ponding of water at the entrance and is expressed as:

$$H = H_V + H_e + H_f \qquad (6.2)$$

- "H" is head or energy in feet of water;
- H_V" is $\frac{V^2}{2g}$ where V is average velocity in culvert or $\frac{Q}{A}$;
- "H_e" is $K_e \frac{V^2}{2g}$ where K entrance loss coefficient (Table 8, Appendix 1);
- "H_f" is the energy required to overcome the friction of the culvert barrel and expressed as:

$$H_f = \left[\frac{29.2n^2 L}{R^{1.33}}\right] \frac{V^2}{2g} \qquad (6.3)$$

Where:

- n coefficient of roughness (see Table 4);
- L length of culvert barrel, (ft);
- V average velocity in the culvert, (ft/s);
- g gravitational acceleration (32.2 ft/s^2);
- R hydraulic radius (Area / Wetted Perimter, ft).

Substituting into the previous equation:

$$H = \frac{V^2}{2g} + K_e \frac{V^2}{2g} + \left[\frac{29.2n^2 L}{R^{1.33}}\right] \frac{V^2}{2g} \qquad (6.4)$$

and simplifying:

$$H - \left[1 + K_e + \frac{29.2n^2 L}{R^{1.33}}\right] \left[\frac{V^2}{2g}\right] \text{ for full flow.} \qquad (6.5)$$

For various conditions of outlet control flow, h_O is calculated differently. When the elevation of the water surface in the outlet channel is equal to or above the elevation of the top of the culvert opening at the outlet, h_O is equal to the tailwater depth or:

$$h_O = TW$$

If the tailwater elevation is below the top of the culvert opening at the outlet, h_O is the greater of two values: (1) Tailwater, TW, as defined above, or (2) $(d_C + D)/2$, where d_C = critical depth. The critical depth, d_C, for box culverts may be obtained from Appendix 4 or may be calculated from the formula:

$$d_C = 0.315\left[\frac{Q}{B}\right]^{2/3} \tag{6.6}$$

- dc - critical depth for box culvert, (ft);
- Q - discharge, (ft^3/s);
- "B" - bottom width of box culvert, (ft).

- The critical depth for circular pipes may be obtained from Appendix 5, or may be calculated by trial and error. Charts developed by the Bureau of Public Roads may be used for determining the critical depth. Utilize values of D, A and d_C, which will satisfy the equation:

$$\frac{Q^2}{g} = \frac{A^3}{D} \tag{6.7}$$

- "d_C" is the critical depth for culvert, (ft);
- Q is the discharge, (ft^3/s);
- g is the gravitational constant (32.2 ft/s^2);
- A is the cross-sectional area, (ft^2).

The equation is also applicable for trapezoidal or irregular channels, in which instances "D" becomes the channel top width in feet.

7.0 BRIDGES

Once a design discharge and depth of flow have been established, the size of the bridge opening may be determined. The bridge opening shall be designed so that it is in compliance with Section 5 and Section 9.0 of this manual and meets all FEMA requirements.

The basic hydraulic calculations involved in the hydraulic design involve solution of the following:

$$V = \frac{Q}{A} \qquad (7.1)$$

- "V" is the average velocity through the bridge, (ft/s);
- "Q" is the flow (ft^3/s)
- "A" is the actual flow area, (ft^2).

$$h_f = K_b \frac{V^2}{2g} \qquad (7.2)$$

- "h_f" is the head loss through the bridge in feet;
- "K_b" is a head loss coefficient (Normally .2 to .5);
- "V" is the average velocity through the bridge in feet per second;
- "g" is the gravitational acceleration (32.2 feet per second per second).

As can be seen from the above, the loss of head through the bridge is a function of the velocity head. This methodology is based on a bridge opening with no piers.

Even though the principle fundamental theory is shown above for a simple crossing, the bridge opening shall designed utilizing the latest version of HEC-RAS computer software. The HEC-RAS Computer Program is available from the U.S. Army Corps of Engineers, Hydrologic Engineering Center, 609 Second Street, Davis, California 95616; or it can be downloaded from their website at www.hec.usace.army.mil/.

Input and output data from the software shall be included within the storm drainage calculations as required by Section 2 of this manual.

8.0 DETENTION POND DESIGN

8.1 General

Storm water runoff and the velocity of discharge are considerably increased through development and growth of the City. Prior to the development of land, surface conditions provide a high percentage of permeability and longer time of concentration. With the construction of buildings, parking lots, and subdivisions, permeability and the time of concentration are significantly decreased. These modifications may create harmful effects on properties downstream.

The intent of detention pond design in the City of Arkadelphia storm water management policy is to control flood discharges for ultimate fully urbanized watershed development conditions without increasing peak discharges above the peak discharges for natural watershed or pre-development conditions.

8.2 Applicable Design Criteria

Preservation of existing floodplains along the major creeks shall be strongly encouraged; therefore, regional detention/retention ponds may be used to maintain the natural floodplain environment. On-site detention/retention ponds may be allowed for developments, and in such cases, the detention/retention pond shall be a minimum size of one acre, where feasible, to allow for proper maintenance, side slopes and outlet work operation. Detailed engineering studies of the entire watershed basin shall be required to evaluate the timing of hydrographs from regional and on-site facilities.

All detention pond designs shall be performed by an engineer registered in the State of Arkansas. The following criteria shall serve as minimum requirements for detention pond design:

Storage will be required for any commercial development of one acre or more in size. In addition, storage will be required for any parking lot containing 5,000 square feet of paved surface. The requirement can be satisfied by providing an off-site storage facility.

8.3 Methodology

Criteria for differential runoff and detention guidelines are set out below to attempt to decrease the possible effects of development on downstream properties due to increased runoff.

Differential runoff evaluation consists of determination of rates of runoff before and after development, determination of required volume of detention and verification of adequacy of discharge and control structures.

8.3.1 Differential Runoff Rates

Differential runoff rates shall be evaluated by the rational formula. Differential runoff rates shall be evaluated by equation:

$$R = (Rd - Ru) \tag{8.1}$$

Where R = differential runoff rate
Rd = C .I. factor for developed conditions
Ru = C.I. factor for undeveloped conditions
Determine " C" value (Table 1, Appendix 1).

Use Figure 1, Appendix 2 to find time of concentration and determine intensity (I).

8.3.2 Volume of Detention

Volumes of detention shall be evaluated according to the following methods:

A. Volume of detention for projects of less than 50 acres shall be evaluated by the "simplified volume formula."

B. Volume of detention for projects 50 acres or greater but less than 300 acres may be evaluated either by the "unite hydrograph method".

C. For projects larger than 300 acres, the developer shall submit his proposed method of evaluation for the sizing of the retention basin or detention basin to the City of Arkadelphia. The method will be evaluated for a professional acceptance, applicability and reliability. No detail review for projects larger than 300 acres will be rendered before the method of evaluation of the retention or detention basin is approved.

D. Other analytical methods of evaluation of volume of detention require approval by the City of Arkadelphia.

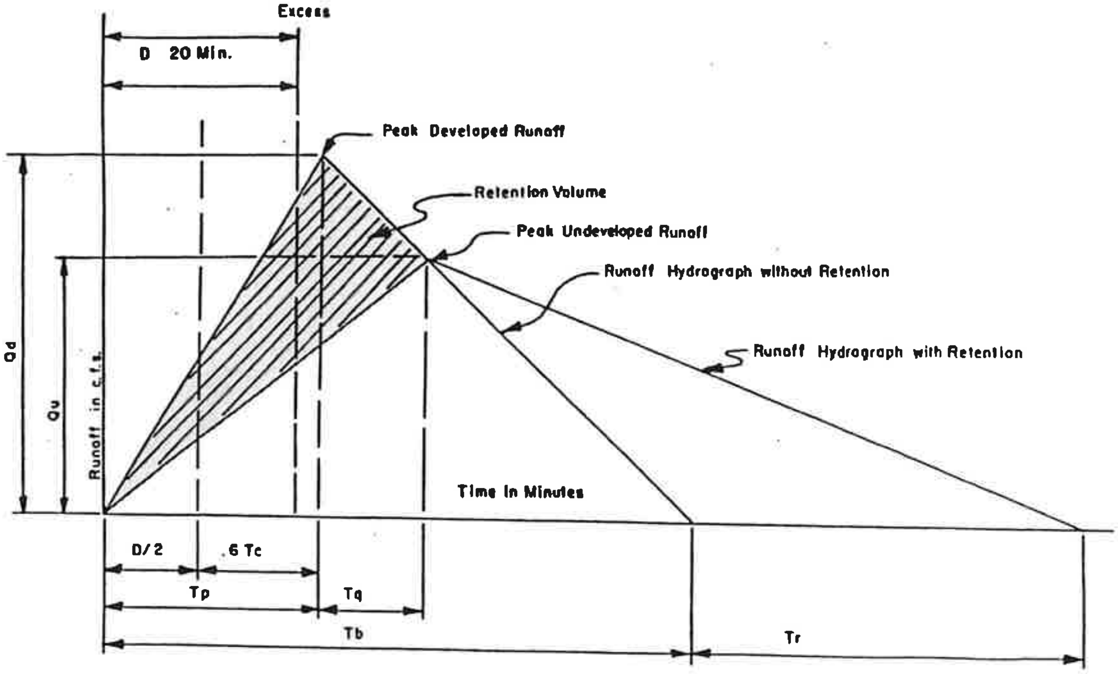
8.3.3 Simplified Volume Formula

Total volume of detention shall be computed by the equation:

$$V = R \times A \times T_c \text{ (minutes) } \times 60 \text{ (sec./min.)} \tag{8.2}$$

- V = Total volume of retention
- R = Differential runoff rate
- A = Area of the project and the acres
- T_c = Time of concentration from Figure 1, Appendix 2.

8.3.3.1 Graphic Representation



For purpose of further analysis, the simplified volume formula may be represented by a triangular synthetic hydrograph as shown in Figure 8.3 with the following elements:

- T_d = base time of hydrograph for developed project without retention
- T_d = 60 minutes
- T_p = Time of peak runoff for developed project
- T_p = 20 minutes
- Q_d = total peak runoff for developed project, (ft^3/s)
- Q_d = A x RD (see 8.1)
- Q_u = total peak runoff of unimproved project in (ft^3/s)
- Q_u = A x Ru (see 8.1)
- A = Total Area of Project, (Acres)
- T_Q = Assumed time of peak differential for unimproved project
- T_r = Assumed precedent recedence time differential for discharge at rates no greater than unimproved condition
- $T_r = (60\ Q_d/Q_u) - 60$
- V = Volume of detention
- $V = (Q_d - Q_u)$ x 39 (min.) x 60 (sec./min.)

8.3.4 Modified Rational Hydrograph Method

This is a modification of the Unit Hydrograph Method of hydrologic evaluation simplified to reflect features of present practice and some elements of topographic characteristics, concentration patterns, and routing. Figure 5-1 illustrated the elements of the modified hydrograph. Steps to develop the hydrograph are as follows:

1. Determine the time of concentration for the project by the use of Figure 1, Appendix 2.

   For analysis of large improved channels, time of travel for overland flow and channel are to be analyzed to determine reasonable (T_c) time of concentration.

2. Determine time of peaking by equation:

   $$T_p = D/2 + .6\,T_c$$

   Where T_c = time of peak discharge of developed project in minutes

   D = 20 min. – storm duration in minutes

3. Determine the base time of the hydrograph without detention, by equation.

4. Determine the base time of the hydrograph with detention by equation.

   $$T_r = T_b\,(\,(Q_d/Q_u) - 1)$$

   Where T_r = Additional time required for discharged at a rate no greater than that of the undeveloped condition.

   Q_d = total peak runoff of the improved project, (ft^3/s)

   Q_d = A x RD (see 8.1)

   Q_u = total runoff of unimproved project, (ft^3/s)

   Q_u = A x R_u (see 8.1)

5. Determine the required volume of detention by equation:

   $$V = \tfrac{1}{2}\,(Q_d - Q_u)\;T_b \times 60$$

The simplified approach shown above is for use with a single watershed within a development. Complex, multiple, watersheds within a development, where the contributing drainage areas are larger than 300 acres, a software program to determine the unit hydrograph and flows should be used to route the inflow hydrograph through the watersheds to the storage area. The Corp's of Engineers HEC-HMS software is the preferred method for this routing, however, other programs can be used with the approval from the City of Arkadelphia.

8.4 Design Requirements

Detention facilities shall be located within the parcel limits of the project under consideration. No detention or ponding will be permitted within public road right-of-ways. Location of detention facilities immediately upstream or downstream of the project will be considered by special request if proper documentation is submitted with reference to practicality, feasibility, and proof of ownership or right-of-use of the area proposed. Conditions for general location of detention facilities are identified in the following sections.

Analysis of all elements of design is always performed by the engineer of record. The following outline is provided to ascertain that certain critical elements of design are in workable compliance to the aims of design. For all projects submit routing calculations of tabulated proof of adequacy for tributary runoff or detention, it is recommended that verification be made of: (a) volume of detention for the total project, (b) tributary (Q) peak runoff to the basin, (c) balance maximum outflow rate from the low-flow structure, (d) ratios of in flow to out flow rates, (e) detention dikes or dams, (g) safety features, (h) maintenance features.

In addition, routing calculations, (projects greater than 50 but less than 300 acres) shall be submitted in legible tabulated form. Proof of adequacy of volume of detention and sizing computations for low-flow structure shall also be submitted. Features of stability and safety may also need to be documented if the scope of the project requires special attention in this area of design.

Projects over 300 acres in area shall provide documented verification of adequacy according to scope and complexity of design.

8.4.1 Dry Reservoirs

Wet weather ponds or dry reservoirs shall be designed with proper safety, stability, and ease of maintenance facilities, and shall not exceed four (4) feet in depth. Maximum side slopes for grass reservoirs shall not exceed maximum side slopes for grass reservoirs shall not exceed one (1) foot vertical for three (3) feet horizontal (3:1) unless adequate measures are included to provide for the above noted features. In no case shall the limits of maximum water surface elevation be closer than thirty (30) feet horizontally from any building and less than one (1) foot vertically below the lowest sill or floor elevation.

The entire reservoir area shall be seeded, fertilized, mulched, sodded or paved as required prior to final plat approval or issuance of certificate of occupancy. Overflow areas shall be protected against erosive velocities.

8.4.2 Open Channels

Normally permitted open channels may be used as detention areas provided that the limits of the maximum design water surface elevation are not closer than thirty (30) feet horizontally from any buildings, and less than one (1) foot below the lowest sill or floor elevation of any building. No detention will be permitted within public road rights-of-way unless approval is given by the City of Arkadelphia. Maximum depth of retention and open channels shall be four (4) feet. Minimum flow line grade shall be 0.5 percent for grass or untreated bottoms or 0.3 percent for paved channels.

For trapezoidal sections, the maximum side slopes of the detention of the channel shall not exceed one (1) foot vertical for three (3) feet horizontal (3:1). For design of stability, and ease of maintenance shall be observed by the design engineer.

The entire reservoir area of the open channel shall be seeded, fertilized, mulched, sodded or paved as required in elevations resulting from channel detention shall not adversely effect adjoining properties.

8.4.3 Permanent Lakes

Permanent lakes with fluctuating volume controls may be used as retention areas provided that the limits of the maximum water surface elevation are no closer than thirty (30) feet horizontal from any building and less than one (1) foot below the lowest sill or floor elevation of any building.

Maximum side slopes for the fluctuating area of permanent lakes shall be one (1) foot vertical to three (3) feet horizontal (3:1) unless provisions are included for safety, stability, and ease of maintenance.

Suggested maximum fluctuation from permanent pool elevations to maximum water surface elevation shall be three (3) feet. Each design has its own particular parameters in relation to the adjoining topography.

Special consideration is suggested to safety and accessibility to small children in design of permanent lakes in residential areas. It is suggested that the minimum of twenty-five percent (25%) of the permanent pool area be no less than 10 feet. Allowances for silting under denuded soil conditions (during construction) for a period no less than one year is also recommended.

The entire fluctuating area of the permanent reservoir shall be seeded, fertilized and mulched, sodded or paved. Any area susceptible to or designed as overflow by higher design intensity rainfall (100-year frequency) shall be sodded or paved, depending on the design velocities.

An analysis shall be furnished of any proposed earthen dam construction soil. A boring of the foundation for the earthen dam may be requested by the City of Arkadelphia. Earthen dam structures shall be designed by a licensed Professional Engineer in the state of Arkansas.

8.4.4 Parking Lots

Detention is permitted in parking lots to maximum depths of 6 inches. In no case should the maximum limits or storage be designed closer than ten (10) feet from a building unless waterproofing of the building and pedestrian accessibility are properly documented and approved.

The minimum freeboard and the maximum design water surface elevation to the lowest sill or floor elevation shall be one (1) foot.

8.4.5 Control Structures

The 100-year frequency storm is to be used to determine the volume of detention storage required. In addition, the outlet structure shall be designed such that peak discharges for the fully urbanized development are not increased for the pre-developed storm frequencies of the 5-year, 10 year, 25 year, 50 year, and 100-year storm event.

Detention facilities shall be provided with obvious and effective control structures. Plan view and sections of the structure with adequate details shall be included in plans.

The maximum discharge shall be designed to take place under total anticipated design-head conditions.

Sizing of the low-flow pipe shall be by inlet control or hydrologic control or hydrologic gradient requirements. Low-flow pipes shall not be smaller than twelve (12) inches in diameter to minimize maintenance and operating problems except in parking lot and roof retention where minimum size of openings shall be designed specifically for each condition. A bar-screen on a minimum 3:1 slope to reduce blockage by debris is suggested on the flow-pipe.

An emergency spillway or overflow area shall be provided at the maximum 100-year pool level. Where the outflow structure conveys flow through the embankment in a conduit, the conduit shall be reinforced concrete designed to support the external loads. The conduit is to withstand the internal hydraulic pressure without leakage under full external load or settlement, and must convey water at the design velocity without damage to the interior surface of the conduit.

The outflow structure shall discharge flows into the natural stream or unlined channels at a non-erosive rate in accordance with the requirements of this design manual.

Earth embankments used to impound required detention volume shall be constructed according to specifications for fill and shall be based on a Geotechnical investigation for the site. The Geotechnical investigation shall be performed by a registered Professional Engineer in the state of Arkansas, with an emphasis in geotechnical analysis and shall include, as a minimum, the type of material on-site, water content, liquid limit, plasticity index and desired compaction.

8.5 Maintenance

Detention facilities, when mandatory, are to be built in conjunction with storm sewer installation and/or grading. Since these facilities are intended to control increased runoff, they must be partially or fully operational soon after the clearing of the vegetation. Silt and debris connected with early construction shall be removed periodically from the detention area and control structure in order to maintain a close to full storage capacity.

Maintenance of detention facilities is divided into two components. The first is long-term maintenance which involves removal of sediment from the basin and outlet control structure. Maintenance to an outlet structure is minimal due toe initial design of permanent concrete or pipe structures. Studies indicate that in developing areas, to be needed once every 5 to 10 years. The City is responsible for long-term maintenance.

Short-term maintenance or annual maintenance is the second component and is the responsibility of the property owner or association. The items considered short-term maintenance are as follows:

1. Minor dirt and mud removal
2. Outlet cleaning
3. Mowing
4. Herbicide spraying
5. Litter Control

The responsibility of all maintenance of the detention facilities and subdivision projects shall remain with the developer until the project has been approved for final platting. Upon final plat approval, the short-term maintenance responsibility shall be vested in the trustees indenture of trusts shall clearly indicate resident responsibility for maintenance in cases of projects without common ground.

The responsibility of maintenance of the retention facilities and single lot development projects shall remain with the general contractor until final inspection of the development is performed and approved, and a legal occupancy of the project, the maintenance of detention facilities shall be bested with the owner of the project.

If the trustees or owner fail to provide reasonable degree of maintenance and the facilities become inoperable or ineffective, as determined by the City of Arkadelphia, remedial work will be performed by the City of Arkadelphia and assess the trustees or owner for the cost of repair and maintenance.

Access must be provided for maintenance in detention basin design for periodic desilting and debris removal. Basins with permanent storage must include dewatering facilities to provide for maintenance. Detention basins with a drainage area of 300 acres or more must include a desilting basin in the upstream pool area.

Security fencing with a minimum height of 6 feet shall encompass the detention storage area if the velocity, depth, or slopes create a potentially dangerous condition as determined by the City Engineer. The fence shall be designed so as to allow access for maintenance and so as not to restrict storm water flow into or out of the detention basin.

A maintenance equipment access ramp shall be provided. The slope of the ramp shall not exceed 6:1 and the minimum width shall be 10 feet.

8.5.1 Easements

Two types of easements shall be provided in plans for detention facilities:

A. Maintenance Easement:

All detention reservoirs with the exception of parking lot and roof detention shall be enclosed by a maintenance easement for public use. The limits of the easement shall extend ten (10) feet beyond the maximum anticipated flooding area.

B. Drainage Easement:

A minimum ten (15) foot wide drainage easement shall be provided within the reservoir area, connecting the tributary pipes and the discharge system for possible future elimination of detention.

8.6 Calculations

Computations performed for detention pond sizing shall be submitted in a format consistent with Form 6 in Appendix 3.

9.0 FLOODPLAIN GUIDELINES

9.1 General

The purpose of this section is to give guidelines on the modifications and management of the floodplains within the City of Arkadelphia. The requirements given here apply to the study of existing water courses and the definition of the associated floodplains. Any variances to these requirements must be reviewed and approved by the City of Arkadelphia.

9.2 General Guidelines

Any developer or individual that wishes to modify a floodplain, be it 100-year or some other frequency, or floodway, must prepare and submit to the City of Arkadelphia a report that explains the nature of this modification. This report must be based on the fully-urbanized 100-year floodplain. This report needs to be reviewed and approved by the City Engineer before the modifications can take place. This report shall include the revised mapped 100-year fully-urbanized floodplain. It shall also include any revised hydrology that has been computed.

In addition, anyone wishing to modify the floodplain or floodway must comply with all of the regulations set forth in the National Flood Insurance Program (NFIP). That is to say, a Letter of Map Revision must be submitted to the Federal Emergency Management Agency, to incorporate changes to the floodplain. In some cases a Conditional Letter of Map Revision may be required prior to construction. All of FEMA's requirements regarding LOMR's and CLOMR's must be met.

In order for the construction plans to be approved by the City there must be one (1) foot of freeboard between the 100-year fully-urbanized water surface elevation and the adjacent finish floors of any structure.

There shall not be any rise in the floodplain or floodway base flood water surface elevation. Encroachment shall be limited to the floodplain fringe. Floodway encroachment will not be permitted. Construction within or modification to the floodplain or floodway will only be permitted if FEMA requirements are met and the base flood water surface elevation is not modified. In addition the modifications within the floodplain or floodway must maintain the pre-developed storage capacity of the floodplain.

9.3 Hydrology

Any hydrologic study performed within the City of Arkadelphia must comply with the guidelines set forth in this manual. This includes submitting to the City a hydrologic work map that includes watershed boundaries, and all other hydrologic parameters.

9.3.1 Rational Method

For areas less than 300 acres, the rational method can be used to compute runoff. This method is described in Section 3 of this manual. Table 1 in Appendix 1, shows typical values for C-factors and shows some typical values for the inlet time. The intensity-duration-frequency curve for Arkadelphia is included in Figure 1, Appendix 2.

9.3.2 Unit Hydrograph Method

For areas greater than 300 acres the Snyder's Unit Hydrograph Method is to be used. Section 3 of this manual details the computational procedure for this method.

Complex, multiple, watersheds within a development, where the contributing drainage areas are larger than 300 acres, a software program to determine the unit hydrograph and flows should be used to route the inflow hydrograph through the watersheds to the storage area. The Corp's of Engineers HEC-HMS software is the preferred method for this routing, however, other programs can be used with the approval from the City of Arkadelphia.

9.4 Hydraulics

Any modification to a floodplain within the City of Arkadelphia requires a hydraulic study, performed by a Professional Engineer licensed in the State of Arkansas, to determine the floodplain elevations. All hydraulic studies along water courses must comply with FEMA's guidelines; however, there are a few additional requirements that must be met before the flood study is approved and modifications of the floodplain is allowed.

First of all, the flood study should map the 100-year fully developed floodplain boundary. Lots and other substantial structures adjacent to the watercourse must be constructed one (1) foot above the 100-year fully urbanized water surface elevation. In addition, a Letter of Map Revision Request is required for all developments that modifies the floodplain. A conditional Letter of Map Revision is required only in those instances that FEMA requires one. All other FEMA guidelines must be met.

The Corps of Engineers HEC-RAS computer program shall be used to compute the water surface elevation. To do so, cross sections along the watercourse must be surveyed no greater than 400 ft. apart for tangent sections of channel and no greater than 200 ft. apart for curvilinear sections of channel unless otherwise approved by the City of Arkadelphia. Roughness values shall be determined based on the table in Table 4, Appendix 1. A printout of the computer model as well as an electronic copy of the HEC-RAS files shall be submitted with the Hydraulic Report for any work proposed in the floodplain

Table 4, Appendix 1, shows the maximum permissible velocities that are to be allowed in the channel. Velocities above that which is shown in Table 4 must be reduced or approved by the City of Arkadelphia.

10. EROSION CONTROL

10.1 General

This section summarizes the requirements set forward by the Environmental Protection Agency's (EPA's) Clean Water Act, administered in the state by the Arkansas Department of Environmental Quality (ADEQ). The Arkansas Department of Environmental Quality can be contacted at 501-372-0688 or www.adeq.state.ar.us

Further details regarding these requirements can be found in the *Federal Register,* Volume 63, Number 128 dated July 6, 1998. Details for some standard erosion control devices are included in Figures 3 through 10 in Appendix 2. A copy of the permit (Permit No. ARR10A000) application, Notice of Intent, and Notice of Termination are included in Figure 11 and 12, respectively, in Appendix 3.

Any development within the City of Arkadelphia must comply with both Federal and State requirements regarding erosion protection.

10.2 National Pollutant Discharge Elimination System (NPDES) Requirements

As part of the Water Quality Act of 1987, storm water discharges associates with industrial activity from a point source to waters of the United States is unlawful, unless authorized by an National Pollutant Discharge Elimination System (NPDES) permit. Construction activities which disturb an area greater than 5 acres by grading, clearing, grubbing or other construction activity is defined as an industrial activity, subject to the requirement of an NPDES permit. In order to effectively manage the permit process, the EPA has produced a general permit for construction activities, which defines specific conditions and requirements to be met as part of the permit. The general permit establishes the procedures required for proper coverage, the requirement for a Storm Water Pollution Prevention Plan (SWPPP) and requirements for termination of permit coverage.

In addition to NPDES permits for construction activities, large and medium size municipalities are required to obtain NPDES permits for their Municipal Separate Storm Sewer System (MS4) to control storm water outflow into waters of the United States. This permit will require local jurisdictions to take an active role in monitoring and controlling pollution due to storm water runoff from a variety of sources including construction activities. Therefore, in addition to meeting the requirements for the general permit, the site operator is obligated to contact the local jurisdiction to determine local requirements that may be required in addition to general permit coverage for discharge of industrial storm water runoff.

As noted above, all construction activities that disturb 5 acres or more land area or are a part of a common development or plan of sale is subject to the NPDES permit requirement. Failure to abide by the terms of the general permit or failure to develop and implement a site-specific NPDES permit is a violation of federal law, which can subject the owner or operator to severe fines or imprisonment.

Compliance with the requirements of the general permit consists of four major components: determination of eligibility, preparation and implementation of a Storm Water Pollution Prevention Plan, submission of the Notice of Intent, and submission of the Notice of Termination. Note that the Storm Water Pollution Prevention Plan (SWPPP) is prepared in conjunction with the construction documents for the site and before the submission of the Notice of Intent (NOI) to the EPA.

10.3 Eligibility Determination

Permittees are only eligible for coverage under the Construction General Permit (CGP) provided that their storm water discharges and storm water discharge-related activities do not adversely impact federally listed endangered or threatened species or critical habitats. Applicants are required to conduct an assessment of the impacts of their storm water discharges and storm water discharge-related activities on endangered and threatened species and critical habitat. Addendum A of the Construction General Permit provides detailed instructions to assist applicants in conducting an assessment and pursuing formal consultation with federal wildlife protection agencies if necessary. The process is briefly described below, however, operators are strongly advised to refer to addendum A of the permit.

1. *Determine if the construction site is found within designated critical habitat for listed species.* Operators may contact the U.S. Fish and Wildlife Service for information on critical habitat. If the project site is located within critical habitat, the operator must consider impacts to critical habitat when following the remaining steps.

2. *Determine if listed species are located in the county(ies) where the construction activity will occur.* Operators can obtain a county-by-county list of federally listed threatened and endangered species from the U.S. Fish and Wildlife Service (FWS) office listed above. After a review of the information from the FWS, if no listed species are located in the proposed site's county(ies) (or if the site's county is not listed), and the construction site is not located within designated critical habitat, the operator is eligible for CGP coverage without further inquiry into the presence of or effect to listed species. If it is determined that listed species are located in the site's county, the operator must proceed to step 3.

3. *Determine if any federally listed endangered or threatened species may be present in the project area*) refer to Addendum A for a description of what constitutes the project area). Addendum A provides several options that the operator may conduct to satisfy this requirement. The operator may be able to obtain further guidance from the local Fish and Wildlife Service office on which option is most appropriate for the operator to conduct given the site location and listed species occurring in the country. If through the operator's assessment no species are determined to exist in the project area, the operator is eligible for CGP coverage (not that due to the large number of requests, the FWS typically will not conduct its own assessment or provide any formal "approval" or written documentation at this stage in the process). If listed species are found in the project area, applicants must indicate the location and nature of this presence in the SWPPP and proceed to the following step.

4. *Determine if listed species or critical habitats are likely to be adversely affected by the construction activity's storm water discharges or storm water discharge-related activities.* The scope of effects to consider will vary with each site. If it is unclear whether the proposed project is likely to adversely a listed species or

critical habitat, the local Fish and Wildlife Service office should be contacted for assistance. If it is determined that adverse effects are likely, the operator must follow step 5.

5. *Determine if measures can be implemented to avoid any adverse effects.* In some cases measures may be able to be implemented to avoid or eliminate the likelihood of adverse effects prior to applying for permit coverage. These measures may involve relatively simple changes to the construction activity such as rerouting a storm water discharge to bypass an area where species are located, relocating BMPs, or by changing the "footprint" of the construction activity. The operator may wish to contact the FWS to find out what measures might be suitable to avoid or eliminate the likelihood of adverse impacts to listed species and/or critical habitat. If measures are adopted (or changes are made to the proposed construction activity) that would avoid or eliminate adverse effects, the operator must abide by those measures during the course of permit coverage. If measures to avoid the likelihood of adverse effects are not available, the applicant must proceed to the step 6.

6. *If a determination has been made that construction activity will affect endangered species, then the applicant must receive clearance from Fish and Wildlife Services and/or the National Marine Fisheries Service to obtain permit coverage.* In this case, the operator must initiate formal or informal Endangered Species Act consultation with the Fish and Wildlife Service. This process is described in detail in Addendum A.

After permit eligibility has been determined, preparation of the Storm Water Pollution Prevention Plan may begin.

10.4 Preparation of the Storm Water Pollution Prevention Plan

The Storm Water Pollution Prevention Plan (SWPPP) is the document(s) that defines the measures to be employed to prevent the release of pollution from the construction site. The SWPPP consists of two components, a narrative description of the project, and a drawing of the site with proposed improvements and pollution reduction methods shown. The SWPPP shall be included within the construction documents and reviewed for compliance by the City of Arkadelphia for all developments either for or constructed within the planning jurisdiction of the City of Arkadelphia. The SWPPP shall be prepared by a Profession Engineer licensed in the state of Arkansas.

The SWPPP identifies the techniques that the operator will use to reduce site erosion and sediment loss and manage construction-related wastes. It identifies the maintenance procedures that the operator will perform to preserve the efficiency of the techniques used. The SWPPP must clearly describe the control measures, the timing and sequence of implementation, and which permittee (contractor) is responsible for implementation of the control measures.

Unlike many construction documents, the SWPPP is very likely to change during the course of construction due to variations in construction techniques and/or site conditions. These modifications should be made by the original preparer of the SWPPP or someone else experienced in the design of erosion and sediment control systems in order to maintain the effectiveness of the original SWPPP design.

The SWPPP is not submitted to the ADEQ as part of the NOI; instead it must be available onsite or nearby for inspection by EPA or ADEQ personnel, state and/or local jurisdiction staff, and the public upon request.

In preparing the SWPPP the following information must be presented (detailed explanations of each item are presented in Section 6):

1. Site Description
    - A. Description of Construction
    - B. Project Sequencing
    - C. Total and Disturbed Areas of Site
    - D. Estimate of Runoff Coefficient (C) Before and After Construction
    - E. General Location Map
    - F. Site Map With Drainage and Layout Information
    - G. Location and Description of Any Discharge Associated with Industrial Activity Other Than Construction
    - H. Name of Receiving Waters
    - I. If Applicable, Information on Wetlands
    - J. Copy of Permit Requirements
    - K. If Applicable, Information on Listed Species or Critical Habitat Affected by Activity
    - L. If Applicable, Information on Historic Places Affected by Activity

2. Controls To Be Used Onsite
    - A. Construction, Erosion and Sediment Controls
        - 1. Stabilization Practices
        - 2. Structural Practices
    - B. Post-Construction Storm Water Management Controls
        - 1. Flow and Pollutant Reduction Practices
        - 2. Velocity Dissipation Devices
    - C. Other Controls
        - 1. Solid Material Discharge
        - 2. Offsite Sediment Tracking
        - 3. Compliance with State and Local Requirements for Waste Disposal
        - 4. Construction and Waste Materials Storage
        - 5. Pollutant Sources from Construction Support Activities
        - 6. Protection Measures for Listed Species or Critical Habitat
    - D. Compliance with State and Local Requirements for Sediment and Erosion Control

3. Maintenance Procedures for Control Measures

4. Inspection Requirements

5. Planned Non-Storm Water Discharges

Outlines for both the narrative and the drawings are included in Section 6 of this manual to ensure that each of the above issues is addressed in the SWPPP. A form is also presented for the narrative portion to simplify preparation of the document. An example SWPPP can be downloaded from ADEQ at the following web site:

www.adeq.state.ar.us/water/npdes/stormwater/construction.htm

10.5 Notice of Intent

The Notice of Intent (NOI) is the primary document used by the ADEQ to monitor and enforce compliance with the NPDES permitting requirements. The NOI is to be submitted after preparation of construction plans and SWPPP at least 48 hours prior to the beginning of construction activities at the site. Unless notified by ADEQ during the 48 hour period after submission, the NOI is considered acceptable and construction activities, including implementation of the SWPPP, can proceed under assumed coverage of the NPDES general permit.

The operator(s) of the site is required to submit the NOI and is ultimately responsible for the effective reduction of pollution and sediment loss from the site. An NOI must be in place for the site throughout the time the site is in a disturbed condition (except when a site has been temporarily stabilized and transferred to the homeowner).

A copy of the NOI form is included in Appendix C of this manual. Detailed instructions for completion of the NOI can be within the permit application. Additional copies can be obtained from the ADEQ. Completed NOIs should be submitted to ADEQ at the designated address shown on the back of the form.

10.6 Notice of Termination

The Notice of Termination (NOT) provides notification to ADEQ that the site has been stabilized in accordance with the requirements of the general permit and that construction on the site is completed or another operator has assumed control (and submitted an NOI). Upon submission of the NOT, the operator loses the authority to discharge storm water under the conditions of the general permit.

As stated in the general permit, the NOT for the site must be submitted within 30 days of one or more of the following conditions being met: 1) final stabilization of the site is achieved; 2) another operator has taken control over all areas that have not been finally stabilized, or 3) for residential construction only, temporary stabilization has been completed and the residence has been turned over to the homeowner.

Final stabilization means that either: 1) all soil disturbing activities have been completed and a uniform perennial vegetative cover with a density of 70% of the native background vegetative cover has been established for all areas outside of paved areas or building limits, or equivalent other stabilization measures (riprap, gabions, geotextiles, etc.) have been employed; 2) for individual lots in residential construction projects, final stabilization as defined in 1) above is achieved, or temporary stabilization including perimeter controls for an individual lot have been implemented, the home has been transferred to the homeowner, and the homeowner has been instructed on the benefits of final stabilization; or 3) for construction on land used for agricultural purposes, the disturbed land is returned to its preconstruction agricultural use. The section on BMP's in this manual outlines techniques and design criteria for stabilization measures.

A copy of the NOT form is included in Appendix 3 of this manual: Detailed instructions for completion of the NOT can be found on the back of the form. Additional copies can be obtained from ADEQ. Completed NOTs should be submitted to ADEQ at the designated address shown on the back of the form.

10.7 Enforcement

The City of Arkadelphia reserves the right to at any time suspend construction activities until the responsible party is in compliance with the SWPPP. The City of Arkadelphia can warrant additional control measures not indicated on the SWPPP to ensure compliance is guaranteed and pollution is controlled. A Certificate of Occupancy will not be issued for any structures within the development until the site has been stabilized in accordance with the requirements for the general permit and the notice of termination has been filed.

10.8 Inspection Requirement

Qualified personnel (provided by the permittee or cooperatively by multiple permittees) shall inspect disturbed areas of the construction site that have not been finally stabilized, areas used for storage of materials that are exposed to precipitation , structural control measures, and locations where vehicles enter or exit the site, at least once every fourteen (14) calendar days and within 24 hours of the end of a storm event of 0.5 inches or greater.

Based on the results of the inspection, the SWPPP shall be modified as necessary to include additional or modified BMPs designed to correct identified problems. Revisions to the SWPPP shall be completed within 7 calendar days following the inspection. A report summarizing the scope of the inspection, name(s) and qualifications of personnel making the inspection, the date(s) of the inspection, and major observations relating to the implementation of the SWPPP shall be made and retained as part of the SWPPP for at least three

10.9 Stabilization Requirement For Inactive Areas

During construction, some areas that are disturbed may be inactive for extended periods of time. The general permit addresses this issue by requiring that areas that are inactive for periods longer than 14 days must be stabilized through the use of seeding, mulching, sod, geotextiles or vegetative buffer strips. If it is anticipated that construction will resume within 21 days from when activities ceased, stabilization is not required. Proper sequencing and phasing of operations can minimize the need for temporary stabilization.

10.10 Sediment Basin Requirement

The general permit states that for common drainage areas that serve an area of 10 or more acres that are disturbed at one time, a sediment basin shall be provided where attainable until final stabilization of the site occurs. As stated in the BMP, the required volume for the sediment basin must provide storage for the calculated volume of runoff from a 2-year, 24-hour storm for each acre of drainage area that for the sediment basin is 3600 cubic feet of storage area per acre disturbed. Sediment basins shall be designed and constructed to the minimum standards provided in the BMP section of this manual.

By phasing development and the amount of land disturbed at one time, the size of the basin can be reduced or eliminated entirely. However, if necessary, sediment basins provide excellent temporary and permanent storm water treatment and can serve as an amenity to the site. Where a sediment basin with the above storage requirements is not attainable, smaller sediment basins and/or sediment traps may be used. However, at a minimum, silt fences or equivalent controls are required on all sideslopes and downslope boundaries of the site.

10.11 Storm Water Management Measures

As part of the SWPPP, storm water management measures must be addressed to reduce pollutants in storm water runoff from the site once construction is complete and the development is occupied or placed in operation. Although sometimes referred to as "post-construction" controls, best management practices to control the quality of storm water runoff from developed areas need to be considered during the earliest stages of planning for the project. Practices such as reducing the amount of impervious surface, open drainage swales, extended detention wet ponds, and others should be given consideration. Appropriate measures must be incorporated into project plans and the SWPPP. Note that the permittee is only responsible for design and installation of the management measures, and maintenance of the measure(s) during construction (prior to final stabilization of the site).

Specific techniques listed in the permit include storm water detention (dry sedimentation basins), retention structures (extended detention wet ponds), measures to allow for infiltration (trenches, open drainage swales), and velocity dissipation. Other techniques are discussed in the other manuals in this series.

10.12 Coverage of Support Activities

This permit also authorizes storm water discharges from support activities (e.g., concrete or asphalt batch plants, equipment staging yards, material storage areas, excavated material disposal areas, borrow areas) provided:

a) The support activity is directly related to a construction site having NPDES permit coverage for discharges of storm water associated with construction activity;

b) The support activity is not a commercial operation serving multiple unrelated construction projects by different operators, and does not operate beyond the completion of the construction activity at the last construction project it supports; and

c) Appropriate controls and measures are identified in a Storm Water Pollution Prevention Plan covering the discharges from the support activity.

All discharges of storm water from ready-mix concrete batch plants covered as a support activity must also comply with the following limitations:

a) pH – between 6.0 and 9.0 standard units;
b) Oil and Grease – 15 mg/l as a daily maximum; and
c) Total Suspended Solids – 65 mg/l as a daily maximum.

10.13 Spill Notification

The general permit allows for storm water discharge from construction sites only. Discharges of other substances from construction activities or from operations on a site during construction are not permitted. In the event of a spill of a hazardous substance, the operator is required to notify the National Response Center (NRC) at (800) 424-8802 to properly report the spill. In addition, the operator shall submit a written description of the release (including the type and the approximate amount of material released), the date of the release, the circumstances of the release, and the steps to be taken to prevent future spills to the EPA Regional Office. In addition, the SWPPP must be revised within 14 calendar days after the release to reflect the release, stating the information above along with modifications to minimize the possibility of future occurrences.

If fuels, oils or other substances are to be present on site, it is imperative that closed containers be provided along with containment areas for large quantity spills. Hazardous chemicals include fertilizers, paints, oils, grease, pesticides, and fuels, along with other construction chemicals. While much of this manual focuses on the sediment and erosion control aspects of the SWPPP, the potential for damaging pollution from chemicals is great. Provisions must be provided to address potential pollution through the use of the BMPs presented along with compliance of OSHA and other regulatory requirements.

10.14 Retention of Records

As part of the general permit, the SWPPP and supporting documentation must be retained for a period of 3 years after the completion of the project. This is to protect the operator(s) of the site from future claims concerning water quality and measures implemented at the site. It is recommended that each of the operator(s) maintain a copy of the SWPPP for the 3-year period.

Appendix 1

Table of Contents

TABLE 1
Coefficients of Runoff and Minimum Inlet Times

Land Use	Runoff Coefficient, C	Minimum Inlet Time (Min.)
Residential		
Duplex/Patio Home	0.6	15
Single Family	0.5	15
Greater than 1 acre lots	0.4	15
Commercial	0.9	10
Industrial	0.9	10
Multiple Unit Dwelling	0.8	10
Parks and Cemetaries	0.4	15
Undeveloped Open Areas	0.3	20
Shopping Centers	0.9	10
Paved Areas	0.95	10
Schools	0.6	15
Patio Homes	0.6	15

TABLE 2
Roughness Coefficients for Closed Conduits*

Material of New Construction	Recommended Roughness Coefficient, n
Concrete Pipe Storm Sewer	0.013
Corru`gated Metal Pipe Culverts	0.024

Material of Existing Systems	Recommended Roughness Coefficient, n
Concrete Pipe Storm Sewer	
Fair Alignment, Ordinary Joints	0.015
Poor Alignment, Poor Joints	0.017
Concrete Pipe Culverts	0.012
Corrugated Metal Pipe Culverts	0.030

Note: For materials other then those listed here, use manufacturer's suggestion and/or City of Arkadelphia's recommendations.

TABLE 3
Rainfall Depths for Clark County

THESE NUMBERS ASSUME EVEN DISTRIBUTION FOR SMALL AREAS
REFER TO FIGURE 15 IN TP-40 FOR LARGE AREAS (OVER 20 SQUARE MILES)

Information Obtained From Hydro-35:

2 YEAR	5	0.5	***100 YEAR***	5	0.84
	15	1.05		15	1.83
	60	1.9		60	3.72

TP-40 INPUT				**HYDRO-35 INPUT**	
FREQUENCY	**DURATION**	**SOURCE**	**RAINFALL INCHES**	**DURATION MINUTE**	**RAINFALL INCHES**
2-Year	30MIN	*TP-40*	1.50	5	0.50
	1HR	*HYDRO-35*	1.90	15	1.05
	2HR	*TP-40*	2.30	60	1.90
	3HR	*TP-40*	2.60		
	6HR	*TP-40*	3.10		
	12HR	*TP-40*	3.70		
	24HR	*TP-40*	4.25		
5-Year	30MIN	*TP-40*	1.90	5	0.57
	1HR	*HYDRO-35*	2.31	15	1.22
	2HR	*TP-40*	2.90	60	2.31
	3HR	*TP-40*	3.25		
	6HR	*TP-40*	3.95		
	12HR	*TP-40*	4.70		
	24HR	*TP-40*	5.50		
10-Year	30MIN	*TP-40*	2.12	5	0.63
	1HR	*HYDRO-35*	2.61	15	1.34
	2HR	*TP-40*	3.35	60	2.61
	3HR	*TP-40*	3.70		
	6HR	*TP-40*	4.60		
	12HR	*TP-40*	5.50		
	24HR	*TP-40*	6.50		
25-Year	30MIN	*TP-40*	2.50	5	0.71
	1HR	*HYDRO-35*	3.05	15	1.53
	2HR	*TP-40*	3.80	60	3.05
	3HR	*TP-40*	4.40		
	6HR	*TP-40*	5.40		
	12HR	*TP-40*	6.45		
	24HR	*TP-40*	7.50		
50-Year	30MIN	*TP-40*	2.70	5	0.77
	1HR	*HYDRO-35*	3.38	15	1.68
	2HR	*TP-40*	4.30	60	3.38
	3HR	*TP-40*	4.90		
	6HR	*TP-40*	5.90		
	12HR	*TP-40*	7.00		
	24HR	*TP-40*	8.10		
100-Year	30MIN	*TP-40*	3.05	5	0.84
	1HR	*HYDRO-35*	3.72	15	1.83
	2HR	*TP-40*	4.80	60	3.72
	3HR	*TP-40*	5.40		
	6HR	*TP-40*	6.50		
	12HR	*TP-40*	7.90		
	24HR	*TP-40*	9.10		

TABLE 4
Roughness Coefficients for Open Channels*

Channel Description	Recommended Roughness Coefficients			Maximum Velocity (ft/s)
	Minimum	Normal	Maximum	
Minor Natural Streams				
Moderately Well Defined Channel				
Grass and Weeds, Little Brush	0.025	0.030	0.033	8
Dense Weeds, Little Brush	0.030	0.035	0.040	8
Weeds, Light Brush on Banks	0.030	0.035	0.040	8
Weeds, Heavy Brush on Banks	0.035	0.050	0.060	8
Weeds, Dense Willow on Banks	0.040	0.060	0.080	8
Irregular Channel With Pools and Meanders				
Grass and Weeds, Little Brush	0.030	0.036	0.042	8
Dense Weeds, Little Brush	0.036	0.042	0.048	8
Weeds, Light Brush on Banks	0.036	0.042	0.048	8
Weeds, Heavy Brush on Banks	0.042	0.060	0.072	8
Weeds, Dense Willow on Banks	0.048	0.072	0.096	8
Floodplain, Pasture				
Short Grass, No Brush	0.030	0.035	0.040	8
Tall Grass, No Brush	0.035	0.040	0.050	8
Floodplain, Cultivated				
No Crops	0.030	0.035	0.040	8
Mature Crops	0.035	0.045	0.050	8
Floodplain, Uncleared				
Heavy Weeds, Light Brush	0.050	0.060	0.070	8
Medium to Dense Brush	0.070	0.100	0.160	8
Trees with Flood Stage below Branches	0.080	0.100	0.120	8
Major Natural Streams				
The roughness coefficient is less than that for minor streams of similar description becase banks offer less effective resistance				
Moderately Well Defined Channel	0.025		0.060	8
Irregular Channel	0.035		0.100	8
Unlined Vegetated Channels				
Mowed Grass, Clay Soil	0.025	0.030	0.035	8
Mowed Grass, Sandy Soil	0.025	0.030	0.035	6
Unlined Non-Vegetated Channels				
Clean Gravel Section	0.022	0.025	0.030	8
Shale	0.025	0.030	0.035	10
Smooth Rock	0.025	0.030	0.035	15
Earth Lined, Sandy	0.028	0.035	0.040	6
Earth Lined, Clay	0.028	0.035	0.040	8
Lined Channels				
Smooth Finished Concrete	0.013	0.015	0.020	15
Riprap (rubble)	0.030	0.040	0.050	12
Gabion	0.028	0.032	0.035	15
Pavement				
Concrete		0.015		
Asphalt		0.017	-	-

*** Note: Deviations from these values must be approved by the City of Arkadelphia.***

TABLE 5A
Velocity Head Loss Coefficients for Closed Conduits

Description of Conditions	Kj
Inlet on Main Line	0.5
Inlet on Main Line with Branch Lateral	0.25
Manhole on Main Line with bend at:	
90 degrees	0.25
60 degrees	0.35
45 degrees	0.5
22.5 degrees	0.95
Wye Connection or Cut In	
60 degrees	0.6
45 degrees	0.75
22.5 degrees	0.95
Inlet or Manhole at the Beginning of Line	1.25
Conduit Curves for 90 degrees*	
Curve Radius	
2 to 8 times the diameter **	0.4
8 to 20 times the diameter	0.25
Greater than 20 times the diameter	0
Bends where the radius is equal to the Diameter	
90 degree bend	0.05
60 degree bend	0.43
45 degree bend	0.35
22.5 degree bend	0.2

The values of the coefficient "Kj" for determining the loss of head due to obstructions in pipes are shown in Table 6-B and the coefficients are used in the following equation to calculate the head loss at the obstruction:

Hj = Kj (V2^2/2*g)

* Where deflection other than 90 degrees are used, the 90 degree deflection coefficeient can be used with the following percentage factors:
60 degree bend = 0.85
45 degree bend = 0.70
22.5 degree bend = 0.40

**The diameter is the inside diameter of the pipe.

TABLE 5B
Head Loss Coefficients Due to Sudden Enlargements and Contractions

D2/D1*	Sudden Enlargements, Kj	Sudden Contractions, Kj
1.2	0.1	0.08
1.4	0.23	0.18
1.6	0.35	0.25
1.8	0.44	0.33
2	0.52	0.36
2.5	0.65	0.4
3	0.72	0.42
4	0.8	0.44
5	0.84	0.45
10	0.89	0.46
> then 10	0.91	0.47

D2/D1 = Ratio of larger to smaller diameter

TABLE 6
Velocity Requirements for Closed Conduits*

Material of New Construction	Velocity Minimum	Velocity Maximum
Storm Sewers	2.500	15
Inlet Laterals	2.500	15
Culverts	2.500	10

For velocity requirements in Open Channels see Table 4. Storm Sewers shall discharge into open channels at a maximum velocity of 6 feet per second.

TABLE 7
*Design Criteria for the Design of Roads, Culverts, and Channels**

Road Classification	Design Return Period**	Design Spreads
Major Thoroughfare		
Principal Arterial	10-Year	Two Lanes Open Ea. Direction
	100-Year	Top of Curb
Minor Arterial	10-Year	One Lane Open Ea. Direction
	100-Year	Top of Curb
Collector	10-Year	Allow 1 Lane Open
	100-Year	Top of Curb
Local	10-Year	Top of Curb
	100-Year	Contained within the Right of Way
Rural Road w/ Bar Ditches	10-Year	One Foot Below Pavement
	100-Year	Contained within the Right of Way

Other Drainage Structures	Design Return Period
Enclosed Storm Sewer System	25-Year
Culvert or Bridge Along a Creek, River, or other Watercourse	25-Year
Culvert or Bridge not Located on a Creek River or other Watercourse	10-Year
Channel Improvements	25-Year***

**Note: The City Engineer may reserve the right to require more stringent requirements depending on the location of a specific project. All deviations from what is shown must be approved by the City of Arkadelphia.*

*** All design periods are based on Fully Urbanized conditions. Flows for channels and channel crossings may be obtained from the City of Arkadelphia.*

****Note: For Channel Improvements the 25-year storm should be contained within the channel. Adjacent structures and lots must be a minimum of one foot above the 100-year fully urbanized floodplain.*

Appendix 2

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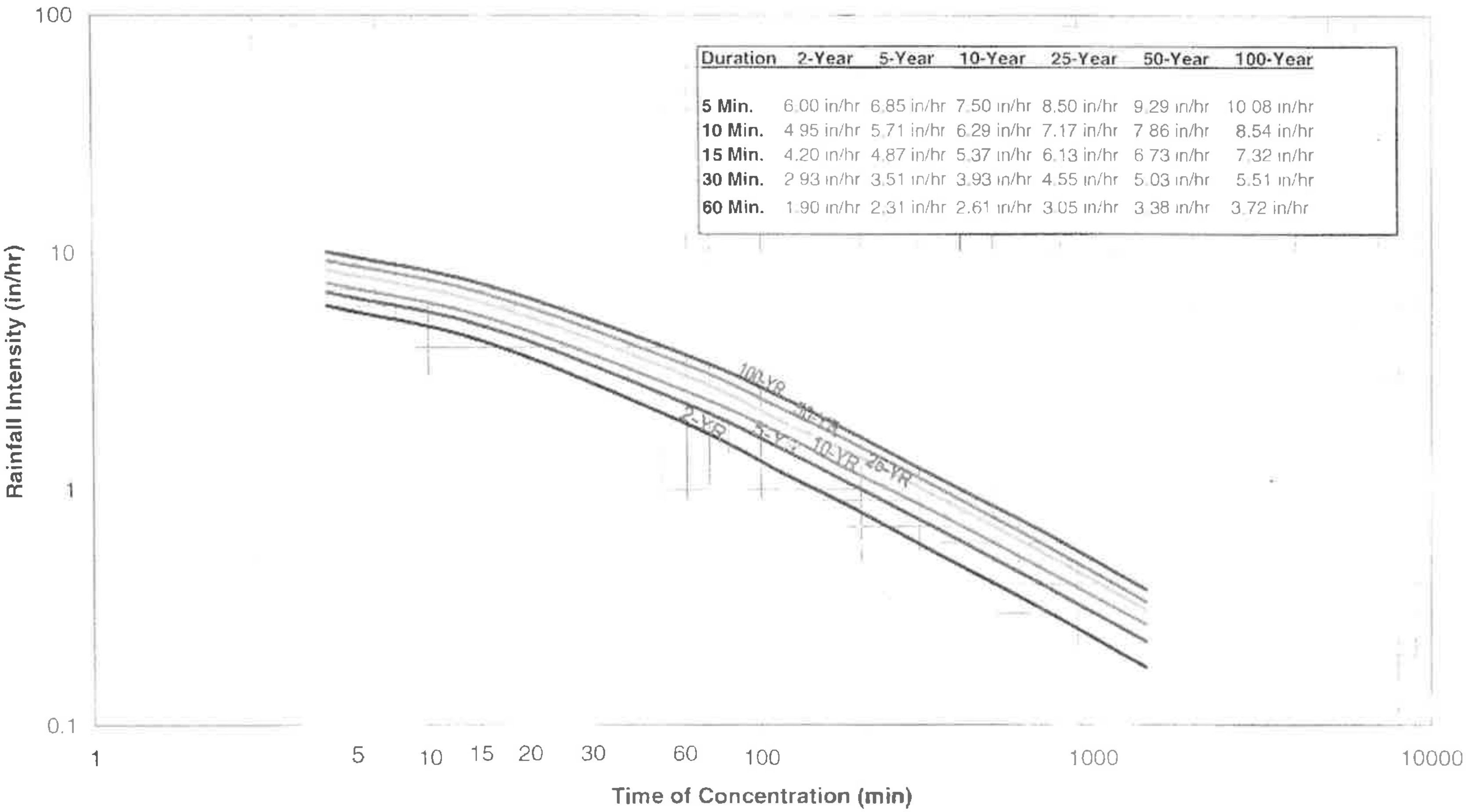
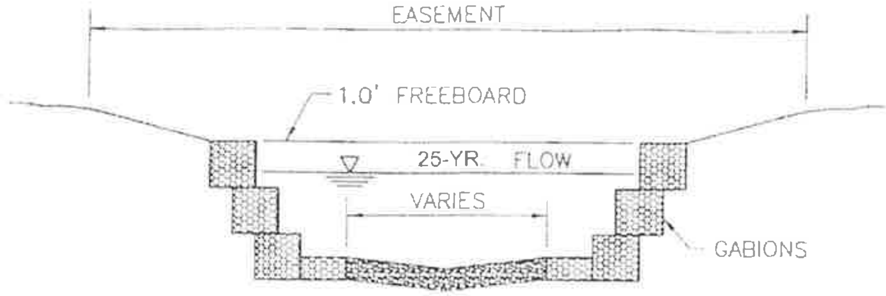
FIGURE 1
Rainfall Intensity and Duration Curves
for Clark County Arkansas

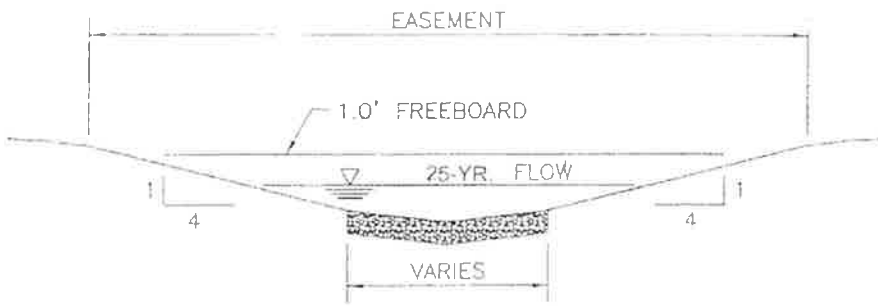


Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5 Min.	6.00 in/hr	6.85 in/hr	7.50 in/hr	8.50 in/hr	9.29 in/hr	10.08 in/hr
10 Min.	4.95 in/hr	5.71 in/hr	6.29 in/hr	7.17 in/hr	7.86 in/hr	8.54 in/hr
15 Min.	4.20 in/hr	4.87 in/hr	5.37 in/hr	6.13 in/hr	6.73 in/hr	7.32 in/hr
30 Min.	2.93 in/hr	3.51 in/hr	3.93 in/hr	4.55 in/hr	5.03 in/hr	5.51 in/hr
60 Min.	1.90 in/hr	2.31 in/hr	2.61 in/hr	3.05 in/hr	3.38 in/hr	3.72 in/hr

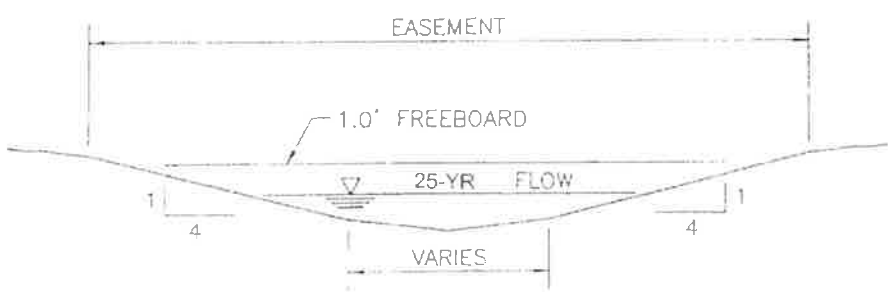
Figure 2
Open Channel Types



TYPICAL CHANNEL IMPROVEMENT WITH GABION LINING
NOT TO SCALE

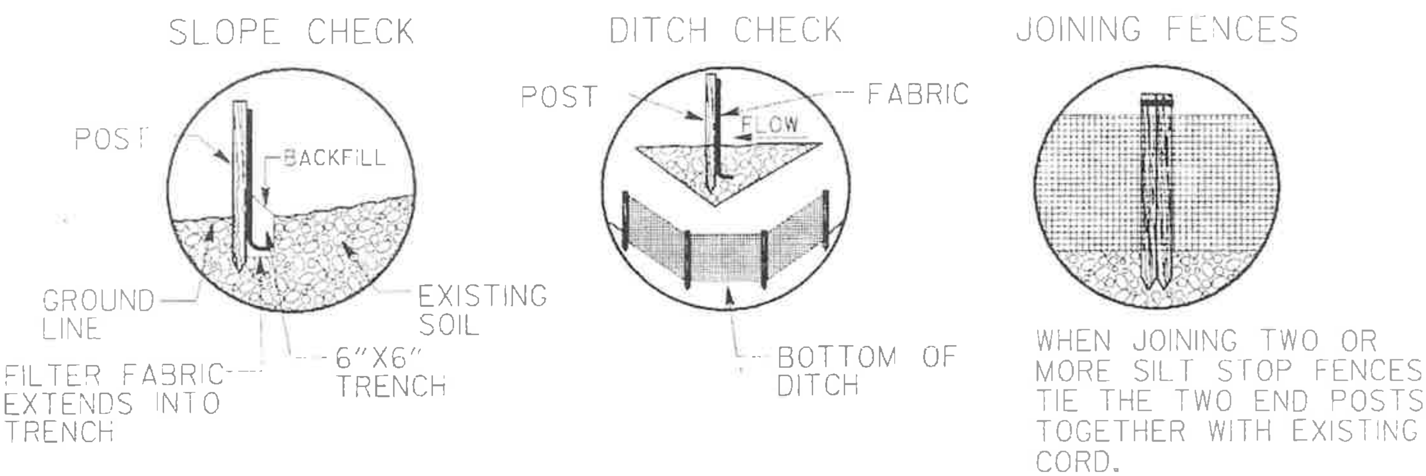


TYPICAL IMPROVED CHANNEL WITH
ROCK PILOT CHANNEL LINING
NOT TO SCALE



TYPICAL IMPROVED UNLINED CHANNEL SECTION

FIGURE 3
SILT FENCE DETAIL



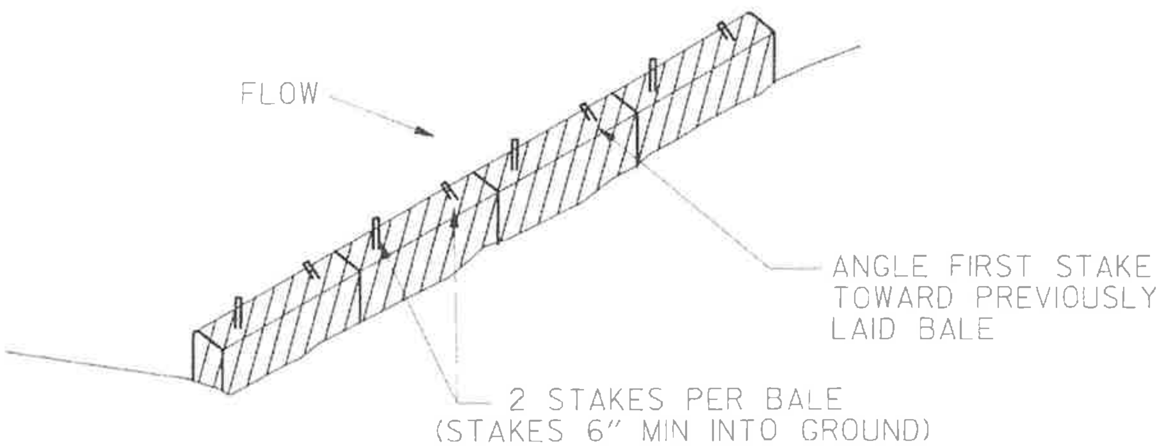
NOTE:

1.) SILT FENCE FABRIC SHALL BE MIRAFI 100 X OR EQUAL.
2.) INSTALL SILT FENCES AND HAY BALES AT LOCATIONS DIRECTED BY OWNER.
3.) FENCE POSTS SHALL BE GALVANIZED STEEL AND MAY BE ROLLED, FORMED OR TUBULAR IN SECTION. "T" POSTS MAY BE USED WHEN IN CONFORMANCE WITH SPECIFICATION.

(NOT TO SCALE)

FIGURE 4

HAY BALE DETAIL

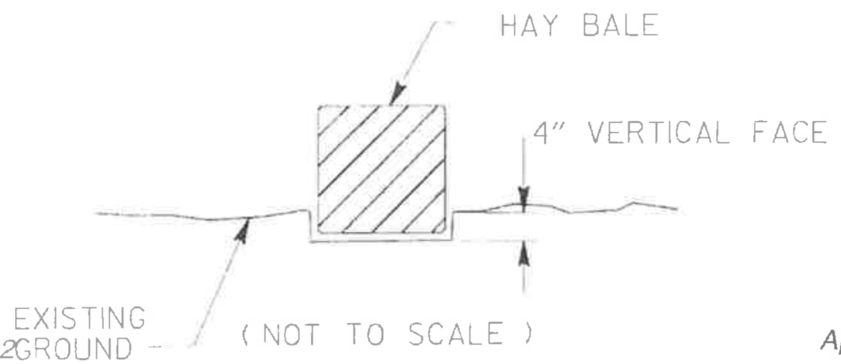


(NOT TO SCALE)

NOTE:

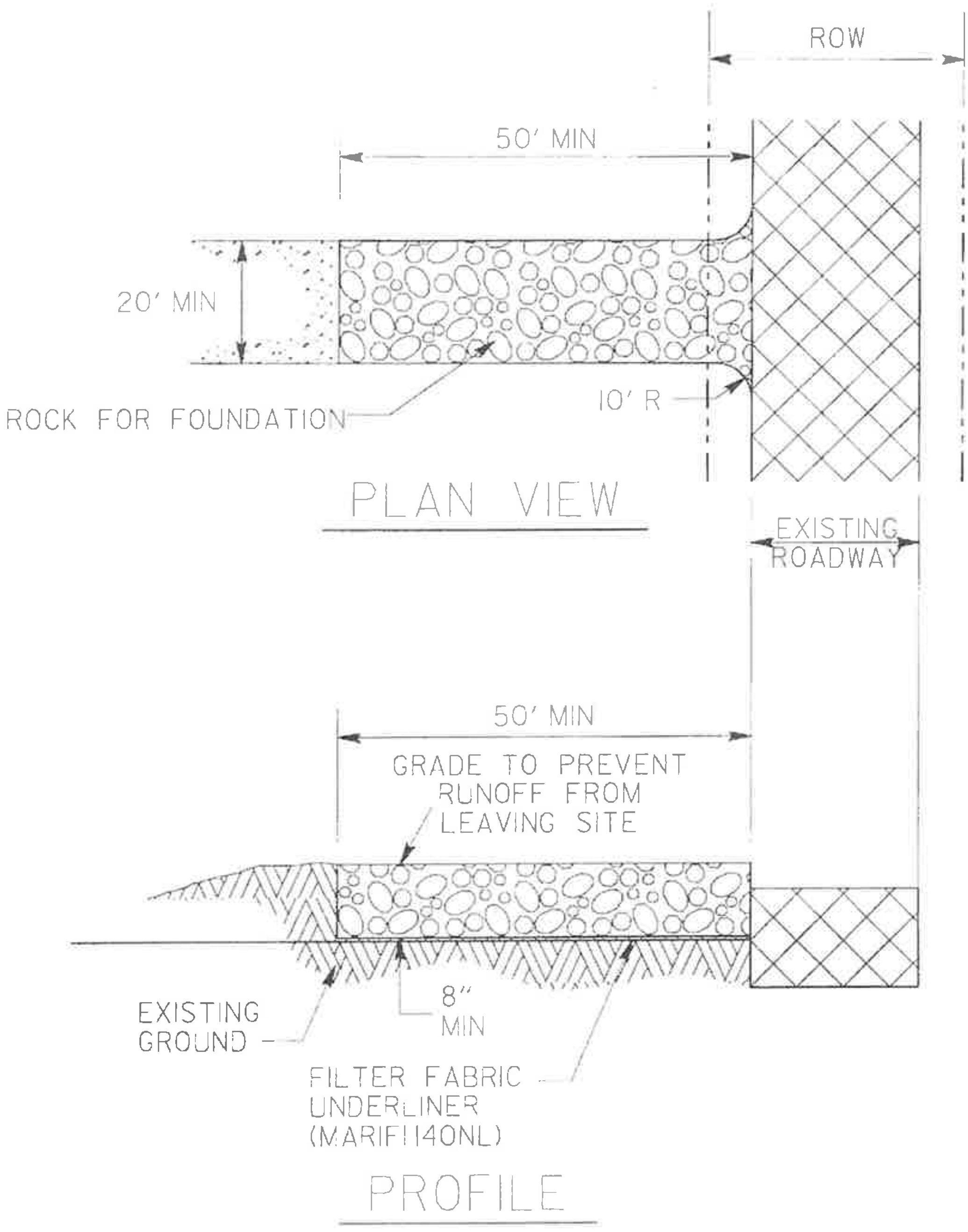
HAY BALES SHALL BE EMBEDDED A MINIMUM OF FOUR (4) INCHES AND SECURELY ANCHORED USING 3/8" DIAMETER STEEL STAKES OR 2" x 2" WOOD STAKES DRIVEN THROUGH THE BALES INTO THE GROUND A MINIMUM OF SIX (6) INCHES.

EMBEDDING DETAIL



(NOT TO SCALE)

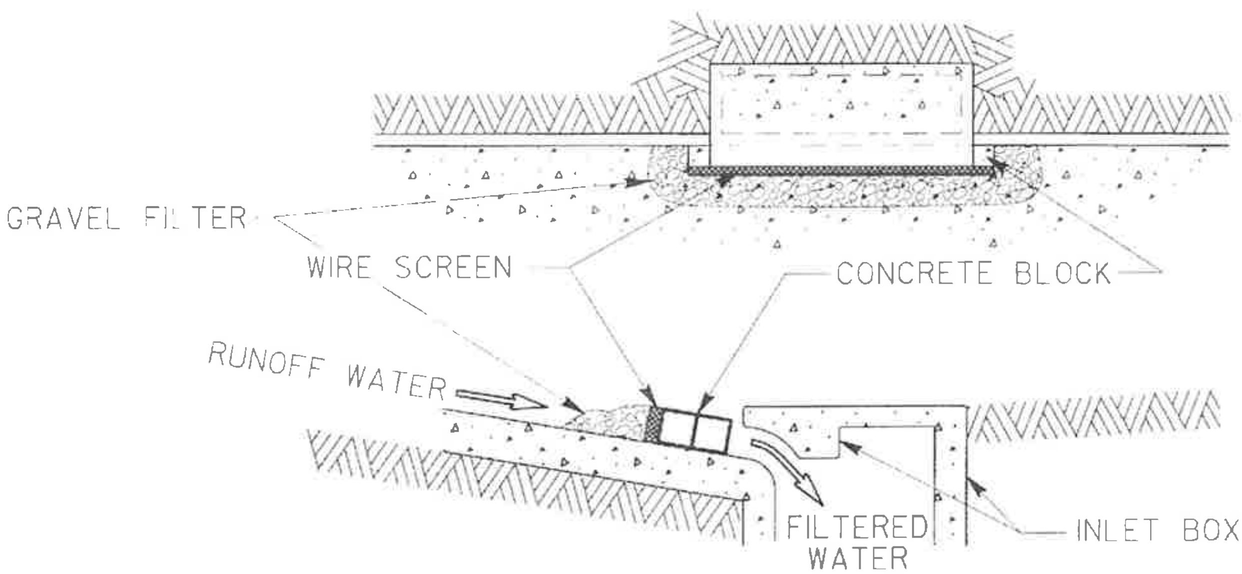
FIGURE 5
CONSTRUCTION ENTRANCE DETAIL



(NOT TO SCALE)

FIGURE 6

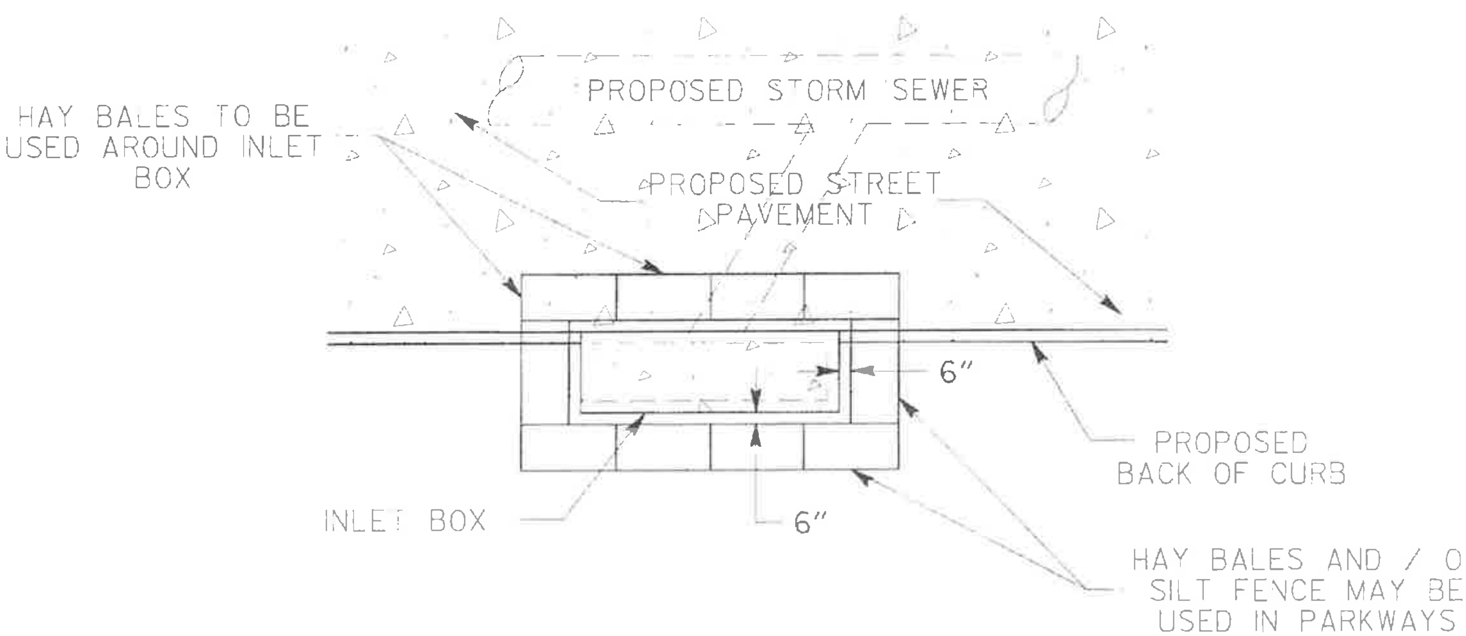
SEDIMENT BARRIER AT INLETS



(NOT TO SCALE)

FIGURE 7

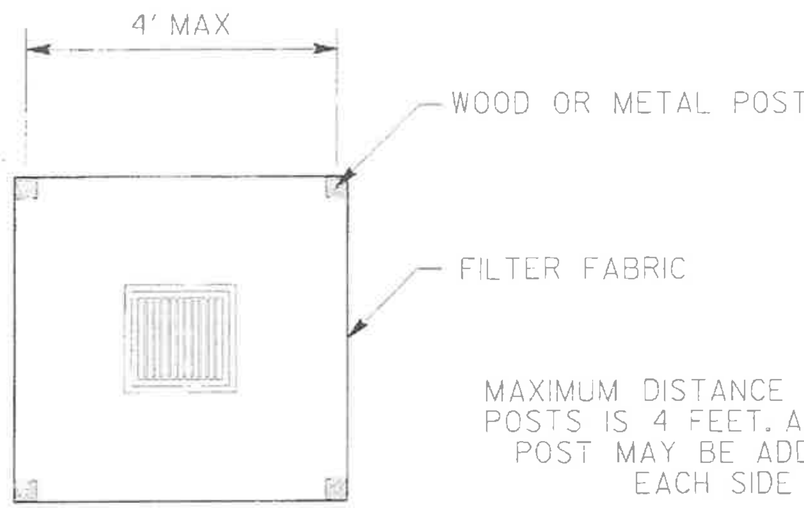
TYPICAL DETAIL OF EROSION CONTROL AROUND INLETS



DURING UTILITY CONSTRUCTION
(NOT TO SCALE)

FIGURE 8

SILT FENCE INLET SEDIMENT FILTER



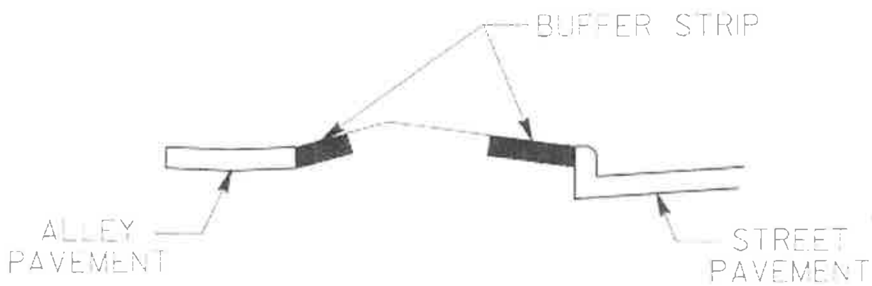
MAXIMUM DISTANCE BETWEEN POSTS IS 4 FEET. AN EXTRA POST MAY BE ADDED TO EACH SIDE

NOTE:
BOTTOM OF THE FILTER FABRIC IS BURIED IN TRENCH THE SAME AS WHEN IT IS INSTALLED AS A SILT FENCE SEE SILT FENCE DETAIL, THIS SHEET

(NOT TO SCALE)

FIGURE 9

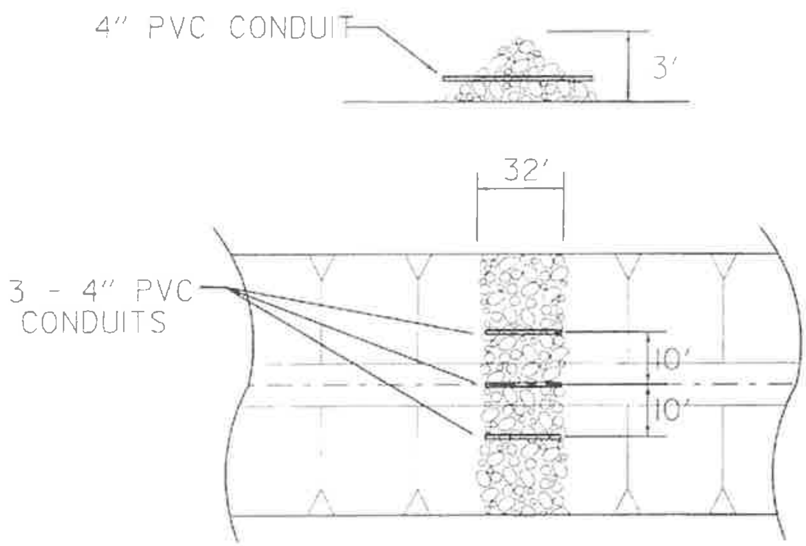
VEGETATED BUFFER STRIP



(NOT TO SCALE)

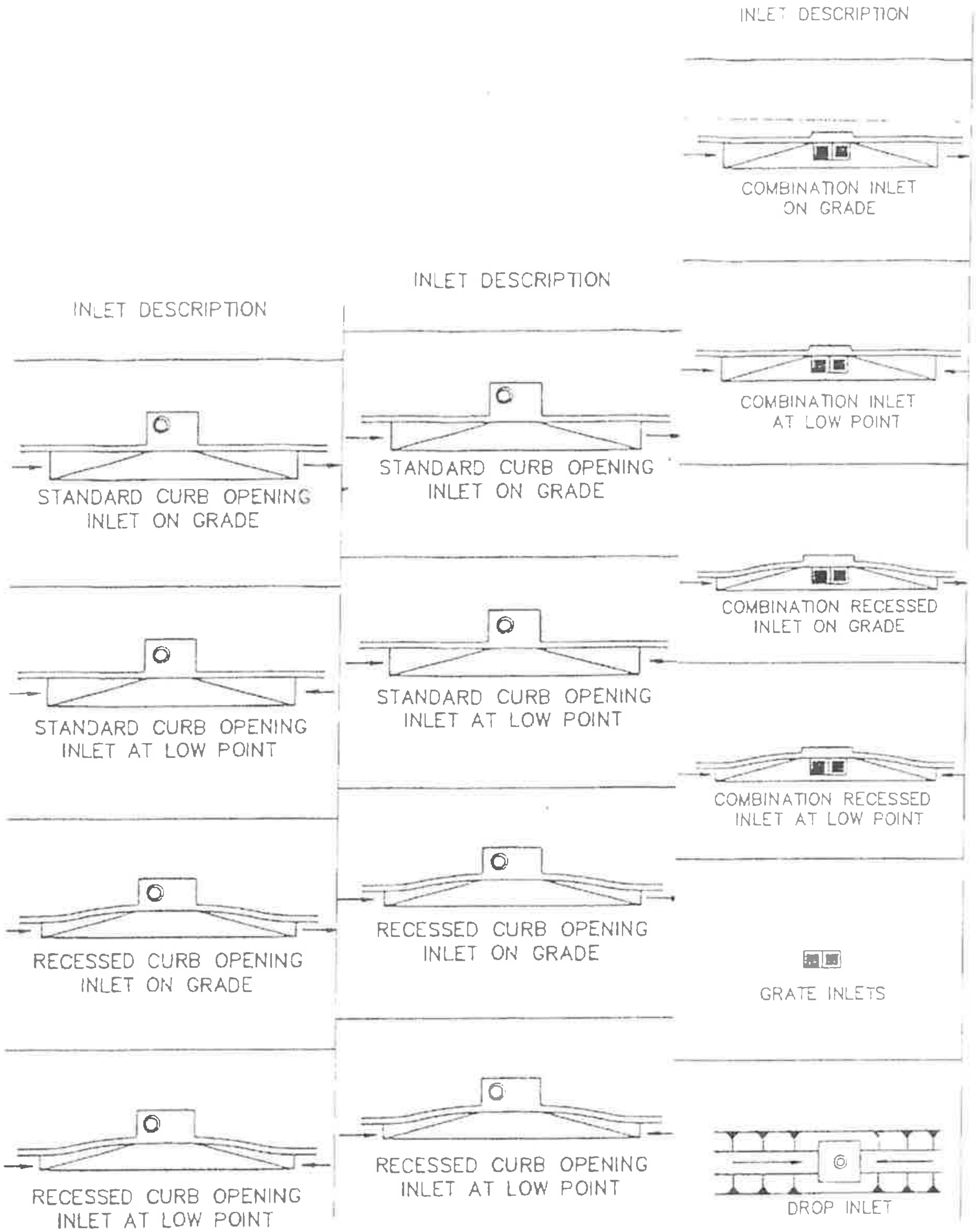
FIGURE 10

ROCK FILTER DAM



(NOT TO SCALE)

Figure 11
Description of Inlet Types



Appendix 3

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Inlet Design Calculation Form

Column 1	Inlet number or designation. The first inlet shown is the most upstream.
Column 2	Construction plan station of the inlet.
Column 3	Design Storm Frequency is the same as the Design Storm Frequency of the sewer.
Column 4	Time of concentration for each inlet is taken from Table 1 in Appendix 1.
Column 5	Using the time of concentration and the Design Strom Frequency, rainfall intensity is taken from Figure 1 in Appendix 2.
Column 6	Runoff Coefficient is taken from Table 1 Appendix 1 according to the zoning of the drainage area.
Column 7	Area drained by the specific inlet. Care should be taken to keep the drainage area flow separate into the appropriate street gutters.
Column 8	Product of Column 5 multiplied by Column 6 and 7.
Column 9	If there is any flow which was not fully intercepted by an upstream inlet, it should be entered her.
Column 10	Sum of Columns 8 and 9.
Column 11	Capacity of the street in which the inlet is located, from either Figures 7, 8 or 9 in Appendix 4. If the total gutter flow shown in column 10 is in excess of the value in Column 11, the inlet should be moved upstream. If it is substantially less than the value in Column 11, an investigation should be made to see if the inlet can be moved downstream.
Column 12	Street gutter slope to be used in selecting the proper size inlet.
Column 13	Crown type of the street on which the inlet is located.
Column 14	Selected size of the inlet taken from Figures in Appendix 4.
Column 15	Inlet type taken from Figure 11 in Appendix 2.
Column 16	If the selected inlet does not intercept all of the gutter flow, the difference between the two values should be entered here and in Column 9 of the inlet which will intercept the flow.

INLET [illegible]GN CALCULATIONS

BY ______________________

DATE ______________________

INLET		Design Storm Frequency (yrs.)	AREA RUNOFF Q = CIA					Carry-Over From Upstream Inlet (c.f.s.)	Total Gutter Flow (c.f.s.)	Gutter Capacity (c.f.s.)	Gutter Slope (ft./100 ft.)	Crown Type	SELECTED INLET		Carry-Over To Downstream Inlet (c.f.s.)
No.	Location		Time Of Conc. (min.)	Intensity I (In./hr.)	Runoff Coeff. "C"	Area (Ac.)	"Q" (c.f.s.)						Length "LI" (Feet)	Type	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

COMPUTATION SHEET

DETENTION POND DESIGN

STORAGE-OUTFLOW RELATIONSHIP			
POND ELEV	STORAGE		OUTFLOW (cfs)
	DEPTH (ft)	VOLUME (ac-ft)	
1	2	3	4

PRINCIPLE SPILLWAY :

Description : ______________________

____

____

Elevation : ______________________

EMERGENCY SPILLWAY :

Description : ______________________

____

____

Elevation : ______________________

DESIGN FREQUENCY	HYDROGRAPH DATA						POND ELEVATION (ft MSL)	POND STORAGE (ac-ft.)
	PRESENT WATERSHED DEVELOPMENT		ULTIMATE WATERSHED DEVELOPMENT		PROPOSED POND OUTFLOW			
	TIME TO PEAK (min)	PEAK FLOW (cfs)	TIME TO PEAK (min)	PEAK FLOW (cfs)	TIME TO PEAK (min)	PEAK FLOW (cfs)		
	5	6	7	8	9	10	11	12
5-YR								
10-YR								
25-YR								
50-YR								
100-YR								
-PMF*								

* Refer to TAC Chapter 299 for requitrements for using the Probable Maximum Flood (PMF).

COMPUTATION SHEET

APPENDIX 3
FORM 7

Permit No. ARR10A000

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM AND THE ARKANSAS WATER AND AIR POLLUTION CONTROL ACT

In accordance with the provisions of the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended, Ark. Code Ann. 8-4-101 et seq.), and the Clean Water Act (33 U.S.C. 1251 et seq.),

Owners or operators of Facilities Discharging Storm Water Associated With Industrial Activity from Construction Sites Located in the State of Arkansas

are authorized to discharge

to all receiving waters

in accordance with effluent limitations, monitoring requirements, and other conditions set forth in Parts I through VIII herein.

This permit shall become effective on July 1, 1998.

This permit and the authorization to discharge shall expire at midnight, June 30, 2003.

Owners or operators within the State of Arkansas who fail to submit a written Notice of Intent to the Director to be covered by this general permit are not authorized to discharge under this general permit.

Signed this 31st day of May 1998.

Chuck Bennett
Chief, Water Division
Arkansas Department of Pollution Control
and Ecology

PART I
COVERAGE UNDER THIS PERMIT

A. Permit Area. This permit includes all areas within the State of Arkansas.

B. Eligibility.

1. General. Except for storm water discharges identified under paragraph I.B.3 below, this permit shall authorize all discharges of storm water associated with industrial activity from construction sites (those areas that will result in the disturbance of **five or more acres of total land area**), (henceforth referred to as storm water discharges from construction activities) occurring after the effective date of this permit (including discharges occurring after the effective date where the construction activity commenced before the effective date).

2. **This permit also authorizes storm water discharges from support activities (e.g., concrete or asphalt batch plants, equipment staging yards, materials storage areas, excavated material disposal areas, borrow areas) provided.**

   a. **The support activity is directly related to a construction site that is required to have NPDES permit coverage for discharges of storm water associated with construction activity;**

   b. **The support activity is not a commercial operation serving multiple unrelated construction projects by different operators, and does not operate beyond the completion of the construction activity at the last construction project it supports; and**

   c. **Appropriate controls and measures are identified in a storm water pollution prevention plan covering the discharges from the support activity areas.**

3. Limitations on Coverage. The following storm water discharges associated with industrial activity are not covered by this permit:

   a. storm water discharges associated with industrial activity that originate from the site after construction activities have been completed and the site has undergone final stabilization.

   b. discharges that are mixed with sources of non-storm water other than discharges identified in Part III.A of this permit and in compliance with Part III.C.5 of this permit.

   c. storm water discharges associated with industrial activity from facilities with an existing NPDES individual or general permit for storm water discharges or which are issued a permit in accordance with paragraph I.C. of this permit. Such discharges may be authorized by this permit after an existing permit expires provided the expired permit did not establish numeric effluent limitations for such discharges; and

d. storm water discharges from construction sites that the Director has determined to be or may reasonably be expected to be contributing to a violation or a water quality standard.

e. storm water discharges from construction sites if the discharge or clearing activities are likely to adversely effect a listed endangered or threatened species or its critical habitat.

6. Discharges which are not in compliance with the Endangered Species Act (ESA). In order to obtain coverage, the applicant must certify to meeting one of the criteria detailed in the permit.

The criteria are as follows:

(1) The storm water discharge(s), and the construction and implementation of Best Management Practices (BMPs) to control storm water runoff, are not likely to adversely affect species or critical habitat for a listed species; or (2) the applicant's activity has received previous authorization under section 7 or section 10 of the Endangered Species Act and that authorization addressed storm water discharges and/or BMPs to control storm water runoff (e.g. developer included impact of the entire project in consultation over a wetlands dredge and fill permit under Section 7 of the Endangered Species Act); or (3) the applicant's activity was considered as part of a larger, more comprehensive assessment of impacts on endangered and threatened species under section 7 or section 10 of The Endangers Species Act that which accounts for storm water discharges and BMPs to control storm water runoff (e.g., where an area wide habitat conservation plan and section 10 permit is issued which addresses impacts from construction activities including those from storm water, or a National Environmental Policy Act (NEPA) review is conducted which incorporates ESA section 7 procedures); or (4) consultation under section 7 of the Endangered Species Act is conducted for the applicant's activity which results in either a no jeopardy opinion or a written concurrence on a finding of a no likelihood of adverse effects: or (5) the applicant's activity was considered as part of a larger, more comprehensive site-specific assessment of impacts on endangered and threatened species by the owner or other operator of the site and that owner or operator certified eligibility under item (1), (2), (3), or (4) above (e.g., owner was able to certify no adverse impacts for the project as a whole under item (1), so the contractor can the certify under item (5).

The State of Arkansas notes that it is requiring all applicants to follow directions to ensure protection of the listed species and critical habitat when applying for permit coverage. Those directions require that applicants assess the impacts of their "storm water discharges" and "BMPs to control storm water run off" on listed species and critical habitat that are located "proximity" to those discharges and BMPs are planned or are to be constructed. This definition reflects the purpose of this permit which regulates storm water discharges and measures (i.e., BMPs) to control those discharges. For a list of endangered or threatened species contact Arkansas Natural Heritage Commission or the U.S. Fish and Wildlife Service.

C. Requiring an Individual NPDES Permit or an Alternative General Permit.

1. The Director may require any person authorized by this permit to apply for and obtain either an individual NPDES permit or an alternative NPDES general permit. Any interested person may petition the Director to take action under this paragraph. The Director may require any owner or operator authorized to discharge under this permit to apply for an individual NPDES permit only if the owner or operator has been notified in writing that a permit application is required. This notice shall include a brief statement of the reasons for this decision, an application form, a statement setting a deadline for the owner or operator to file the application, and a statement that on the effective date of the individual NPDES permit or the alternative general permit as it applies to the individual owner or operator, coverage under this general permit shall automatically terminate. The Director may grant additional time to submit the application upon request of the applicant. However, coverage under this permit will be terminated, if a owner or operator, fails to submit the Individual NPDES permit in a timely manner, as required by the Director.

2. Any owner or operator authorized by this permit may request to be excluded from the coverage of this permit by applying for an individual permit. The owner or operator shall submit an individual application in accordance with the requirements of 40 CFR 122.26(c)(1)(ii), with reasons supporting the request to the Director. The request may be granted by issuance of any individual permit or an alternative general permit if the reasons cited by the owner or operator are adequate to support the request.

3. When an individual NPDES permit is issued to a discharger otherwise subject to this permit, or the discharger is authorized to discharge under an alternative NPDES general permit, the applicability of this permit to the individual NPDES owner or operator is automatically terminated on the effective date of the individual permit or the date of authorization for coverage under the alternative general permit, whichever the case may be. When an individual NPDES permit is denied to an owner or operator otherwise subject to this permit, or the owner or operator is denied for coverage under an alternative NPDES general permit, the applicability of this permit to the individual NPDES owner or operator remains in effect, unless otherwise specified by the Director.

D. Authorization.

1. A owner or operator of a construction site must submit a Notice of Intent (NOI) in accordance with the requirements of Part II of this permit in order for storm water discharges

from construction sites to be authorized to discharge under this general permit. **An initial permit fee of $100.00 must accompany the NOI under the provisions of ADPCE Regulation No.9. Subsequent annual fees of $100.00 per year will be billed by the Department.** Failure to remit the required permit fee may be grounds for the Director to deny coverage under this general permit.

2. Where a new operator is selected after the submittal of an NOI under Part II, a new Notice of Intent must be submitted by the operator in accordance with Part II.

3. Unless notified by the Director to the contrary, dischargers who submit a Notice of Intent in accordance with the requirements of this permit are authorized to discharge storm water from construction sites under the terms and conditions of this permit 48 hours after the date the NOI is postmarked. Upon review of the NOI and other available information, the Director may deny coverage under this permit and require submittal of an application for an individual NPDES permit.

4. Facilities within the State of Arkansas discharging from outfalls described in this permit must be authorized to discharge by either this general permit or an individual NPDES permit.

PART II
NOTICE OF INTENT REQUIREMENTS

A. Deadlines for Notification.

1. Except as provided in paragraphs II.A.2 and II.A.3 individuals who intend to obtain coverage for storm water discharges from a construction site under this general permit, shall submit a Notice of Intent (NOI) in accordance with the requirements of this Part at least 48 hours prior to the commencement of construction at any site that will result in the disturbance of **five (5)** or more acres total land area.

2. For storm water discharges from construction sites where the operator changes, (including projects where an operator is selected after a NOI has been submitted under Part II.A.1 above), a NOI shall be submitted at least 48 hours prior to the operator beginning work at the site; and

3. A discharger is not precluded from submitting a NOI in accordance with the requirements of this part after the dates provided in Parts II.A.1 or II.A.2 of this permit. In such instances, the Director may bring an enforcement action for failure to submit a NOI in a timely manner or for any unauthorized discharges of storm water associated with industrial activity that have occurred on or after the dates specified in Parts II.A.1 and II.A.2.

B. Failure to Notify. Owner or operator who fail to notify the Director of their intent to be covered under this permit, and who discharge pollutants to waters of the State without a NPDES permit, are in violation of the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended)

C. Contents of the Notice of Intent.

1. The Notice of Intent form must be the form obtained from ADPCE unless written approval is received for an optional form.

2. All Notices of Intent for coverage under this general permit must be signed in accordance with the provisions of 40 CFR 122.22, as adopted by reference in ADPCE Regulation No. 6, and Part V.H of this permit, and submitted to the Department by certified mail.

3. Owners and operators shall notify the Director upon permanent termination of discharge from their facilities. (See Part II.G)

D. Where to Submit.

1. Facilities which discharge storm water associated with industrial activity at construction sites

must submit signed original of the Notice of Intent to the Department at the following address:

NPDES Permits/Storm Water
Department of Pollution Control and Ecology
P.O. Box 8913
Little Rock, AR 72219-8913

2. **A copy of the NOI or other indication that storm water discharge from the site are covered under a NPDES permit, and a brief description (shall include permit number) of the project shall be posted at the construction site in a prominent place for public viewing (such as alongside a building permit).**

E. Additional Notification. Facilities which are operating under approved State or local sediment and erosion plans, grading plans, local storm water permits, or storm water management plans, in addition to filing copies of the Notice of Intent in accordance with paragraph II.D, shall submit signed copies of the Notice of Intent to the State or local agency approving such plans in accordance with the deadlines in Part II.A. of this permit (or sooner if required by State or local rules).

F. Reaffirmation of Permit Coverage. Upon reissuance of a new general permit, the owner or operator is required to notify the Director of his/her intent to be covered by the new general permit.

G. Notice of Termination (NOT). Where a site has been finally stabilized and all storm water discharges from construction activities authorized by this permit are eliminated, the operator of the facility may submit a Notice of Termination to the Director at the address in Part II.D that is signed in accordance with Part V.H of this permit. Final stabilization is not required if the land is returned to its pre-construction agriculture use. **If Notice of Termination is not submitted when project in completed, owners and contractors will be responsible for annual fees due.**

PART III
SPECIAL CONDITIONS, MANAGEMENT PRACTICES, AND OTHER NON-NUMERIC LIMITATIONS

A. Prohibition of Non-storm Water Discharges.

1. Except as provided in paragraphs I.B.2 and III.A.2, all discharges covered by this permit shall be composed entirely of storm water;

2. a. Except as provided in paragraph III.A.2.(b), discharges of material other than storm water must be in compliance with a NPDES permit (other than this permit) issued for the discharge.

   b. The following non-storm water discharges may be authorized by this permit: discharges from fire fighting activities; fire hydrant flushings; water used to wash vehicles or control dust in accordance with Part III.C.4.b.(3)(b); potable water sources including waterline flushings; irrigation drainage; routine external building wash down which does not use detergents; pavement washwaters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled materials have been removed) and where detergents are not used; air conditioning condensate; springs; uncontaminated ground water; and foundation or footing drains where flows are not contaminated with process materials such as solvents.

B. Releases in Excess of Reportable Quantities.

1. The discharge of hazardous substances or oil in the storm water discharge(s) from a facility shall be prevented or minimized in accordance with the applicable storm water pollution prevention plan for the facility. This permit does not relieve the owner or operator of the reporting requirements of 40 CFR Parts 110, 117 and 302. Where a release containing a hazardous substance or oil in an amount equal to or in excess of a reporting quantity established under either 40 CFR 110, 40 CFR 117, or 40 CFR 302, occurs during a 24-hour period, the following action shall be taken:

   a. Any person in charge of the facility is required to notify the National Response Center (NRC) (800-424-8802) in accordance with the requirements of 40 CFR 110, 40 CFR 117, or 40 CFR 302 as soon as he/she has knowledge of the discharge;

   b. The Owner or operator shall submit within 14 calendar days of knowledge of the release a written description of the release (including the type and estimate of the amount of material released), the date that such release occurred, the circumstances leading to the release, and steps to be taken in accordance with Part III.B.1.c of this permit to ADPCE at the address provided in Part II.D of this permit.

c. The storm water pollution prevention plan described in Part III.C of this permit must be modified within 14 calendar days of knowledge of the release to:

(1) provide a description of the release and the circumstances leading to the release;

(2) the date of the release;

d. Additionally, the plan must be reviewed to identify measures to prevent the reoccurrence of such releases and to respond to such releases, and the plan must be modified where appropriate. The modified plan must be sent to this Department for review.

2. Spills. This permit does not authorize the discharge of hazardous substances or oil resulting from an on-site spill.

C. Responsibilities of operators

Permittees with operational control are responsible for compliance with all applicable terms and conditions of this permit as it relates to their activities on the construction site, including protection of endangered species and implementation of BMPs and other controls required by the SWPPP.

D. Storm Water Pollution Prevention Plans.

A storm water pollution prevention plan shall be developed for each construction site covered by this permit. Storm water prevention plans shall be prepared in accordance with good engineering practices. The plan shall identify potential sources of pollution which may reasonably be expected to affect the quality of storm water discharges associated with industrial activity from the facility. In addition, the plan shall describe and ensure the implementation of practices which are to be used to reduce pollutants in storm water discharges associated with industrial activity at the facility and to assure compliance with the terms and conditions of this permit. Facilities must implement the provisions of the storm water pollution prevention plan required under this part as a condition of this permit.

1. Deadlines for Plan Preparation and Compliance. The plan shall:

a. Be completed prior to the submittal of a NOI to be covered under this permit and updated as appropriate.

2. Signature and Plan Review.

a. The plan shall be signed in accordance with Part V.H, and be retained on-site at the facility which generates the storm water discharge in accordance with Part IV (retention of records) of this permit.

b. The owner or operator shall make plans available upon request to the Director, to a State or local agency approving sediment and erosion plans, grading plans, or storm water management plans, or, in the case of a storm water discharge associated with industrial activity which discharges through a municipal separate storm sewer system with a NPDES permit, to the municipal operator of the system.

c. The Director, or authorized representative, may notify the owner or operator at any time that the plan does not meet one or more of the minimum requirements of this Part. Within 7 days of such notification from the Director, (or as otherwise provided by the Director), or authorized representative, the owner or operator shall make the required changes to the plan and submit to the Director a written certification that the requested changes have been made.

3. Keeping Plans Current. The owner or operator shall amend the plan whenever there is a change in design, construction, operation, or maintenance which has a significant affect on the potential for the discharge of pollutants to the waters of the State and which has not otherwise been addressed in the plan or if the storm water pollution prevention proves to be ineffective in eliminating or significantly minimizing pollutants from sources identified under Part III.C.4.b of this permit, or in otherwise achieving the general objectives of controlling pollutants in storm water discharges associated with industrial activity. Amendments to the plan may be reviewed by ADPCE in the same manner as Part III.C.2 above.

4. Contents of Plan. The storm water pollution prevention plan shall include the following items:

a. Site Description. Each plan shall provide a description of the following:

(1) a description of the nature of the construction activity;

(2) a description of the intended sequence of major activities which disturb soils for major portions of the site (e.g. grubbing, excavation, grading);

(3) estimates of the total area of the site and the total area of the site that is expected to be disturbed by excavation, grading or other activities;

(4) an estimate of the runoff coefficient of the site after construction activities are

completed and existing data describing the soil or the quality of any discharge from the site;

(5) a site map indicating drainage patterns and approximate slopes anticipated after major grading activities, areas of soil disturbance, the location of major structural and nonstructural controls identified in the plan, the location where stabilization practices are expected to occur, surface waters (including wetlands), and locations where storm water is discharged to a surface water; and

(6) the name of the receiving water(s), or if the discharge is to a municipal separate storm sewer, the name of the operator of the municipal system, the ultimate receiving water(s), and the extent of wetland acreage at the site.

(7) Endangered Species

Information on endangered and threatened species including whether any endangered species are in proximity of the storm water discharge and BMPs to be constructed to control storm water runoff.

b. Controls. Each plan shall include a description of appropriate controls and measures that will be implemented at the construction site. The plan will clearly describe for each major activity identified in Part III.C.4.a.(2) appropriate control measures and the timing during the construction process that the measures will be implemented. (For example, perimeter controls for one portion of the site will be installed after the clearing and grubbing necessary for installation of the measure, but before the clearing and grubbing for the remaining portions of the site. Perimeter controls will be actively maintained until final stabilization of those portions of the site upward of the perimeter control. Temporary perimeter controls will be removed after final stabilization). The description and implementation of controls shall address the following minimum components:

(1) Erosion and Sediment Controls.

(a) Stabilization practices. A description of interim and permanent stabilization practices, including site-specific scheduling of the implementation of the practices. Site plans should ensure that existing vegetation is preserved where attainable and that disturbed areas are stabilized. Stabilization practices may include: temporary seeding, permanent seeding, mulching, geotextiles, sod stabilization, vegetative buffer strips, protection of trees, and preservation of mature vegetation and other appropriate measures. A record of the dates when major grading activities occur, when construction activities temporarily or permanently cease on a portion of the site, and when stabilization measures are initiated shall be included in the plan. Except as provided in paragraphs III.C.1.b.(1)(a)(i)and(ii)below, stabilization measures shall be initiated as soon as practicable in portions of the site where construction activities have temporarily or permanently ceased, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased.

(i) where the initiation of stabilization measures by the 14th day after construction activity temporarily or permanently ceases is precluded by snow cover, stabilization measures shall be initiated as soon as practicable.

(ii) where construction activity will resume on a portion of the site within 21 days from when activities ceased, (e.g. the total time period that construction activity is temporarily ceased is less than 21 days) then stabilization measures do not have to be initiated on that portion of the site by the 14th day after construction activity temporarily ceased.

(iii) in arid regions (areas with an average annual rainfall of 0-10 inches) and semi-arid regions (areas with an average annual rainfall of 10-20 inches), where the initiation of stabilization measures by the 14th day after construction activity has been temporarily or permanently ceased is precluded by seasonal arid conditions, stabilization measures shall be initiated as soon as practicable thereafter.

(b) structural practices.

(i) A description of structural practices to divert flows from exposed soils, store flows or otherwise limit runoff and the discharge of pollutants from exposed areas of the site to the degree attainable. Such practices may include:

- silt fences
- earth dikes
- drainage swales
- check dams
- subsurface drains
- pipe slope drains
- level spreaders
- storm drain inlet protection
- rock outlet protection

- sediment traps
- reinforced soil retaining systems
- gabions
- temporary or permanent sediment basins.

Structural practices should be placed on upland soils to the degree attainable. The installation of these devices may be subject to Section 404 of the Clean Water Act.

(ii) For common drainage locations that serve an area with 10 or more disturbed acres at one time, a temporary or permanent detention basin based on either the smaller of 3600 cubic feet per area, or a size based on the runoff volume of a 10 year, 24 hour storm, shall be provided where attainable until stabilization of the site. This does not apply to flows from offsite areas and flows from onsite areas and flows from onsite areas that are either undisturbed of have undergone final stabilization where such flows are diverted around the sediment basin. For drainage locations which serve 10 or more disturbed acres at one time and where a temporary sediment basin based on either the smaller of 3600 cubic feet per acres, or a size based on the runoff volume of a 10 year storm, is not attainable, sediment traps, silt fences, or equivalent sediment controls are required for all side slope and down slope boundaries of the construction area.

(iii) For drainage locations serving less than 10 acres, sediment traps, silt fences, or equivalent sediment controls are required for all side slope and down slope boundaries of the construction area unless a sediment basin providing storage based on either the smaller of 3600 cubic feet per area, or a size based on the run off volume of a 10 year, 24 hour storm is provided.

(2) Storm Water Management. A description of measures that will be installed during the construction process to control pollutants in storm water discharges that will occur after construction operations have been completed. Structural measures should be place on upland soils to the degree attainable. The installation of these devices may be subject to Section 404 of the Clean Water Act. This permit only addresses the installation of storm water management measures, and not the ultimate operation and maintenance of such structures after the construction activities have been completed and the site has undergone final stabilization. Owner or operators are only responsible for the installation and maintenance of storm water management

measures prior to final stabilization of the site, and are not responsible for maintenance after storm water discharges associated with industrial activity have been eliminated from the site.

(a) Such practices may include:

- infiltration of runoff onsite
- flow attenuation by use of open vegetated swales and natural depressions
- storm water retention structures
- storm water detention structures (including wet ponds)
- sequential systems, which combine several practices

A goal of 80 percent removal of total suspended solids from these flows which exceed predevelopment levels should be used in designing and installing storm water management controls (where practicable). Where this goal is not met, the owner or operator shall provide justification for rejecting each practice listed above based on site conditions.

(b) Velocity dissipation devices shall be placed at discharge locations and along the length of any outfall channel as necessary to provide a non-erosive velocity flow from the structure to a water course so that the natural physical and biological characteristics and functions are maintained and protected.

(3) <u>Other Controls</u>.

(a) <u>waste disposal</u>. No solid materials, including building materials, shall be discharged to waters of the United States, except as authorized by a Section 404 permit.

(b) Off-site vehicle tracking of sediments and the generation of dust shall be minimized.

(c) The plan shall ensure and demonstrate compliance with applicable State or local waste disposal, sanitary sewer or septic system regulations.

(4) <u>Approved State or Local Plans</u>.

(a) Facilities which discharge storm water associated with industrial activity from construction activities must include in their storm water pollution prevention plan procedures and requirements specified in applicable sediment and erosion site plans, site permits or storm water management plans approved by State or local officials. Requirements specified in sediment and erosion plans, site permits or storm water management plans approved by State or local officials that are applicable to protecting surface water are, upon submittal of an NOI for coverage under this permit, incorporated by reference and are enforceable under this permit even if they are not specifically included in a storm water pollution prevention plan required under this permit. This provision does not apply to provisions of master plans, comprehensive plans, non-enforceable guidelines or technical guidance documents that are not identified in a specific plan or permit that is issued for the construction site.

(b) dischargers seeking alternative permit requirements shall submit an individual permit application in accordance with Part I.C of this permit to the Director, along with a description of why requirements in approved State or local plans or permits should not be applicable as a condition of an NPDES permit.

(5) Maintenance. A description of procedures to maintain in good and effective operating condition vegetation, erosion and sediment control measures and other protective measures identified in the site plan.

(6) Inspections. Qualified personnel (provided by the discharger) shall inspect disturbed areas of the construction site and areas used for storage of materials that are exposed to precipitation that have not been finally stabilized, structural control measures and locations where vehicles enter or exit the site at least once every seven (7) calendar days and within 24 hours of the end of a storm that is 0.5 inches or greater. Where sites have been finally stabilized, or during seasonal arid periods in arid areas (areas with an average rainfall of 0-10 inches) and semi-arid areas (areas with an average rainfall of 10-20 inches) such inspection shall be conducted at least once every month.

(a) disturbed areas and areas used for material storage that are exposed to precipitation shall be inspected for evidence of, or the potential for, pollutants entering the drainage system. Erosion and sediment control measures identified in the plan shall be observed to ensure that they are operating correctly. Where discharge locations or points are accessible, they shall be inspected to ascertain whether erosion control measures are effective in preventing significant impacts to receiving waters. Locations where vehicles enter or exit the site shall be inspected for evidence of offsite sediment tracking.

(b) based on the results of the inspection, the site description identified in the plan in accordance with paragraph III.C.4.a of this permit and pollution prevention measures identified in the plan in accordance with paragraph III.C.4.b of this permit shall be revised as appropriate, but in no case more than 7 calendar days following the inspection. Such modifications shall provide for timely implementation of any changes to the plan within 7 calendar days following the inspection.

(c) A report summarizing the scope of the inspection, name(s) and qualifications of personnel making the inspection, the date(s) of the inspection, major observations relating to the implementation of the storm water pollution prevention plan, and actions taken in accordance with paragraph III.C.4.b.(6)(b) of the permit shall be made and retained as part of the storm water pollution prevention plan for at least three (3) years from the date the site is finally stabilized. The report shall be signed in accordance with Part V.H of this permit.

5. Non-storm water discharges. Except for flows from fire fighting activities, sources of non-storm water listed in Part III.A.2 of this permit that are combined with storm water discharges associated with industrial activity must be identified in the plan. The plan shall identify and ensure the implementation of appropriate pollution prevention measures for the non-storm water component(s) of the discharge.

E. Contractors.

1. The storm water pollution prevention plan must clearly identify for each measure identified in the plan, the contractor(s) that will implement the measure. All contractors identified in the plan must sign a copy of the certification statement required by Part III.D.2 below in accordance with Part V.H. of this permit. All certifications must be included in the storm water pollution prevention plan.

2. Certification statement. All contractors identified in the storm water pollution prevention plan in accordance with Part III.D.1 of this permit shall sign a copy of the following certification statement before conducting any professional service at the site identified in the storm water pollution prevention plan:

"I certify under penalty of law that I understand the terms and conditions of the general National Pollutant Discharge Elimination System (NPDES) permit that authorizes the storm water discharges associated with industrial activity from the construction site identified as part of this certification."

The certification must include the name and title of the person providing the signature in accordance with Part V.H of this permit; the name, address, and telephone number of the contracting firm; the address (or other identifying description) of the site; and the date the certification is made.

PART IV
RETENTION OF RECORDS

A. The owner or operator shall retain records of all storm water pollution prevention plans and all reports required by this permit, and records of all data used to complete the Notice of Intent to be covered by this permit, for a period of at least three years from the date the site is finally stabilized. This period may be extended by request of the Director at any time.

B. The owner or operator shall retain a copy of the storm water pollution prevention plan required by this permit at the construction site from the date of project initiation to the date of final stabilization.

PART V
STANDARD PERMIT CONDITIONS

A. Duty to Comply. The owner or operator must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the federal Clean Water Act and the Arkansas Water and Air Pollution Control Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application.

B. Penalties for Violations of Permit Conditions. The Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended) provides that any person who violates any provisions of a permit issued under the Act shall be guilty of a misdemeanor and upon conviction thereof shall be subject to imprisonment for not more than one (1) year, or a fine of not more than twenty five thousand dollars ($25,000) or by both such fine and imprisonment for each day of such violation. Any person who violates any provision of a permit issued under the Act may also be subject to civil penalty in such amount as the court shall find appropriate, not to exceed ten thousand dollars ($10,000) for each day of such violation. The fact that any such violation may constitute a misdemeanor shall not be a bar to the maintenance of such civil action.

C. Continuance of the Expired General Permit. An expired general permit continues in force and effect until a new general permit is issued.

D. Need to Halt or Reduce Activity Not a Defense. It shall not be a defense for a owner or operator in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

E. Duty to Mitigate. The owner or operator shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has reasonable likelihood of adversely affecting human health or the environment.

F. Duty to Provide Information. The owner or operator shall furnish to the Director, an authorized representative of the Director, a State or local agency approving sediment and erosion plans, grading plans, or storm water management plans, or in the case of a storm water discharge associated with industrial activity which discharges through a municipal separate storm sewer system with an NPDES permit, to the municipal operator of the system, within a reasonable time, any information which is requested to determine compliance with this permit.

G. Other Information. When the owner or operator becomes aware that he or she failed to submit any relevant facts or submitted incorrect information in the Notice of Intent or in any other report to the Director, he or she shall promptly submit such facts or information.

H. Signatory Requirements. All Notices of Intent, reports, or information submitted to the

Director or the operator of a large of medium municipal separate storm sewer system shall be signed and certified.

1. All Notices of Intent shall be signed as follows:

   a. For a corporation: by a responsible corporate officer. For purposes of this section, a responsible corporate officer means:

      (1) a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation; or

      (2) the manager or one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding $25 million (in second quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

   b. For a partnership or sole proprietorship: by a general partner or the proprietor, respectively; or

   c. For a municipality, State, Federal or other public agency: By either a principal executive or ranking elected official. for purposes of this section, a principal executive officer of a Federal agency includes:

      (1) the chief executive officer of the agency; or

      (2) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency.

2. All reports required by the permit and other information requested by the Director shall be signed by a person described above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

   a. the authorization is made in writing by a person described above and submitted to the Director;

   b. the authorization specifies either an individual or a person having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a well or a well field, superintendent, or position of equivalent responsibility, or position of equivalent responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position); and

c. changes to authorization. If an authorization under this Part is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the above requirements must be submitted to the Director prior to or together with any reports, information, or applications to be signed by an authorized representative.

I. Certification. Any person signing a document under this section shall make the following certification:

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

J. Penalties for Falsification of Reports. The Arkansas Water and Air Pollution Control Act provides that any person who knowingly makes any false statement, representation, or certification in any application, record, report, plan or other document filed or required to be maintained under this permit shall be subject to civil penalties specified in Part V.B of this permit and/or criminal penalties under the authority of the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended).

K. Penalties for Tampering. The Arkansas Water and Air Pollution Control act provides that any person who falsifies, tampers with, or knowingly renders inaccurate, any monitoring device or method required to be maintained under the Act shall be guilty of a misdemeanor and upon conviction thereof shall be subject of imprisonment for not more than one (1) year or a fine of not more than twenty five thousand ($25,000) or by both such fine and imprisonment.

L. Oil and Hazardous Substance Liability. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the owner or operator from any responsibilities, liabilities, or penalties to which the owner or operator is or may be subject under Section 311 of the Clean Water Act or Section 106 of CERCLA.

M. Property Rights. The issuance of this permit does not convey any property rights of any sort, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

N. Severability. The provisions of this permit are severable. If any provisions of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provisions to other circumstances, and the remainder of this permit, shall not be affected thereby.

O. Transfers. This permit is not transferable to any person except after notice to the Director. The Director may require the operator to apply for and obtain an individual permit or alternative general permit as stated in Part I.C.

P. Proper Operation and Maintenance. The owner or operator shall at all times:

1. properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the owner or operator to achieve compliance with the conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar systems which are installed by a owner or operator only when the operation is necessary to achieve compliance with the conditions of the permit.

2. provide an adequate operating staff which is duly qualified to carry out operation, maintenance and testing functions required to insure compliance with the conditions of this permit.

Q. Inspection and Entry. The owner or operator shall allow the Director or an authorized representative, or, in the case of a construction site which discharges to a municipal separate storm sewer, an authorized representative of the municipal operator of the separate sewer system receiving the discharge, upon the presentation of credentials and other documents as may be required by law, to:

a. enter upon the owner or operator's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

b. have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

c. inspect at reasonable times any facilities or equipment (including monitoring and control equipment);

R. Permit Actions. This permit may be modified, revoked and reissued, or terminated for cause including, but not limited to, the following;

a. violation of any terms or conditions of this permit; or

b. obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

c. a change in any conditions that requires either a temporary or permanent reduction or elimination of the authorized discharge; or

d. a determination that the permitted activity endangers human health or the environment and can only be regulated to acceptable levels by permit modification or termination; or

e. failure of the owner or operator to comply with the provisions of ADPCE Regulation No. 9 (Permit Fees). Failure to promptly remit all required fees shall be grounds for the Director to initiate action to terminate this permit under the provisions of 40 CFR 122.64 and 124.5(d), as adopted by reference in ADPCE Regulation No. 6, and the provisions of ADPCE Regulation No. 8.

PART VI
REOPENER CLAUSE

A. If there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with industrial activity covered by this permit, the owner or operator of such discharge may be required to obtain an individual permit or an alternative general permit in accordance with Part I.C. of this permit or the permit may be modified to include different limitations and/or requirements.

B. Permit modification or revocation will be conducted in accordance with the provisions of 40 CFR 122.62, 122.63, 122.64 and 124.5, as adopted by reference in ADPCE Regulation No. 6.

PART VII
DEFINITIONS

"Best Management Practices (BMPs)" means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

"Commencement of Construction" means the initial disturbance of soils associated with clearing, grading, or excavating activities or other construction activities.

"CWA" means the Clean Water Act or the Federal Water Pollution Control Act.

"Dedicated portable asphalt plant" means a portable asphalt plant that is located on or contiguous to a construction site that provides asphalt only to the construction site on which the plant is located or adjacent to. The term does not include facilities that are subject to the asphalt emulsion effluent guideline limitations at 40 CFR Part 443.

"Dedicated portable concrete plant" means a portable concrete plant that is located on or contiguous to a construction site and that provides concrete only to the construction site on which the plant is located on or adjacent to.

"Director" means the Director, Arkansas Department of Pollution Control and Ecology, or a designated representative.

"Final stabilization" means that either:

(i) All soil disturbing activities at the site have been completed and a uniform (e.g., evenly distributed, without large bare areas) perennial vegetative cover with a density of 70% of the native background vegetation cover for the area has been established on all unpaved areas and areas not covered by permanent structures, or equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed. In some parts of the country, background native vegetation will cover less than 100% of the ground (e.g., arid areas, beaches). Establishing at least 70% of the natural cover of native vegetation meets the vegetative cover criteria for final stabilization (e.g., if the native vegetation covers 50% of the ground, 70% of 50% would require 35% total cover for final stabilization; on a beach with no natural vegetation, no stabilization is required); or

(ii) For construction projects on land used for agricultural purposes (e.g., pipeline across crop or range land), final stabilization may be accomplished by returning the disturbed land to its preconstruction agricultural use. Areas disturbed that were not previously used for agricultural activities, such as buffer strips immediately adjacent to "water of the United States", and areas which are not being returned to their preconstruction agricultural use must meet the final stabilization criteria in (i) or (ii) above.

"Flow-weighted composite sample" means a composite sample consisting of a mixture of aliquot collected at a constant time interval, where the volume of each aliquot is proportional to the flow rate of the discharge.

"Large and Medium municipal separate storm sewer system" means all municipal separate storm sewers that are either:

(i) located in an incorporated place with a population of 100,000 or more as determined by the latest Decennial Census by the Bureau of Census: or

(ii) located in the counties with unincorporated urbanized populations of 100,000 or more, except municipal, separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

(iii) owned or operated by a municipality other than those described in paragraphs (i) or (ii) and that are designated by the Director as part of the large or medium municipal separate storm sewer system.

"NOI" means Notice of Intent to be covered by this permit (see Part II of this permit).

"NOT" means Notice of Termination (see Part II.G of this permit).

"Point Source" means any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.

"Runoff coefficient" means the fraction of total rainfall that will appear at the conveyance as runoff.

"Storm Water" means storm water runoff, snow melt runoff, and surface runoff and drainage.

"Storm Water Associated with Industrial Activity from Construction Sites" means the discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing or raw materials storage areas at an industry. Discharges of storm water associated with industrial activity from construction sites (those areas that will result in the disturbance of five (5) or more acres of total land area),(henceforth referred to as storm water discharges from construction activities) occurring after the effective date where the construction activity commenced before the effective date).

APPENDIX 3
FORM 8

ADEQ

A R K A N S A S
Department of Environmental Quality

NOTICE OF INTENT
FOR DISCHARGES OF STORM WATER
ASSOCIATED WITH CONSTRUCTION ACTIVITY
AUTHORIZED UNDER NPDES GENERAL PERMIT ARR10A000

The enclosed form may be used to obtain coverage under NPDES general permit ARR10A000 for discharges of storm water associated with construction activity at any site or common plan of development or sale, that will result in the disturbance of five (5) acres or more total land area.

Return the completed form to:

Arkansas Department of Environmental Quality
NPDES Branch, Water Division
P. O. Box 8913
Little Rock, AR 72219

The following facilities are required to submit the Notice of Intent:

(1) Except as provided in paragraphs (2) and (3) below, individuals who intend to obtain coverage for storm water discharges from a construction site shall submit a Notice of Intent at least 48 hours prior to commencement of construction;

(2) Upon a pending transfer of ownership of a construction operation with a storm water discharge covered by this general permit, the new owner/operator must submit a Notice of Intent at least 48 hours prior to the new operator beginning work at the site;

(3) A discharger is not precluded from submitting a Notice of Intent at a later date as provided above. In such instances, the Director may bring an enforcement action for failure to submit a Notice of Intent in a timely manner or for any unauthorized discharges of storm water that have occurred on or after the dates specified in paragraphs (1) or (2) above.

Unless notified otherwise by the Director within 48 hours after the Notice of Intent is postmarked, owners and operators are authorized to discharge storm water associated with construction activity under the terms and conditions of the general permit

As required by ADEQ Regulation No. 9, you **will be billed an initial permit fee of $200.00 . Do not send any money with this NOI. Subsequent annual fees of $200.00** per year will be billed by the Department. Failure to remit the required permit fee may be grounds for the Director to deny coverage under this general permit, and to require the owner or operator to apply for an individual NPDES permit.

NOTE: DO NOT LEAVE BLANK SPACES IN THE NOTICE OF INTENT. IF ANY QUESTION DOES NOT APPLY, MARK "N/A" IN THE PROVIDED SPACE. ALSO, A STORM WATER POLLUTION PREVENTION PLAN (SWPPP) SHALL BE PREPARED PRIOR TO SUBMITTAL OF THIS NOI PER PART III.D.1 OF THE PERMIT (DO NOT SUBMIT PLANS WITH NOI).

Arkansas Department of Environmental Quality
NPDES Branch, Water Division
P. O. Box 8913
Little Rock, AR 72219
(501) 682-2199

NOTICE OF INTENT
FOR DISCHARGES OF STORM WATER RUNOFF
ASSOCIATED WITH CONSTRUCTION ACTIVITY
AUTHORIZED UNDER NPDES GENERAL PERMIT ARR10A000

I. PERMITTEE INFORMATION

Permittee Name: ______________________

Permittee Address: ______________________

____

City: ______________________

State: __________ Zip: __________

Permittee Type:

- ☐ PRIVATE
- ☐ STATE
- ☐ FEDERAL
- ☐ CORPORATION
- ☐ PUBLIC
- ☐ OTHER

Permittee Telephone Number: ______________________

II. COGNIZANT OFFICIAL (Person having responsibility for overall operation of project)

see Part V.H.1.a.(2), page 23 of permit.

Name: ______________________ Telephone: ______________________

Title: ______________________

III. CONTRACTOR, IF DIFFERENT FROM PERMITTEE (Operator with day to day operational control):

Name: ______________________ State: __________ Zip: __________

Address: ______________________ Telephone: ______________________

City: ______________________

IV. CONSTRUCTION SITE INFORMATION

Project Name: ______________________ Project Contact Person: ______________________

Project Location: ______________________ Project Address: ______________________

Project County: ______________________ Project City: ______________________

Section: ______________________ Zip: __________

Township: ______________________ Telephone Number: ______________________

Range: ______________________ Total amount of soil to be disturbed: __________
(estimate in Acres)

Facility Latitude: ____________________ Project Start Date: ____________________

Facility Longitude: ____________________ Project End Date: ____________________

V. DISCHARGE INFORMATION

Name of Receiving Stream (for discharges to surface waters): ____________________

Name of Receiving Municipality (for discharges to municipal storm sewer system): ____________________

Name of Ultimate Receiving Water: ____________________

NOTE: A STORM WATER POLLUTION PREVENTION PLAN (SWPPP) SHALL BE PREPARED PRIOR TO SUBMITTAL OF THIS NOI PER PART III. D. 1 OF THE PERMIT (DO NOT SUBMIT PLANS WITH NOI).

VI. CERTIFICATION OF PERMITTEE (See Part V.I, page 24 of the Permit)

"I certify that, if this facility is a corporation, it is registered with the Secretary of the State of Arkansas."

"I certify that a storm water pollution prevention plan has been prepared for this facility in accordance with Part III D of this permit, which provides for, or will provide for, compliance with approved state or local sediment and erosion plans, local storm water permits or storm water management plans, in accordance with Part III D. 4. (b)(4) of this permit."

"I certify that the cognizant official designated in this Notice of Intent is qualified to act as a duly authorized representative under the provisions of 40 CFR 122.22(b). If no cognizant official has been designated, I understand that the Department will accept reports signed only by the applicant. I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations." **Also, I certify that as a whole the storm water discharge(s), and the construction and implementation of Best Management Practices (BMP's) to control storm water runoff, are not likely to adversely affect species of critical habitat for a listed species."**

Typed or Printed Name: ____________________ Title: ____________________

Signature: ____________________ Date: ____________________

Initial fee of $200.00 will be billed by ADEQ effective 7/1/2001. Check Number: ________

APPENDIX 3
FORM 9

Arkansas Department of Environmental Quality
NPDES Branch, Water Division
P. O. Box 8913
Little Rock, AR 72219
(501) 682-2199

NOTICE OF TERMINATION
FOR DISCHARGES OF STORM WATER RUNOFF ASSSOCIATED WITH CONSTRUCTION ACTIVITY
AUTHORIZED UNDER NPDES GENERAL PERMIT ARR10A000

Permit Tracking Number to be Terminated: ARR10 ____________

I. PERMITTEE INFORMATION

Permitee Name: ________________________

Permitee Address: ________________________

City: ________________________

State: __________ Zip: __________

Telephone Number: ________________________

Permitee Type:

☐ Private ☐ State
☐ Federal ☐ Corporation
☐ Public ☐ Other

II. CONSTRUCTION SITE INFORMATION

Project Name: ________________________

Physical Location: ________________________

Project County: ________________________

Telephone Number: ________________________

Contact Person: ________________________

Project Address: ________________________

Project City: ________________________

State: __________ Zip: __________

Is the Contractor the same as permittee? ☐ yes ☐ no If no, write in appropriate information.

Name: ________________________

Address: ________________________

Telephone: ________________________

City: ________________________

State: __________ Zip: __________

III. PERMITTEE CERTIFICATION

"I certify under penalty of law that disturbed soils at the identified facility have been finally stabilized (at least 70 % of the disturbed soil has a perennial cover growing) and temporary erosion and sediment control measures have been removed or will be removed at an appropriate time, or that all storm water discharges associated with construction activities from the identified site that areauthorized by an NPDES general permit have been eliminated. I understand that by submitting this Notice of Termination that I amno longer authorized to discharge storm water by the general permit, and that discharging pollutants in storm water associated with construction activity to waters of the United States is unlawful under the Clean Water Act and the Arkansas Water and Air Pollution Control Act where the discharge is not authorized by an NPDES permit."

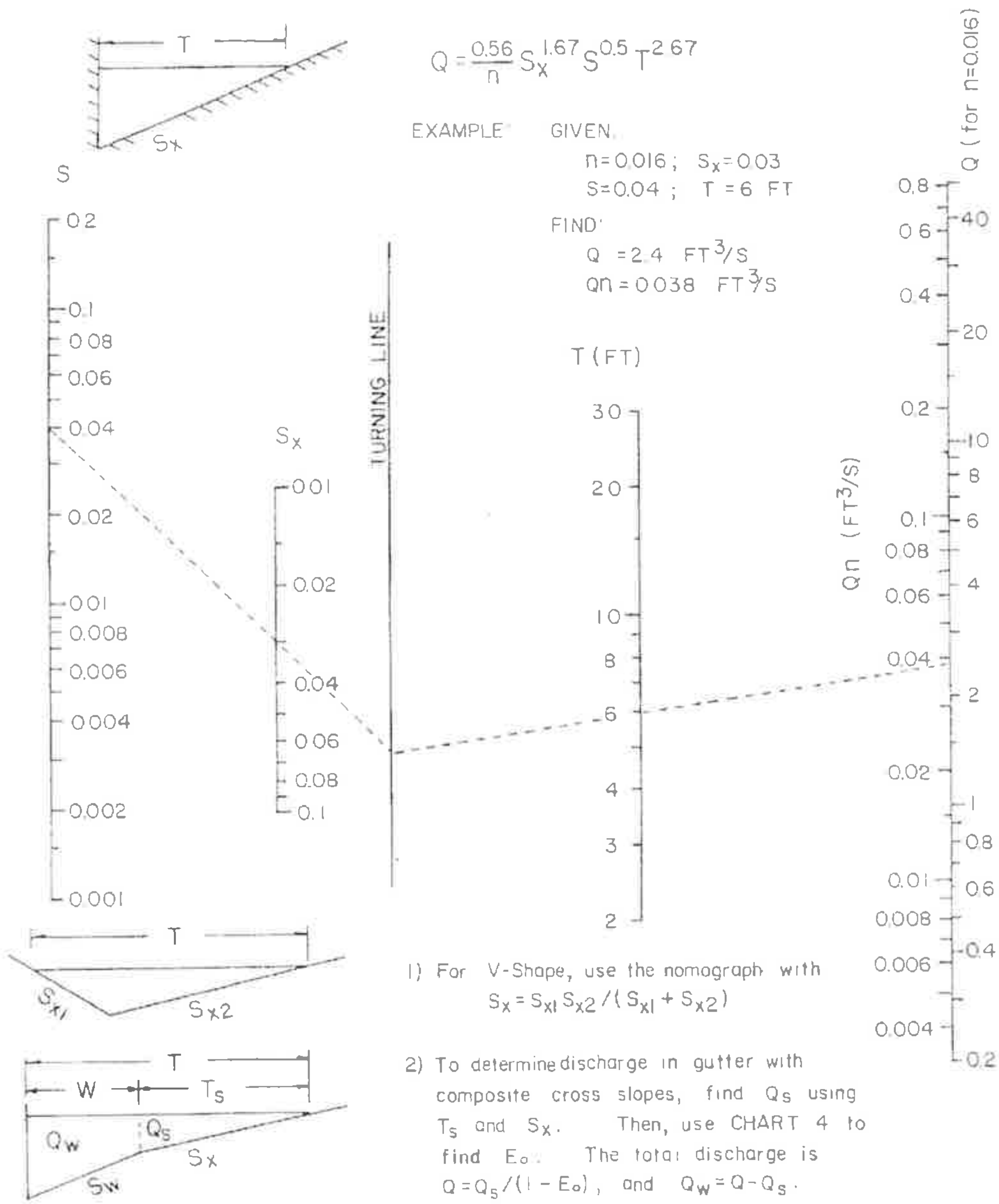
Typed or Printed Name: ________________________ Title: ________________________

Signature: ________________________ Date: ________________________

Appendix 4

Table of Contents

CHART 1B

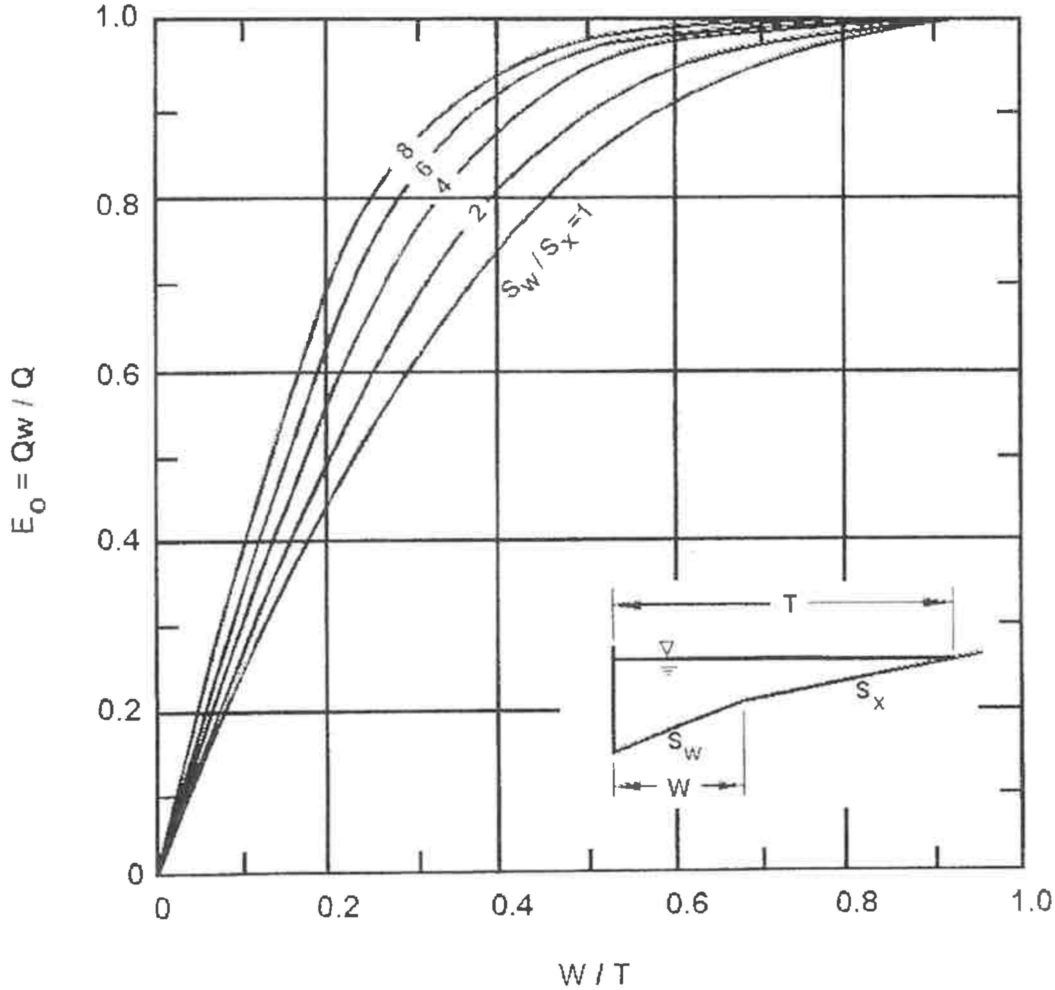


1) For V-Shape, use the nomograph with $S_x = S_{x1} S_{x2} / (S_{x1} + S_{x2})$

2) To determine discharge in gutter with composite cross slopes, find Q_s using T_s and S_x. Then, use CHART 4 to find E_o. The total discharge is $Q = Q_s/(1 - E_o)$, and $Q_w = Q - Q_s$.

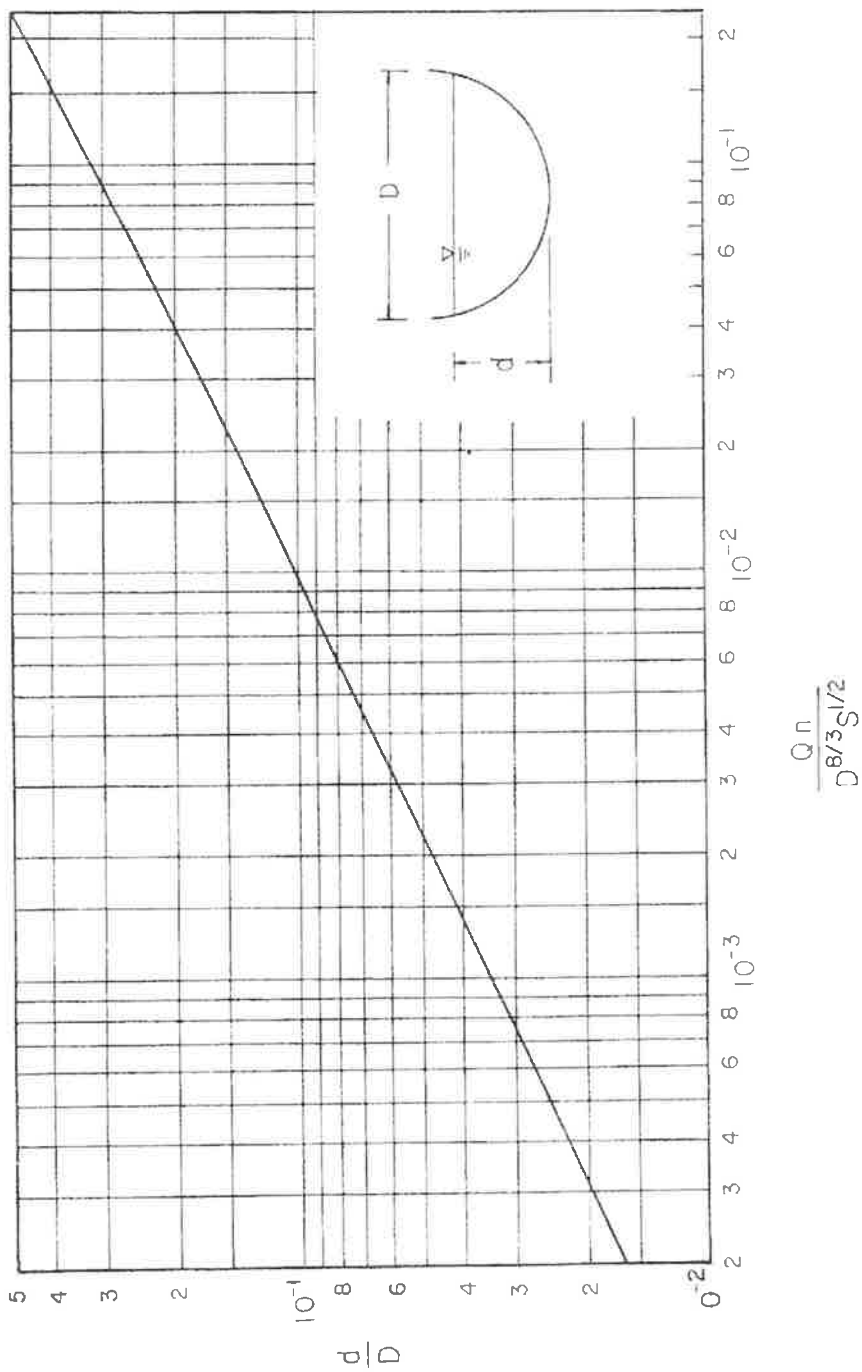
Flow in Triangular Gutter Sections - English Units

CHART 2B



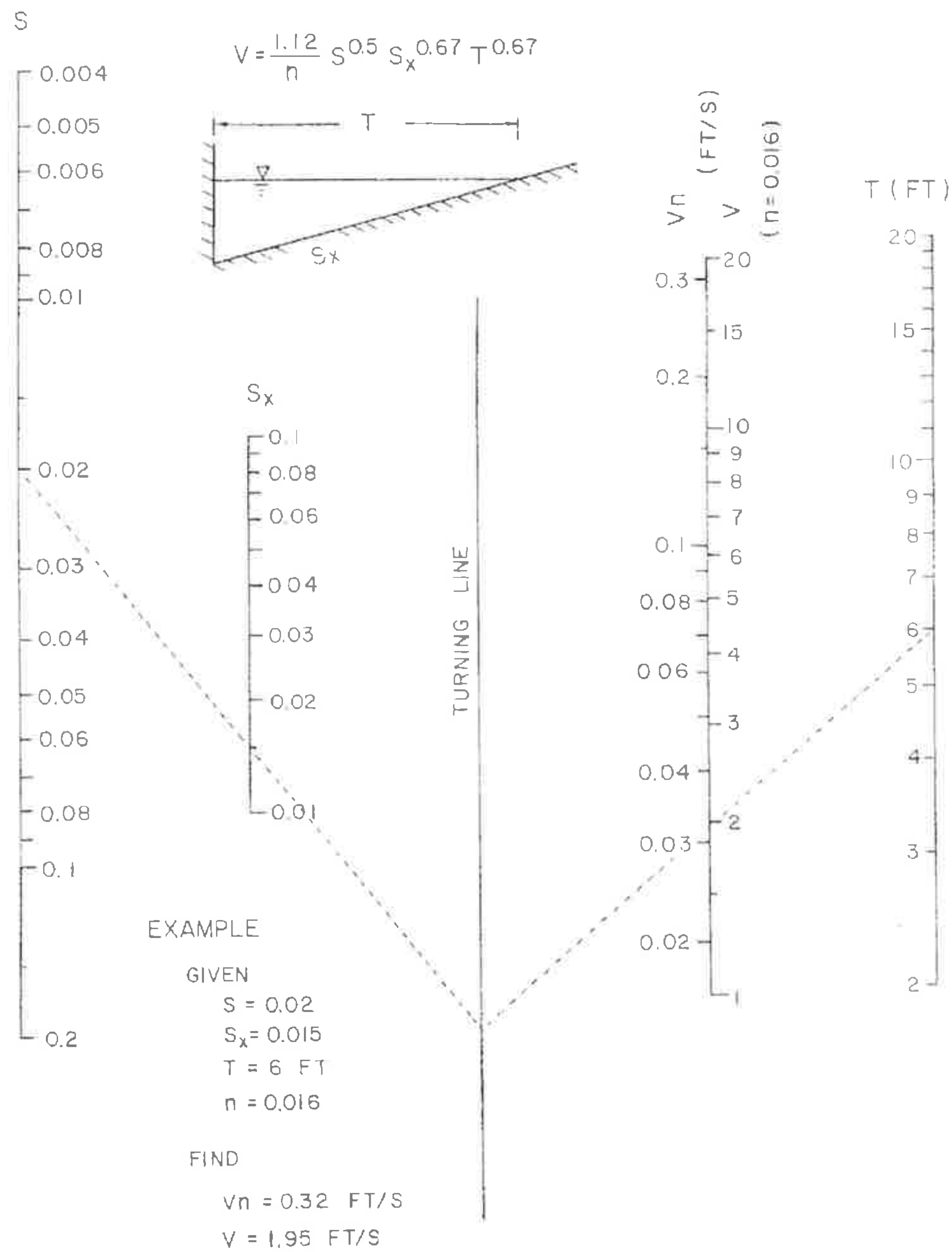
Ratio of Frontal Flow to Total Gutter Flow

CHART 3B



Conveyance in Circular Channels - English Units

CHART 4B



Velocity in Triangular Gutter Sections - English Units

CHART 5B

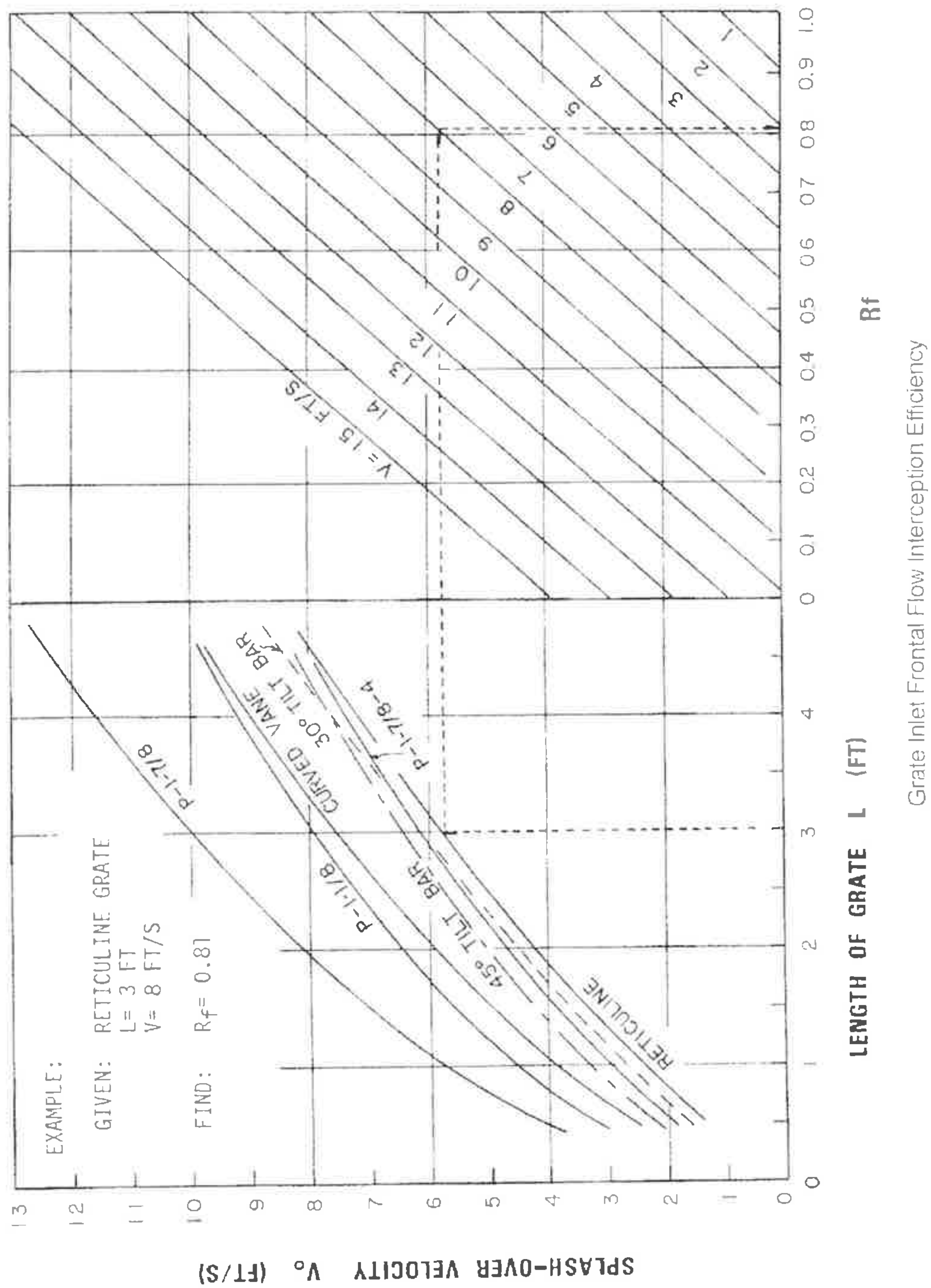
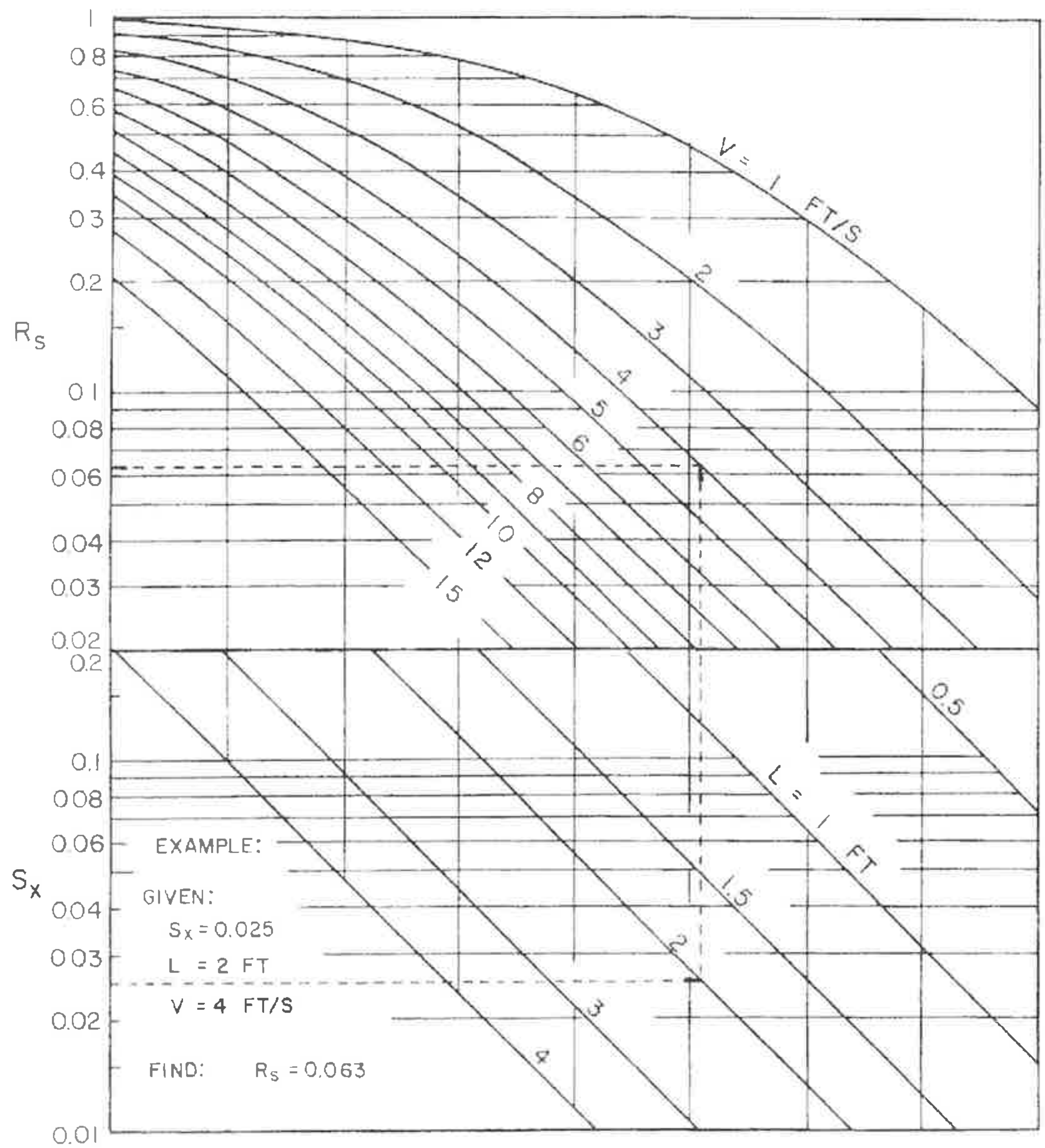
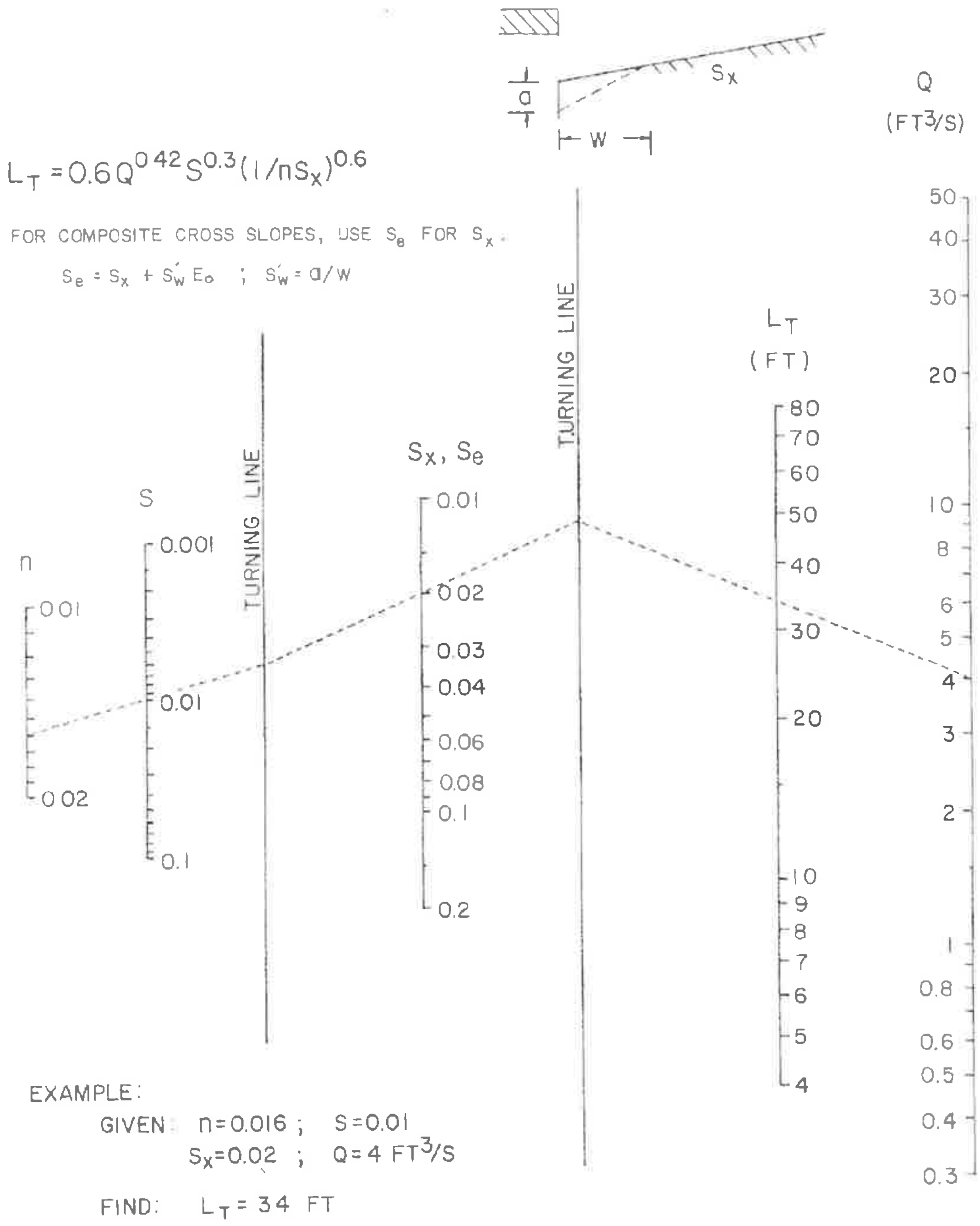

EXAMPLE:
GIVEN: RETICULINE GRATE
L= 3 FT
V= 8 FT/S
FIND: R_f= 0.81
V = 15 FT/S
P-1-7/8
CURVED VANE
30° TILT BAR
P-1-7/8-4
P-1-1/8
45° TILT BAR
RETICULINE
LENGTH OF GRATE L (FT)
SPLASH-OVER VELOCITY V_o (FT/S)
Rf
Grate Inlet Frontal Flow Interception Efficiency

CHART 6B



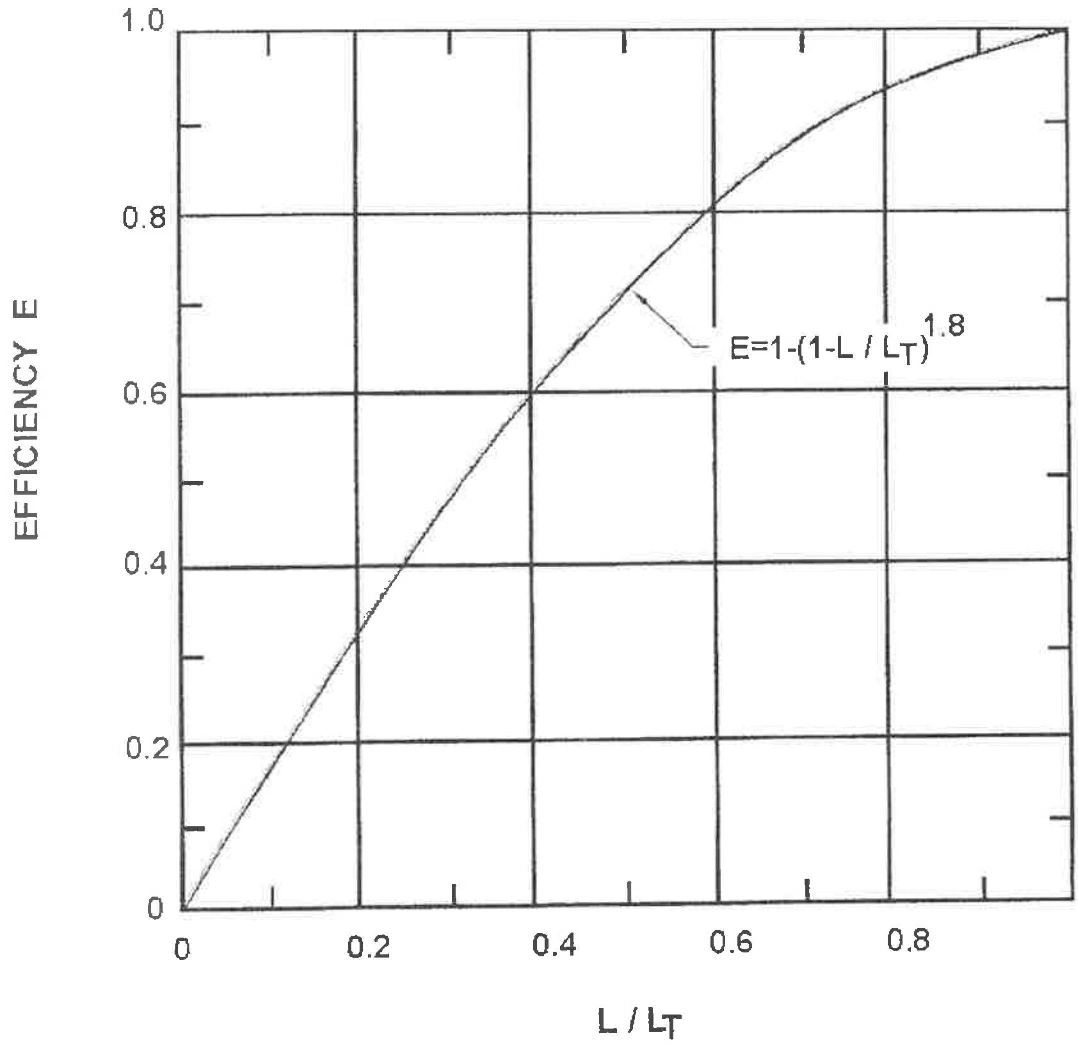
Grate Inlet Side Flow Intercept Efficiency

CHART 7B



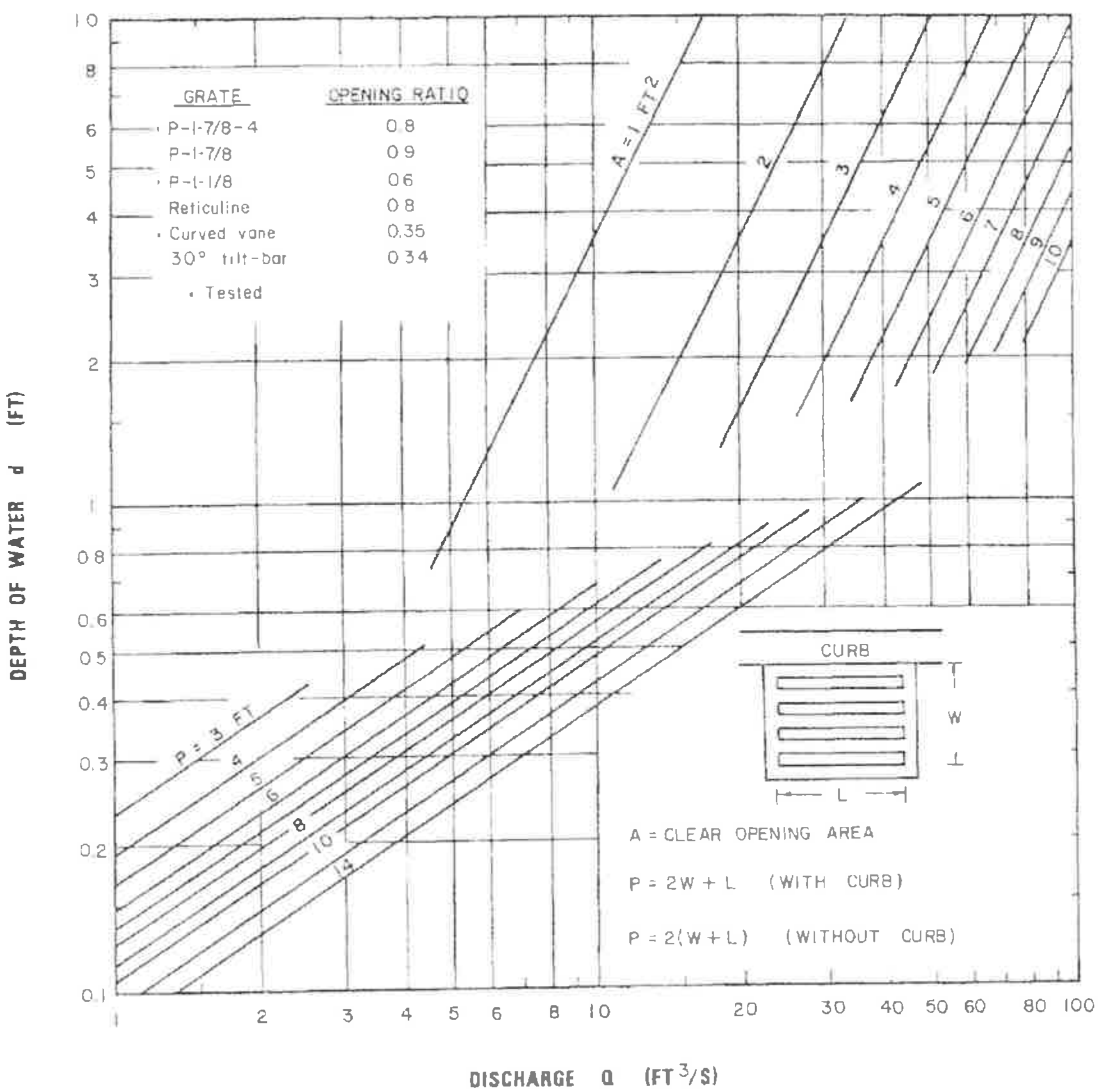
Curb-opening & Slotted Drain Inlet Length for Total Interception - English Units

CHART 8B



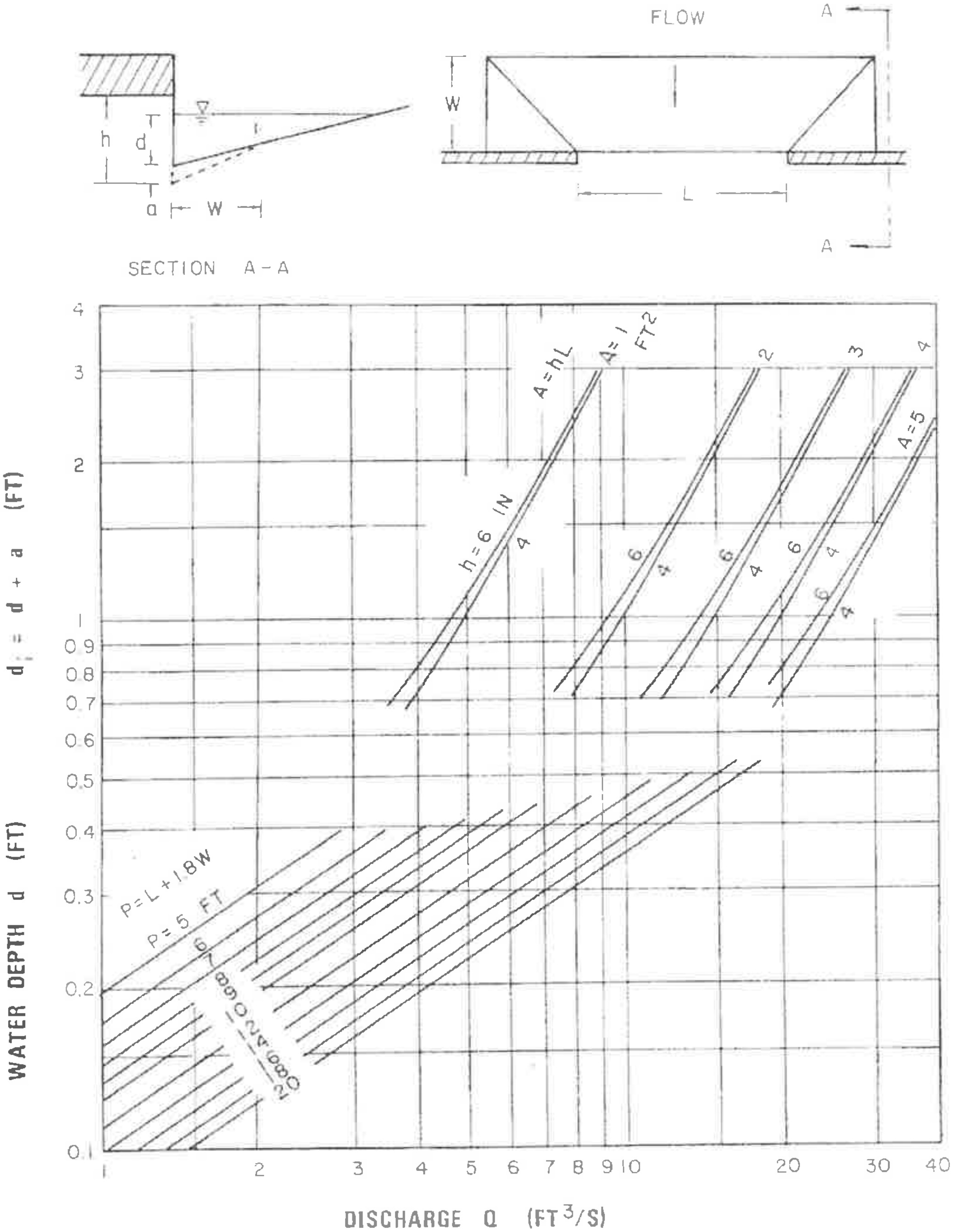
Curb-opening and Slotted Drain Inlet Interception Efficiency.

CHART 9B



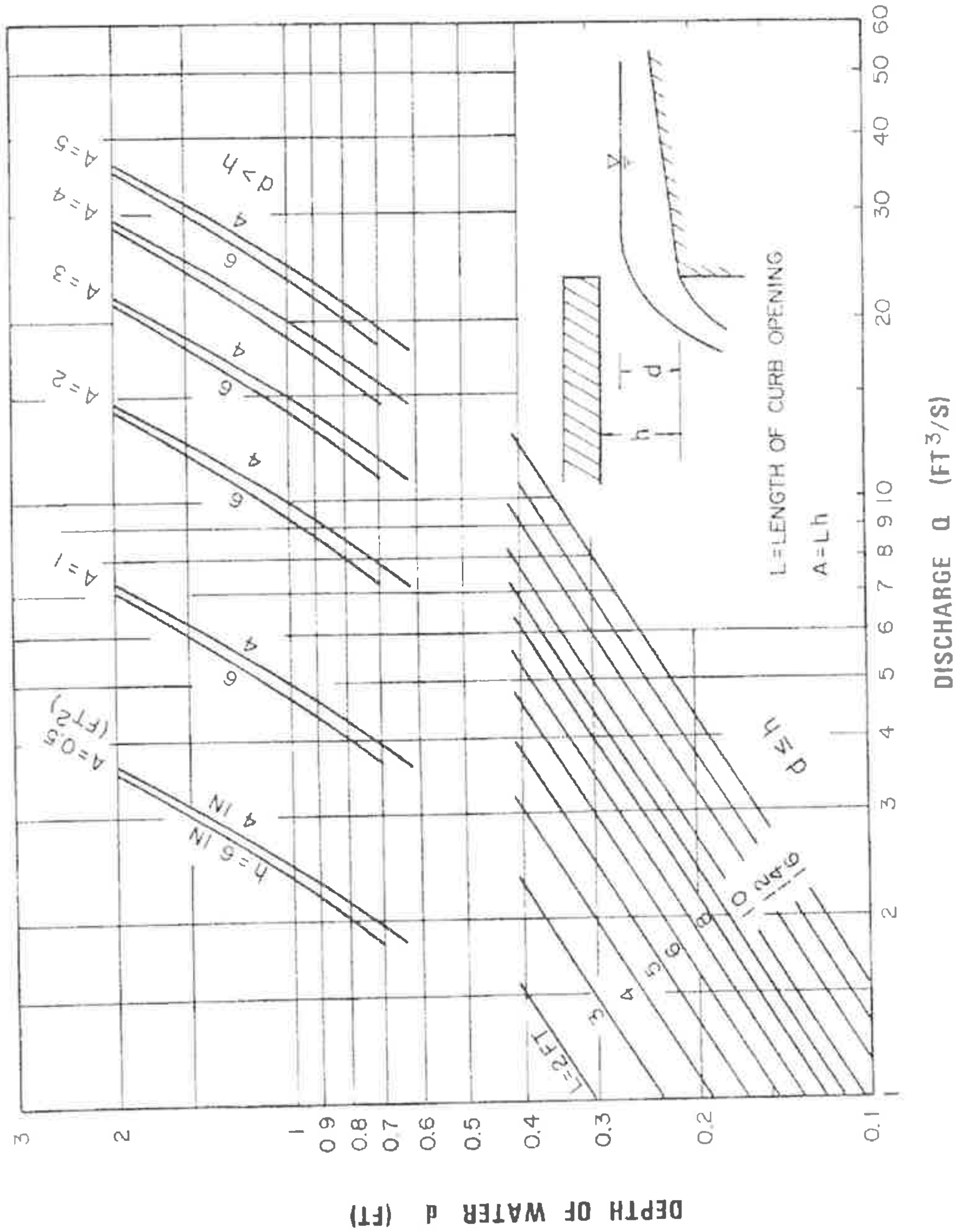
Grate Inlet Capacity in Sump Conditions - English Units

CHART 10B



Depressed Curb-opening Inlet Capacity in Sump Locations - English Units

CHART 11B



Undepressed Curb-opening Inlet Capacity in Sump Locations - English Units

APPENDIX 5

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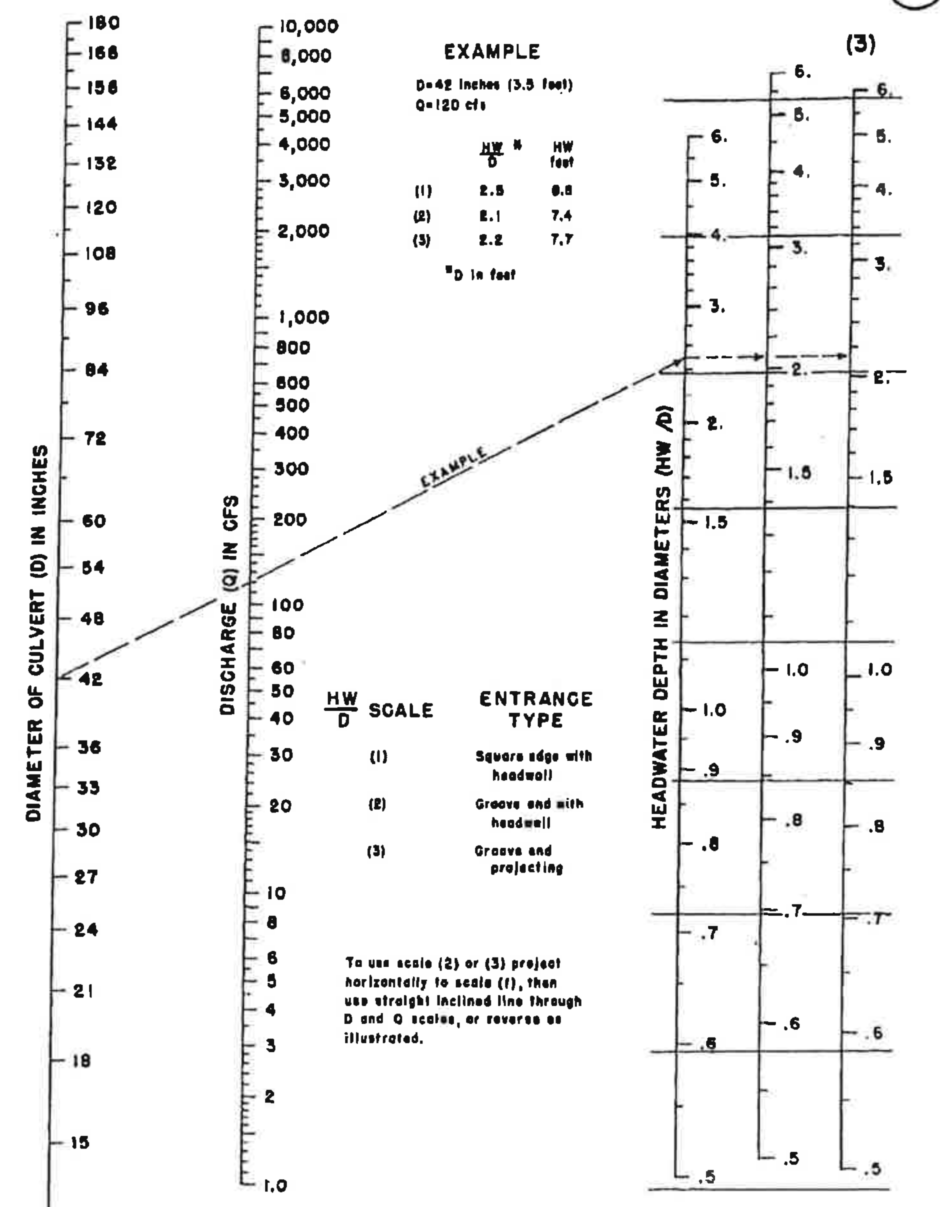
CHART 1B

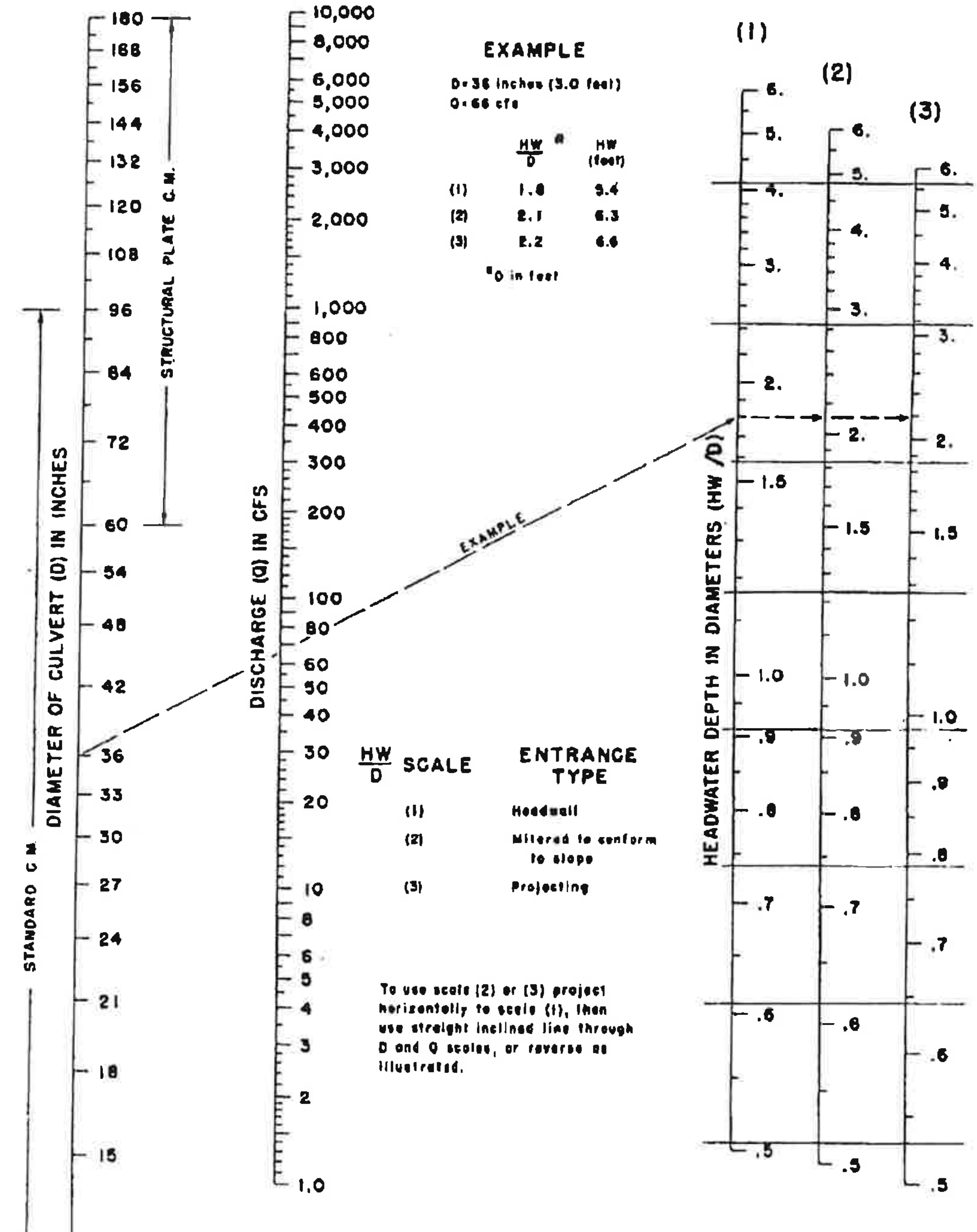


HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3 REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

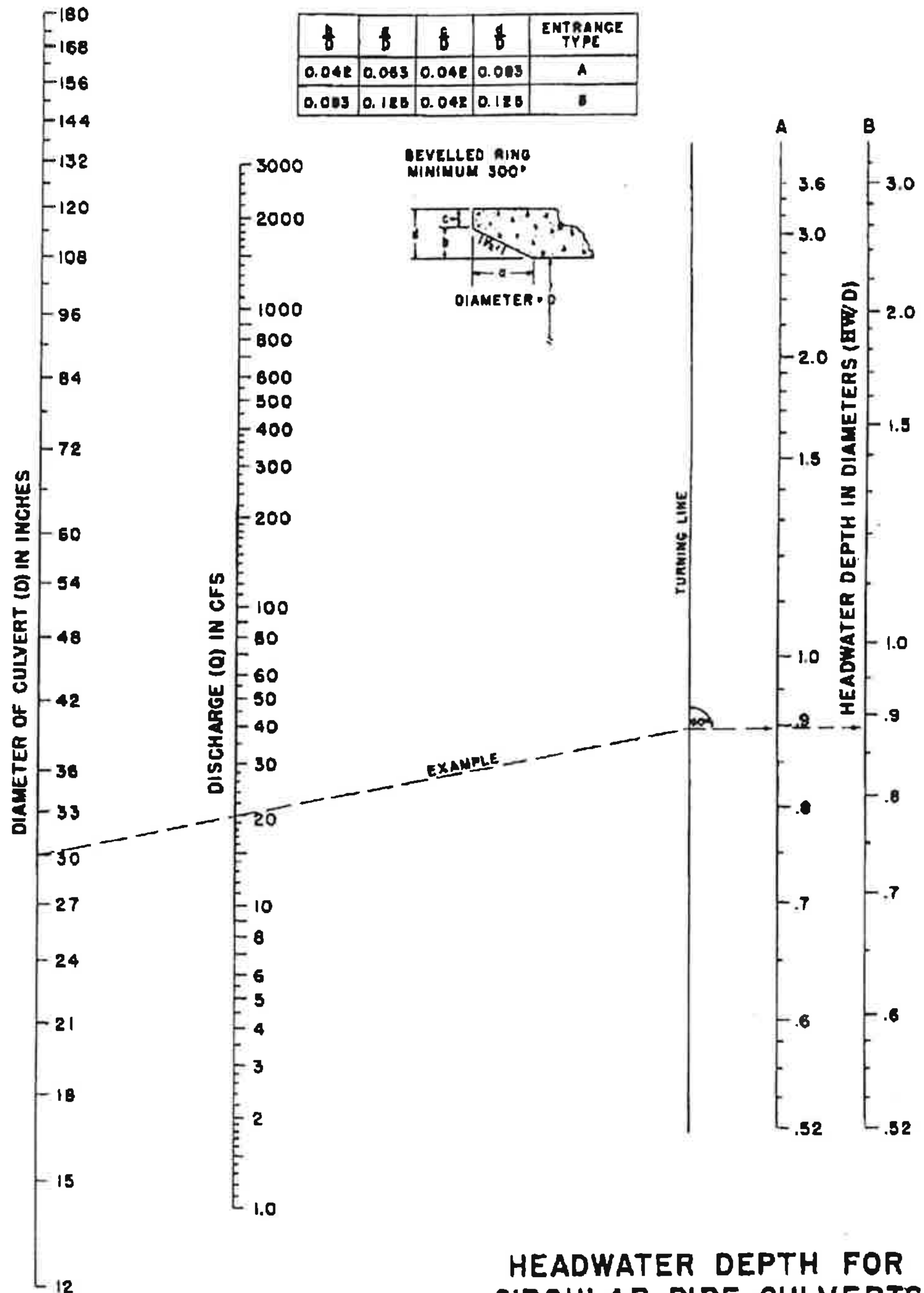
CHART 2B



HEADWATER DEPTH FOR
C. M. PIPE CULVERTS
WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

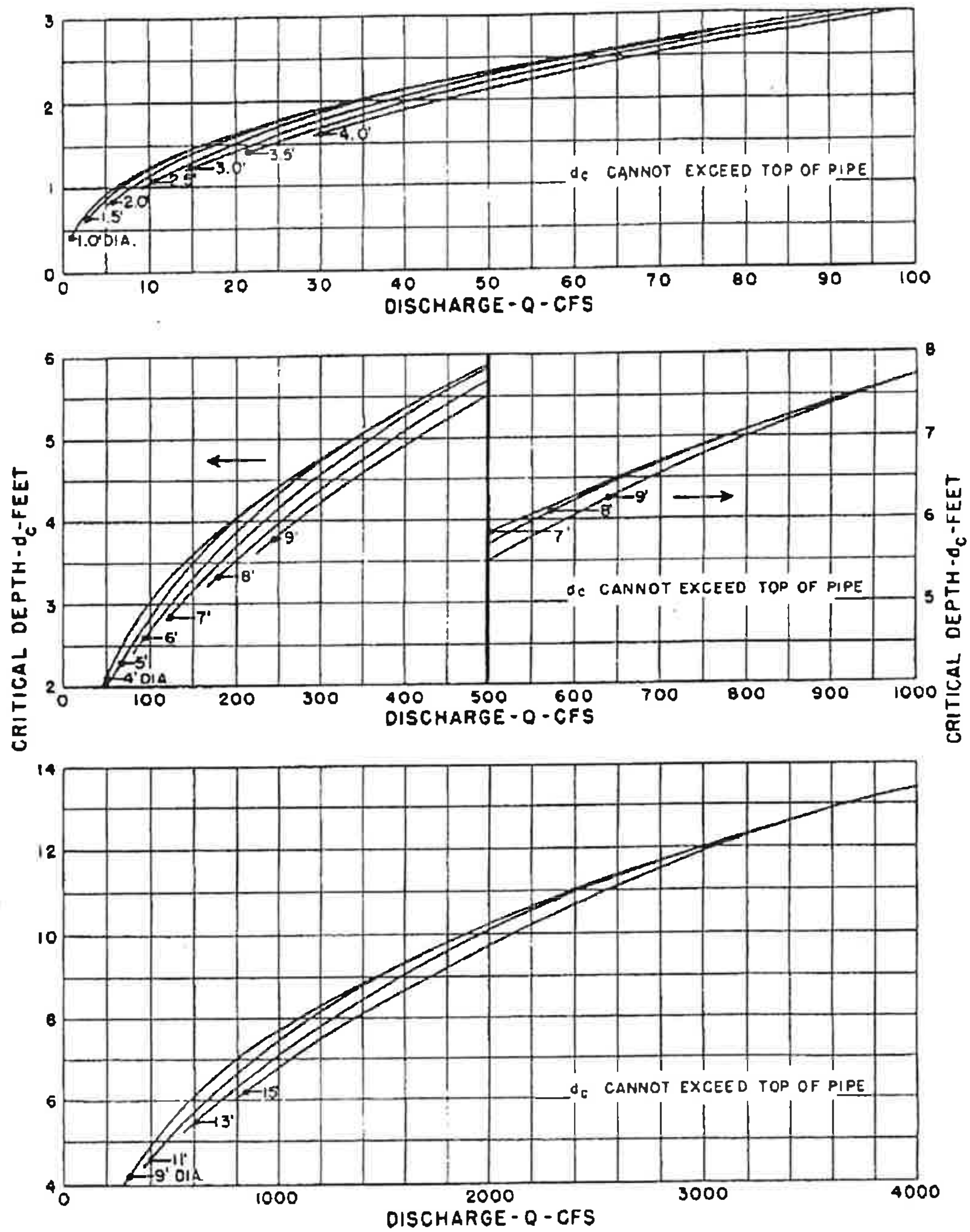
CHART 3B



FEDERAL HIGHWAY ADMINISTRATION
MAY 1973

HEADWATER DEPTH FOR CIRCULAR PIPE CULVERTS WITH BEVELED RING INLET CONTROL

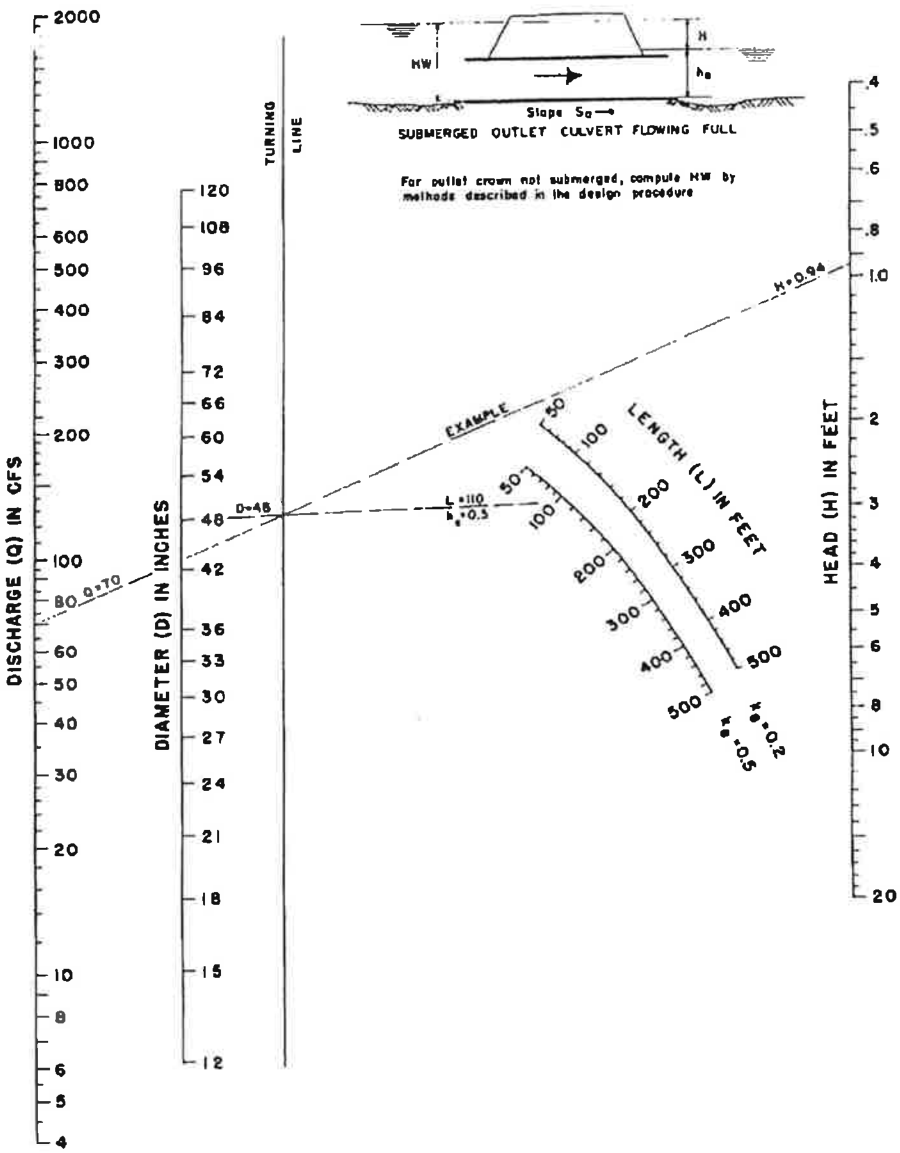
CHART 4B



BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

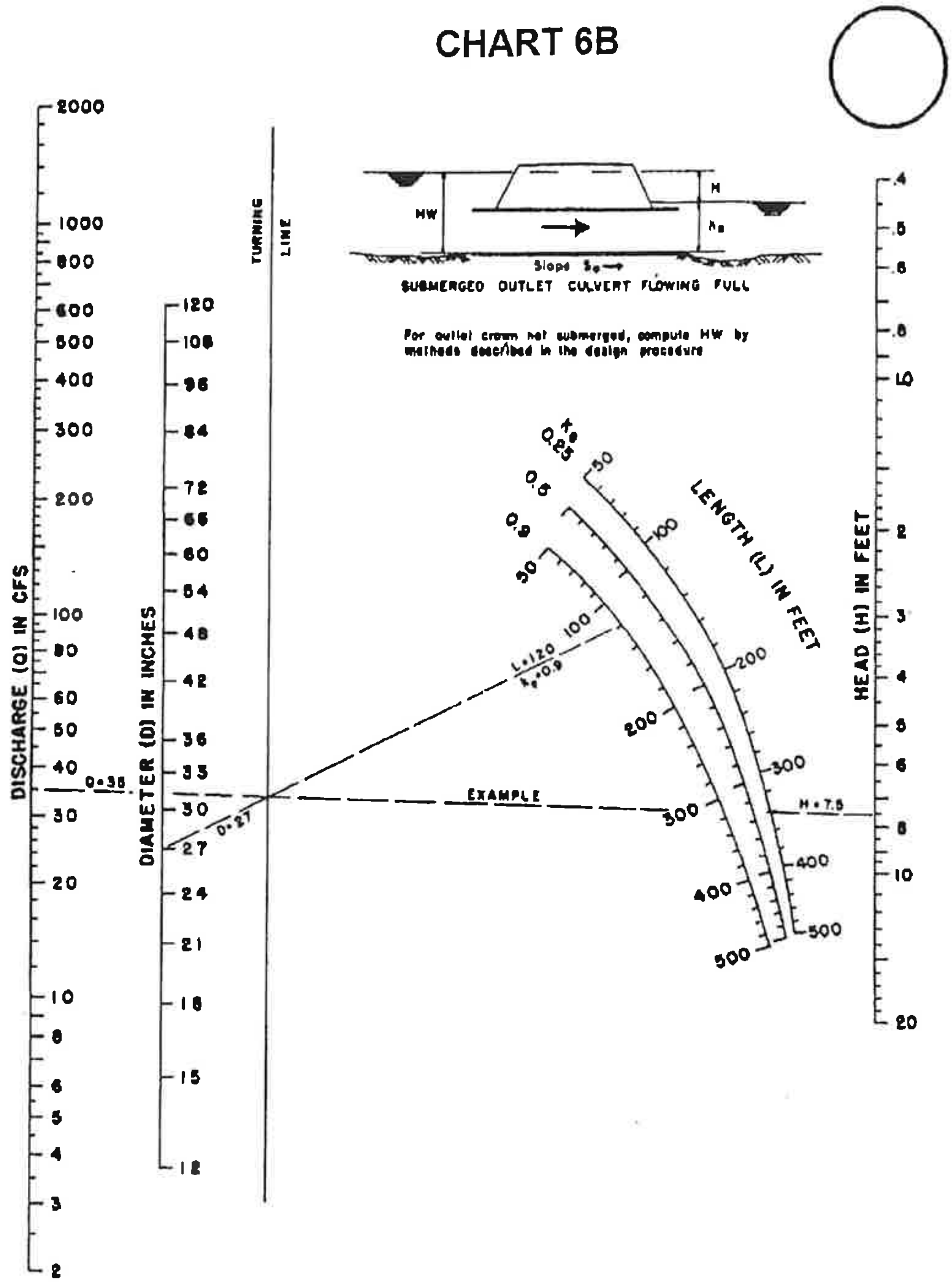
CHART 5B



HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

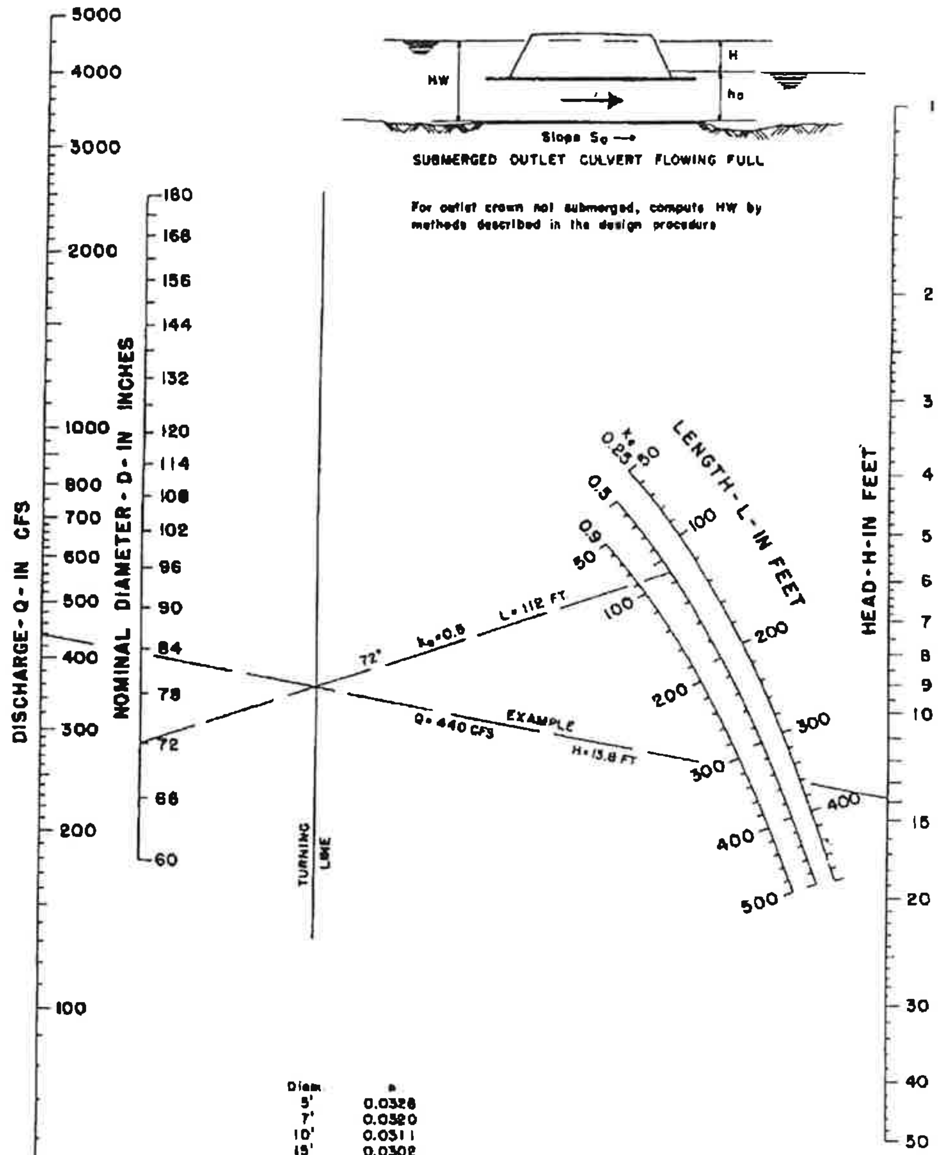
CHART 6B



HEAD FOR
STANDARD
C. M. PIPE CULVERTS
FLOWING FULL
n = 0.024

BUREAU OF PUBLIC ROADS JAN 1963

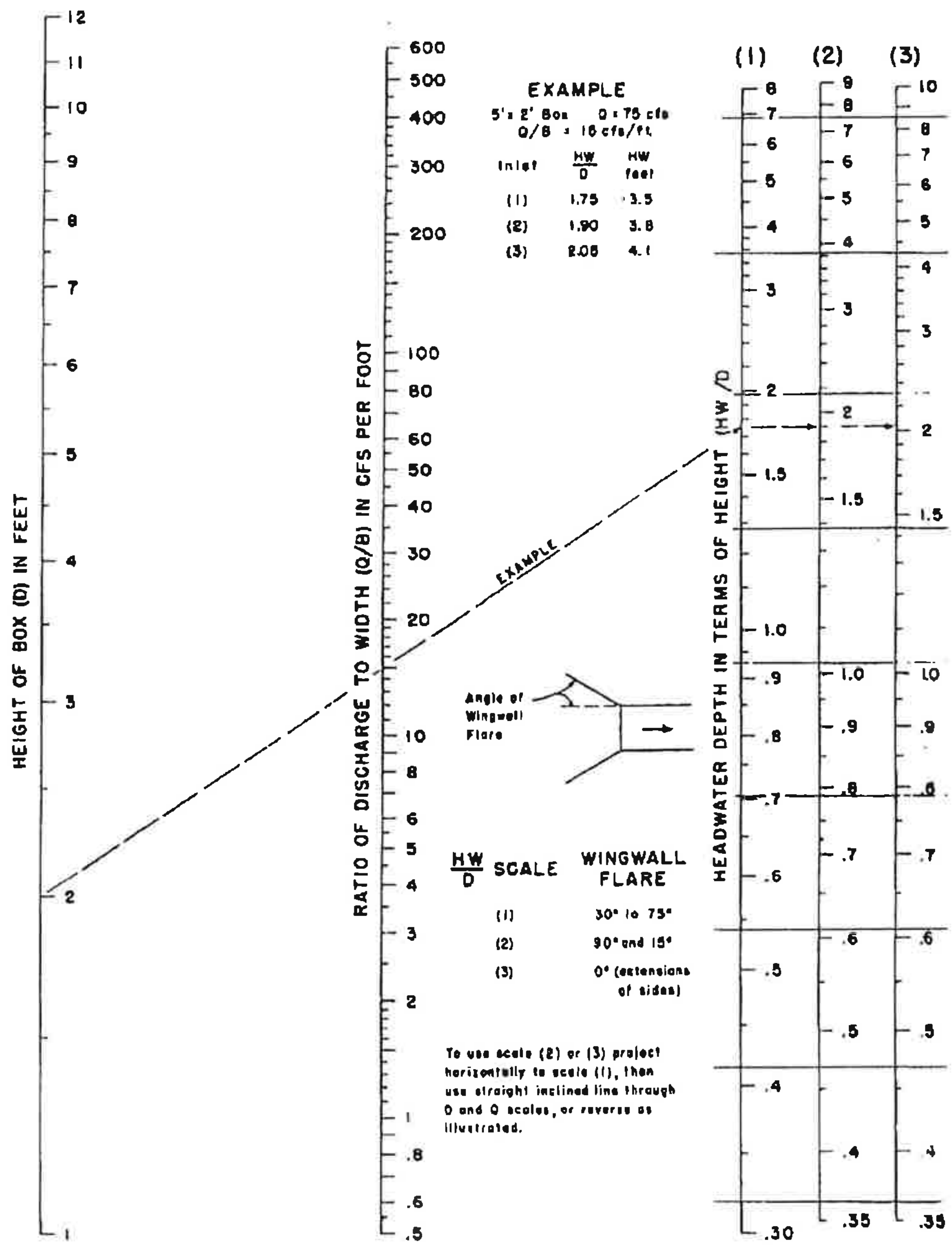
CHART 7B



HEAD FOR
STRUCTURAL PLATE
CORR. METAL PIPE CULVERTS
FLOWING FULL
n = 0.0328 TO 0.0302

BUREAU OF PUBLIC ROADS JAN. 1963

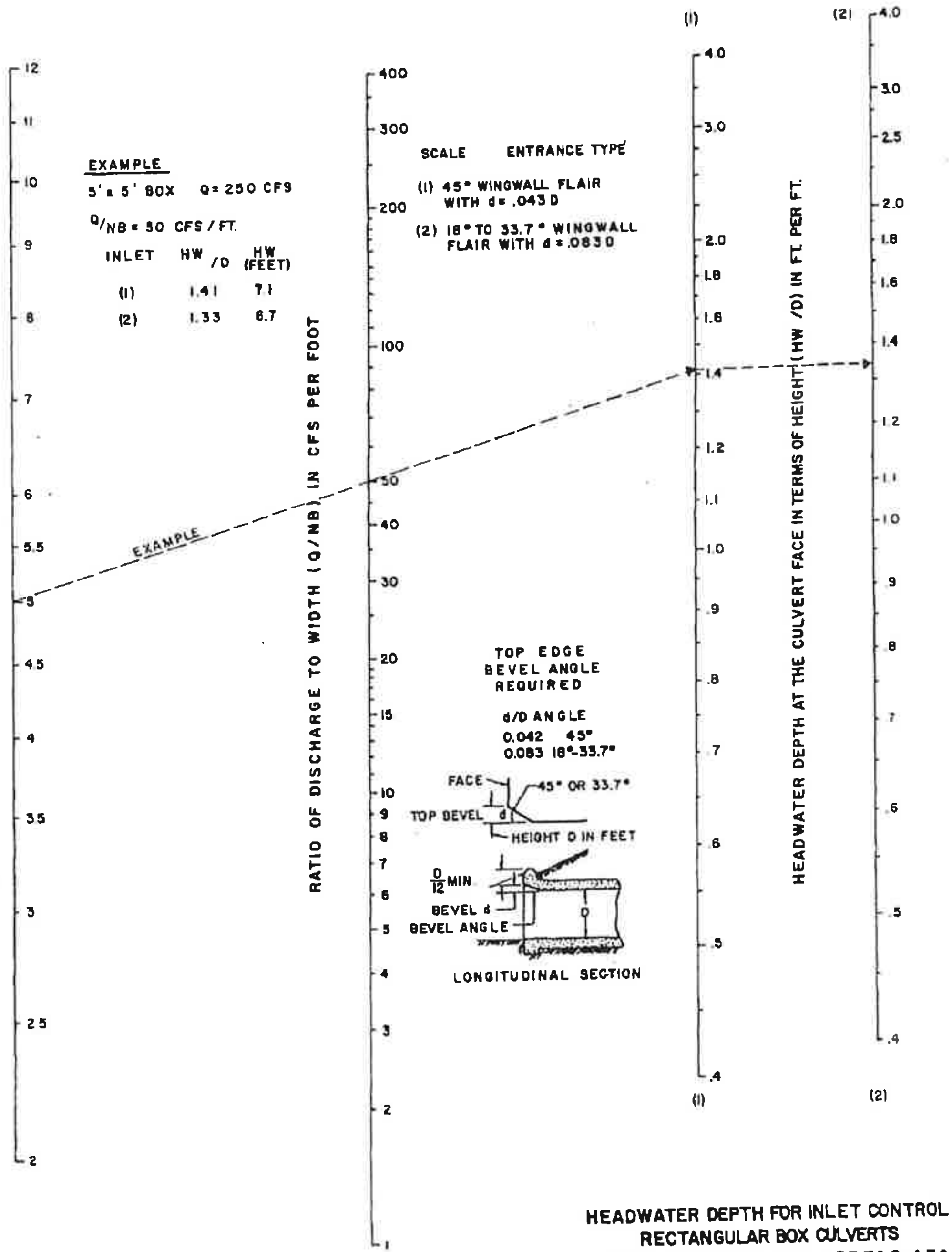
CHART 8B



HEADWATER DEPTH
FOR BOX CULVERTS
WITH INLET CONTROL

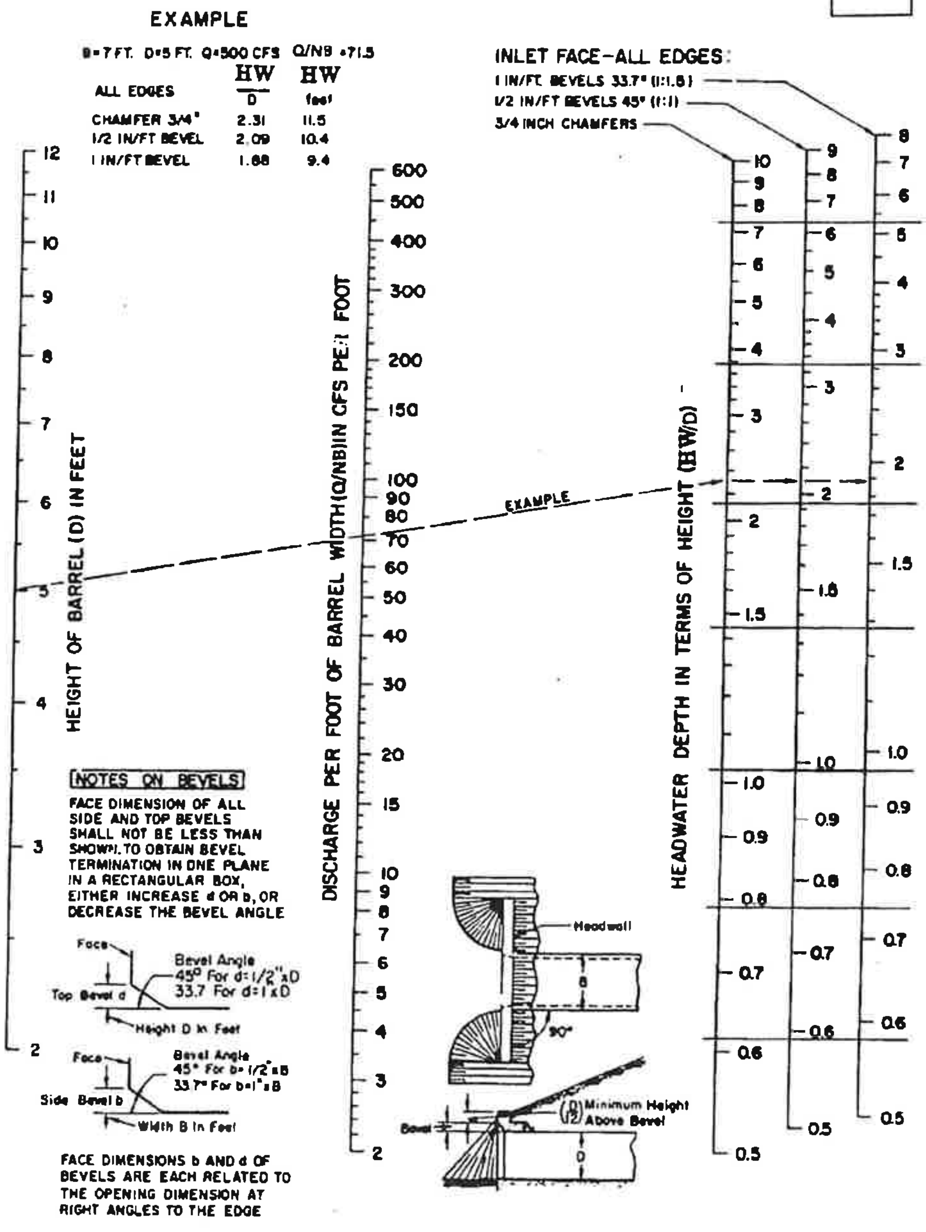
BUREAU OF PUBLIC ROADS JAN. 1963

CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

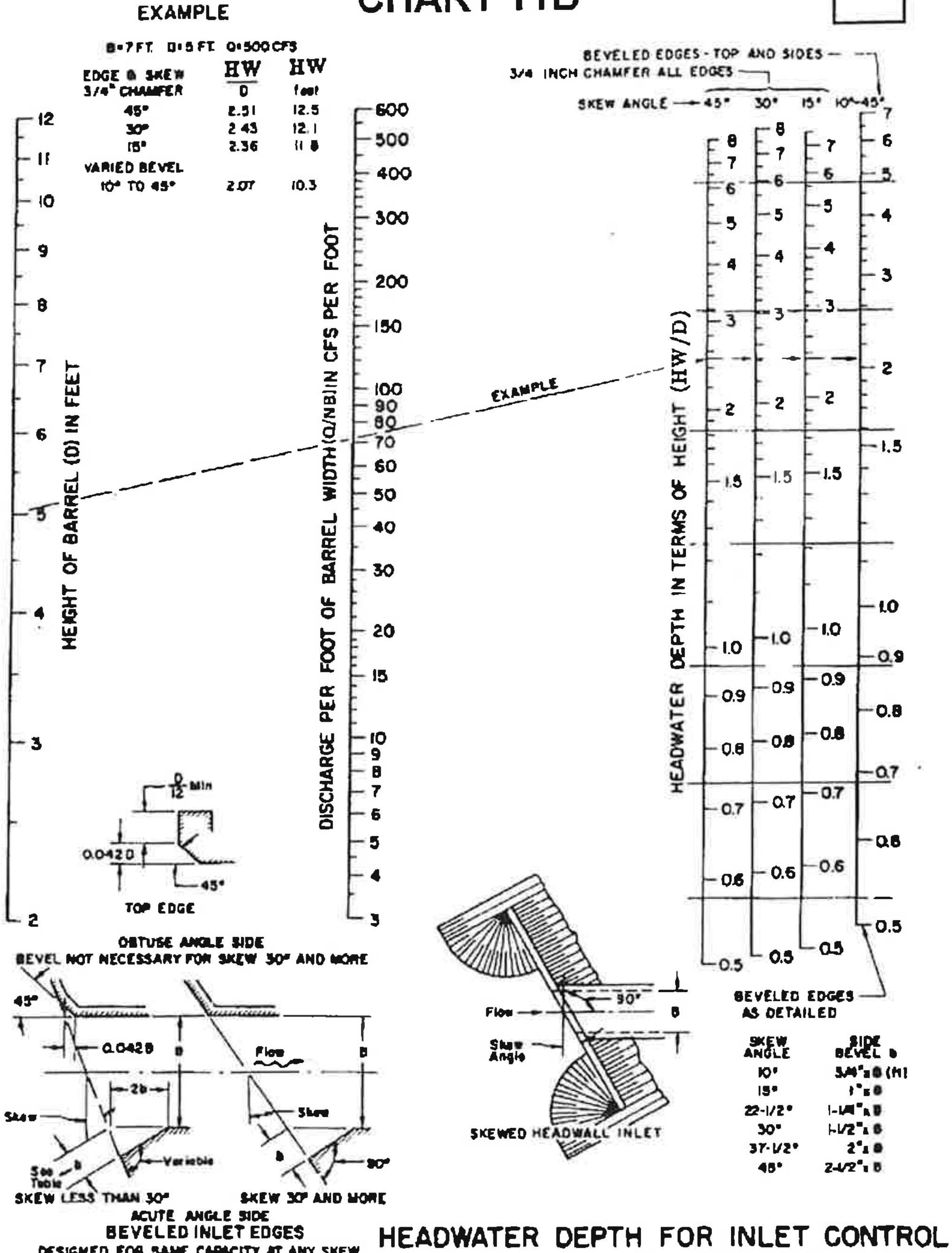
CHART 10B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
90° HEADWALL
CHAMFERED OR BEVELED INLET EDGES

FEDERAL HIGHWAY ADMINISTRATION
MAY 1973

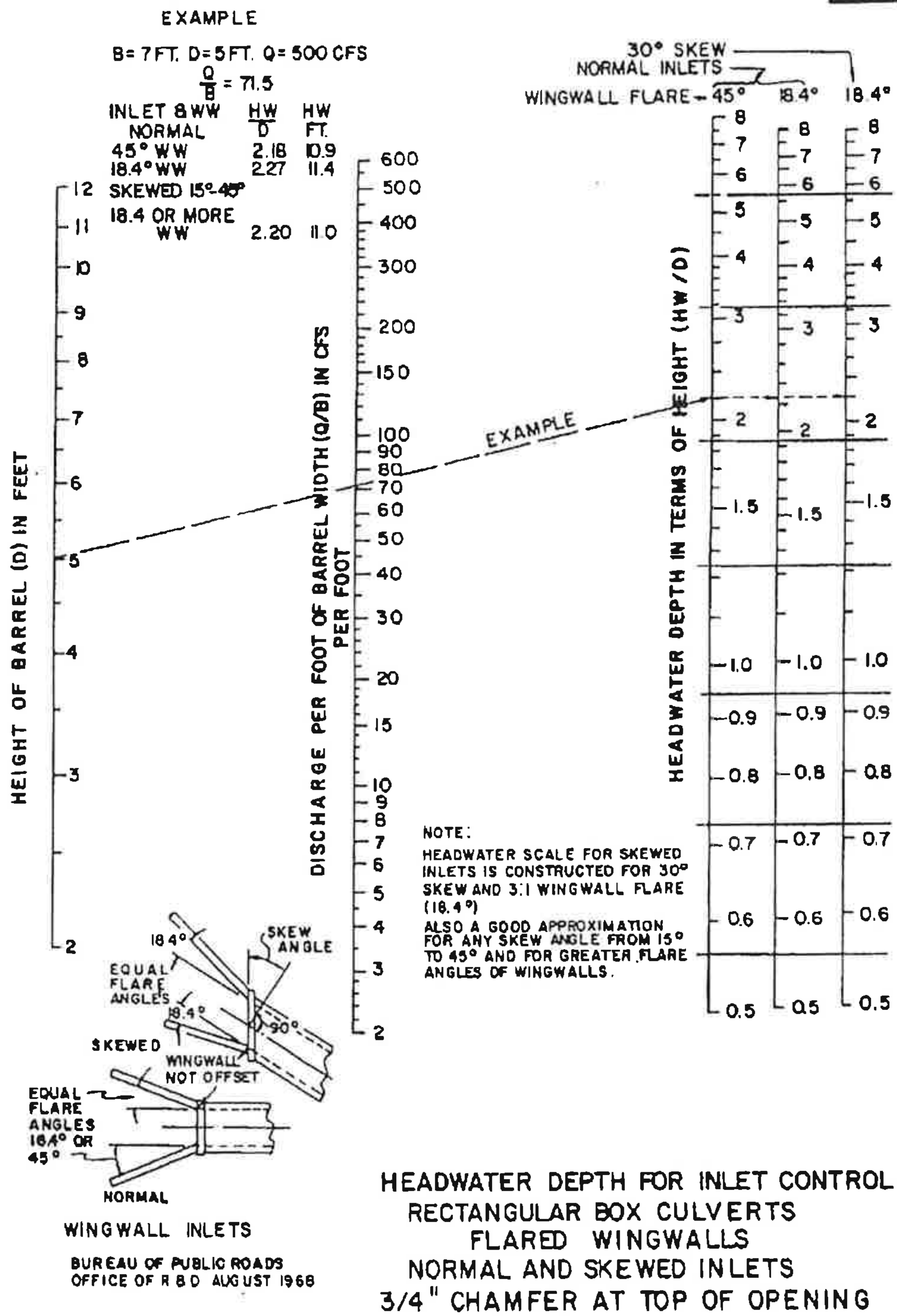
CHART 11B



FEDERAL HIGHWAY ADMINISTRATION
MAY 1973

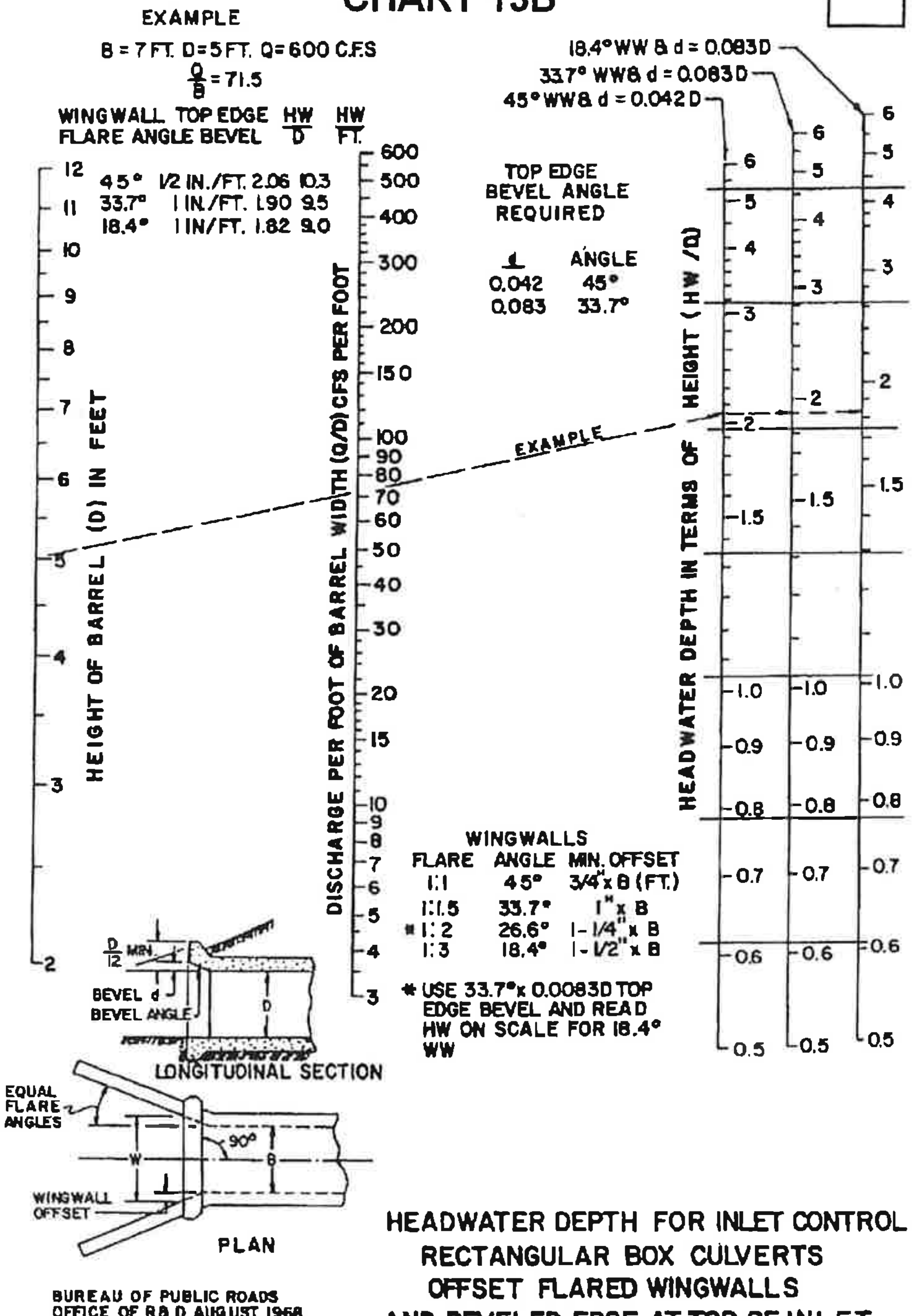
HEADWATER DEPTH FOR INLET CONTROL
SINGLE BARREL BOX CULVERTS
SKEWED HEADWALLS
CHAMFERED OR BEVELED INLET EDGES

CHART 12B



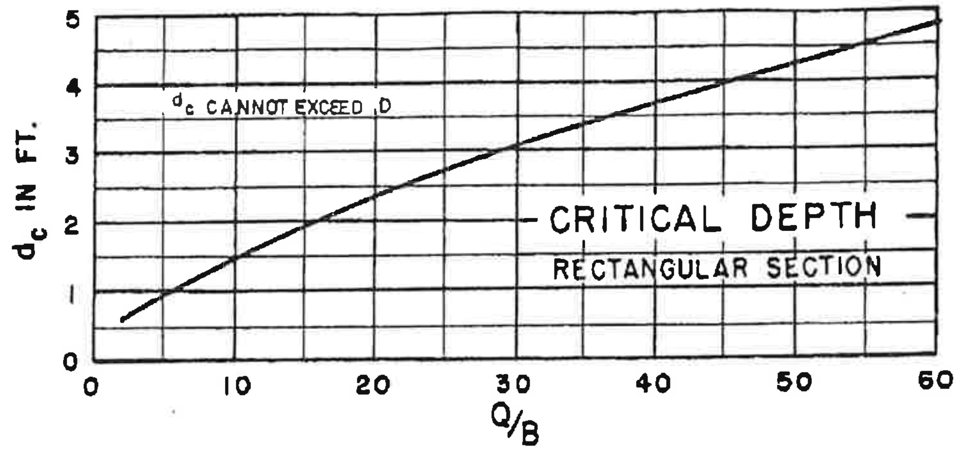
HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS
NORMAL AND SKEWED INLETS
3/4" CHAMFER AT TOP OF OPENING

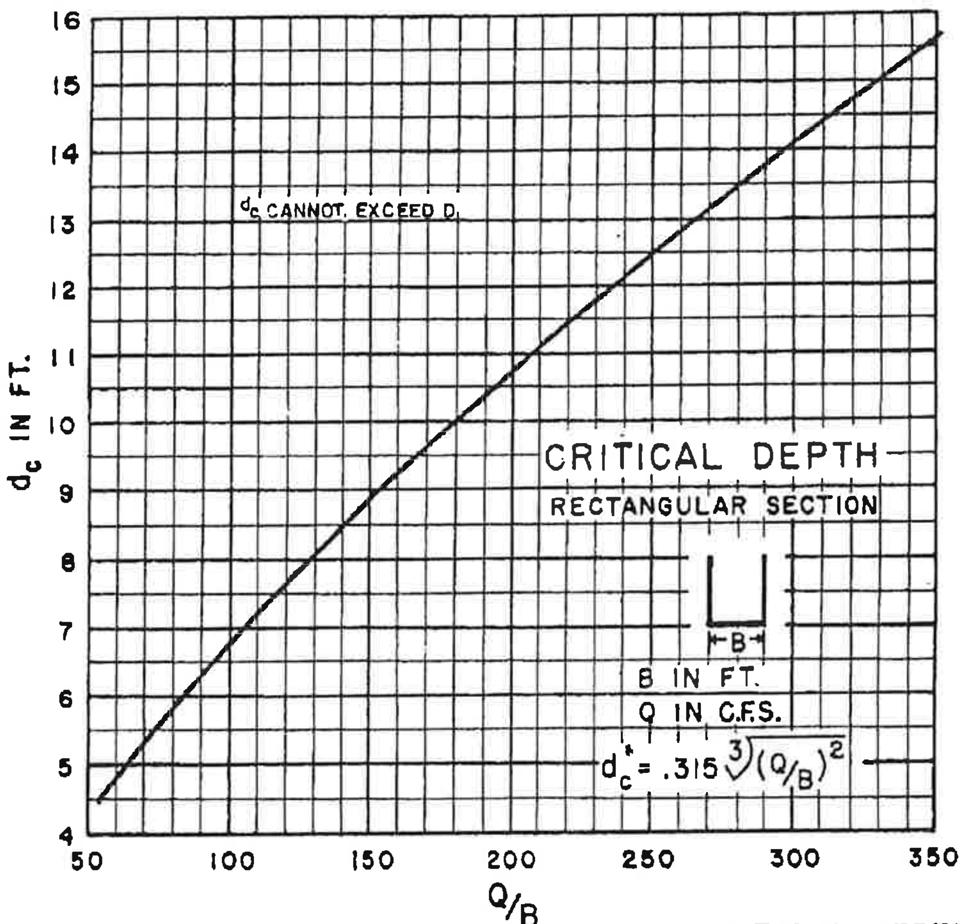
CHART 13B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
OFFSET FLARED WINGWALLS
AND BEVELED EDGE AT TOP OF INLET

CHART 14B

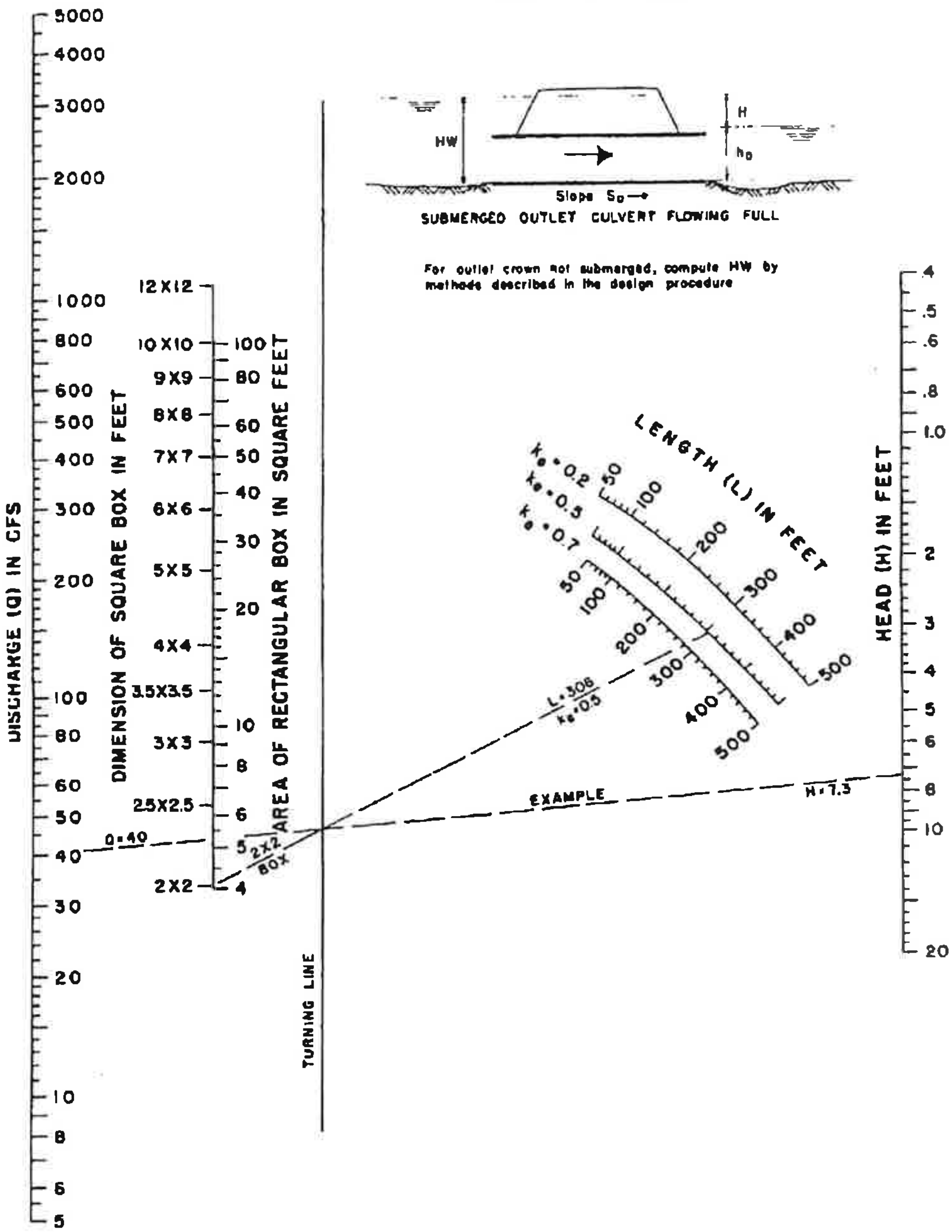




BUREAU OF PUBLIC ROADS JAN 1963

CRITICAL DEPTH
RECTANGULAR SECTION

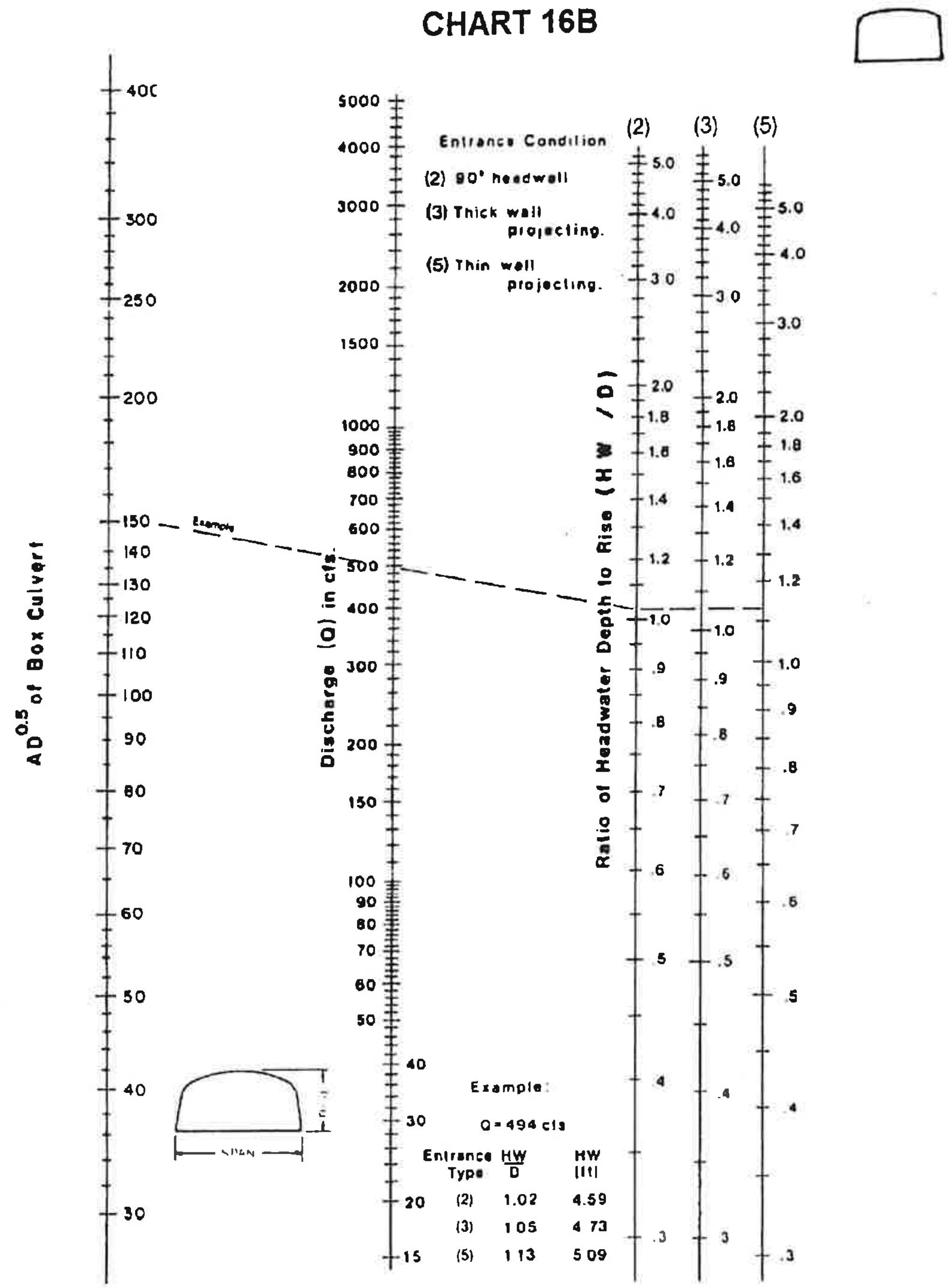
CHART 15B



HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

AU OF PUBLIC ROADS JAN. 1963

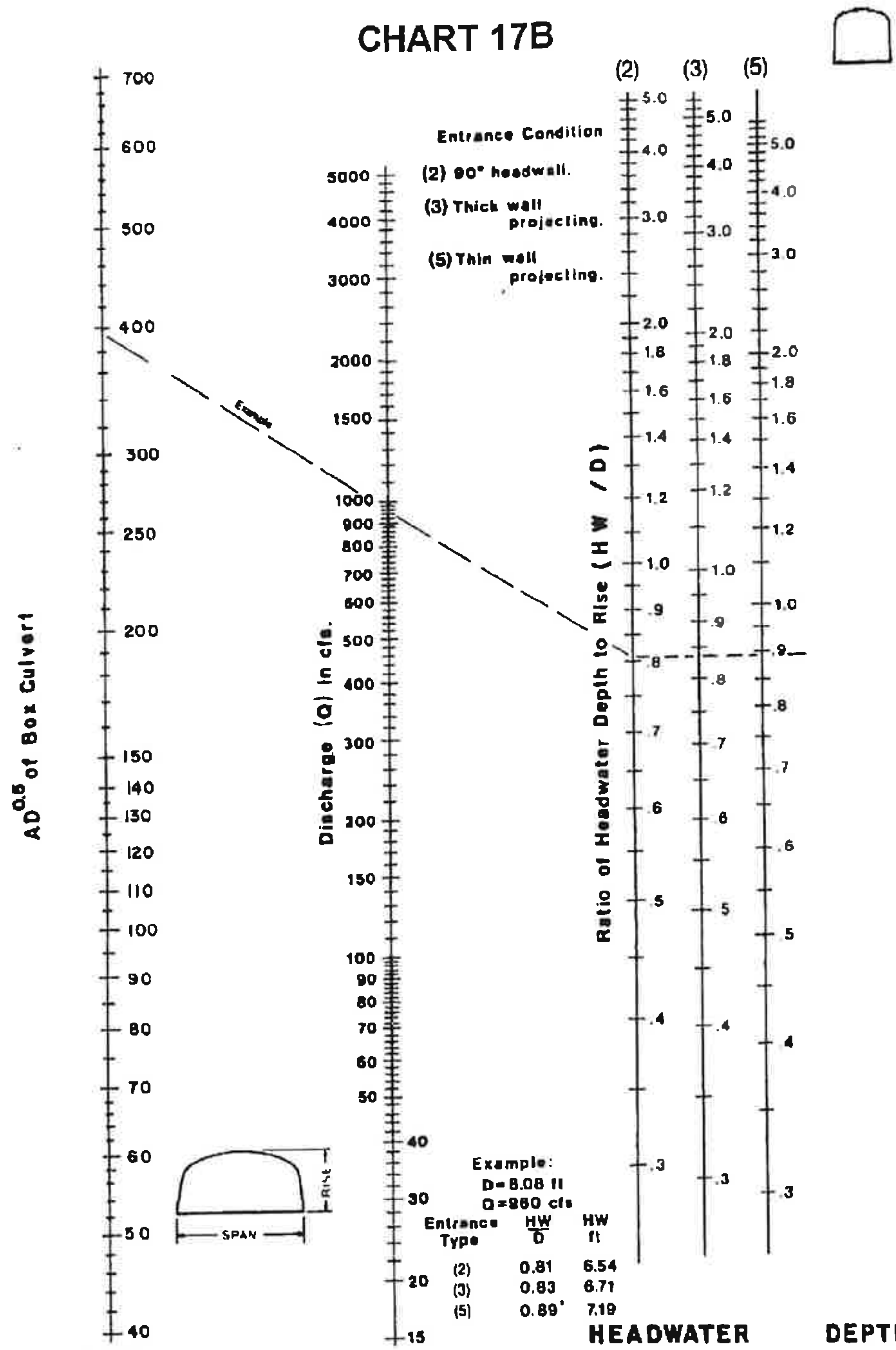
CHART 16B



Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

HEADWATER DEPTH FOR C.M. BOX CULVERTS RISE / SPAN < 0.3 WITH INLET CONTROL

CHART 17B

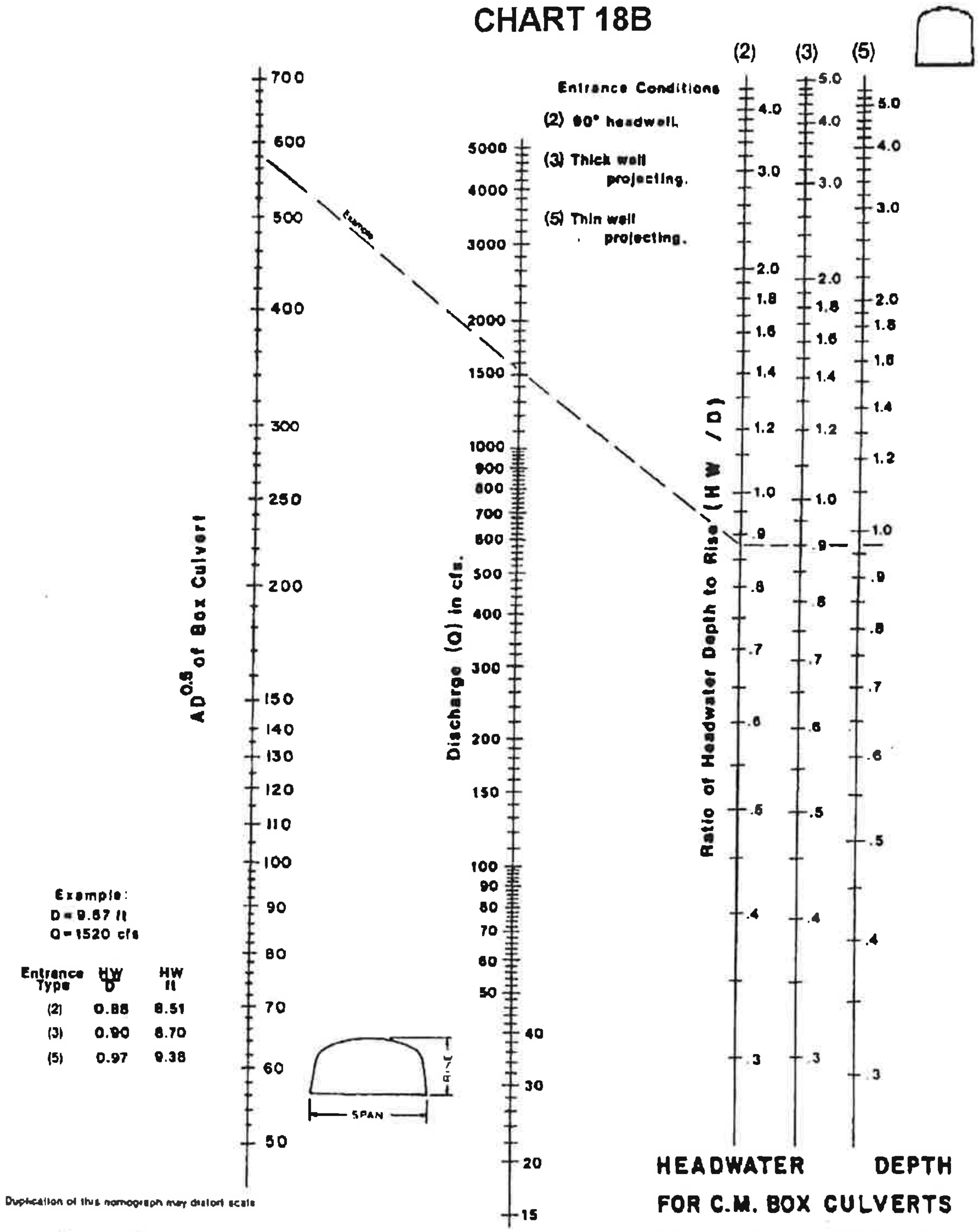


Duplication of this nomograph may distort scale

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

HEADWATER DEPTH FOR C.M. BOX CULVERTS $0.3 \leq$ RISE / SPAN < 0.4 WITH INLET CONTROL

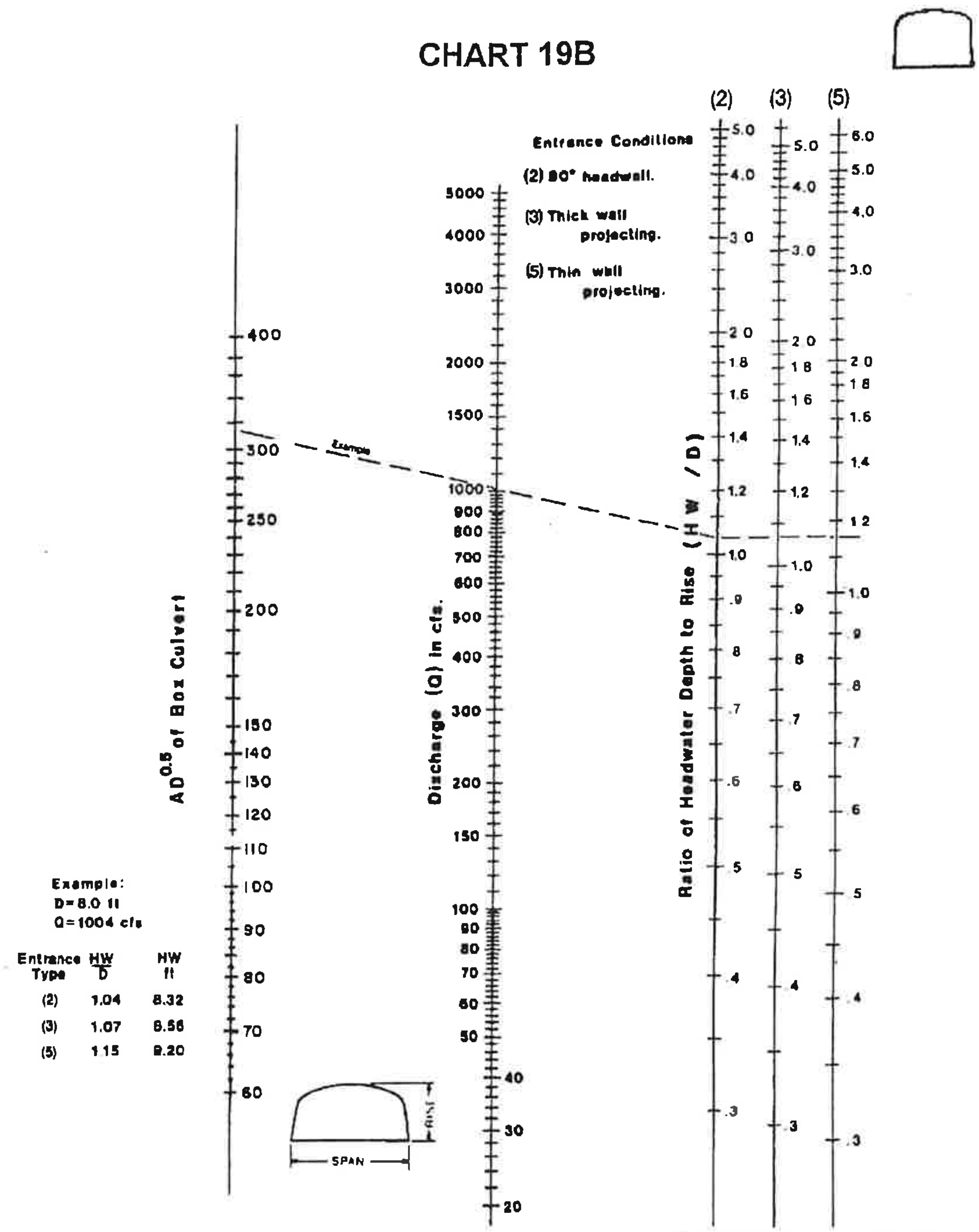
CHART 18B



Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

HEADWATER DEPTH
FOR C.M. BOX CULVERTS
0.4 ≤ RISE / SPAN < 0.5
WITH INLET CONTROL

CHART 19B



Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

HEADWATER DEPTH
FOR C.M. BOX CULVERTS
0.5 ≤ RISE / SPAN
WITH INLET CONTROL

CHART 20B

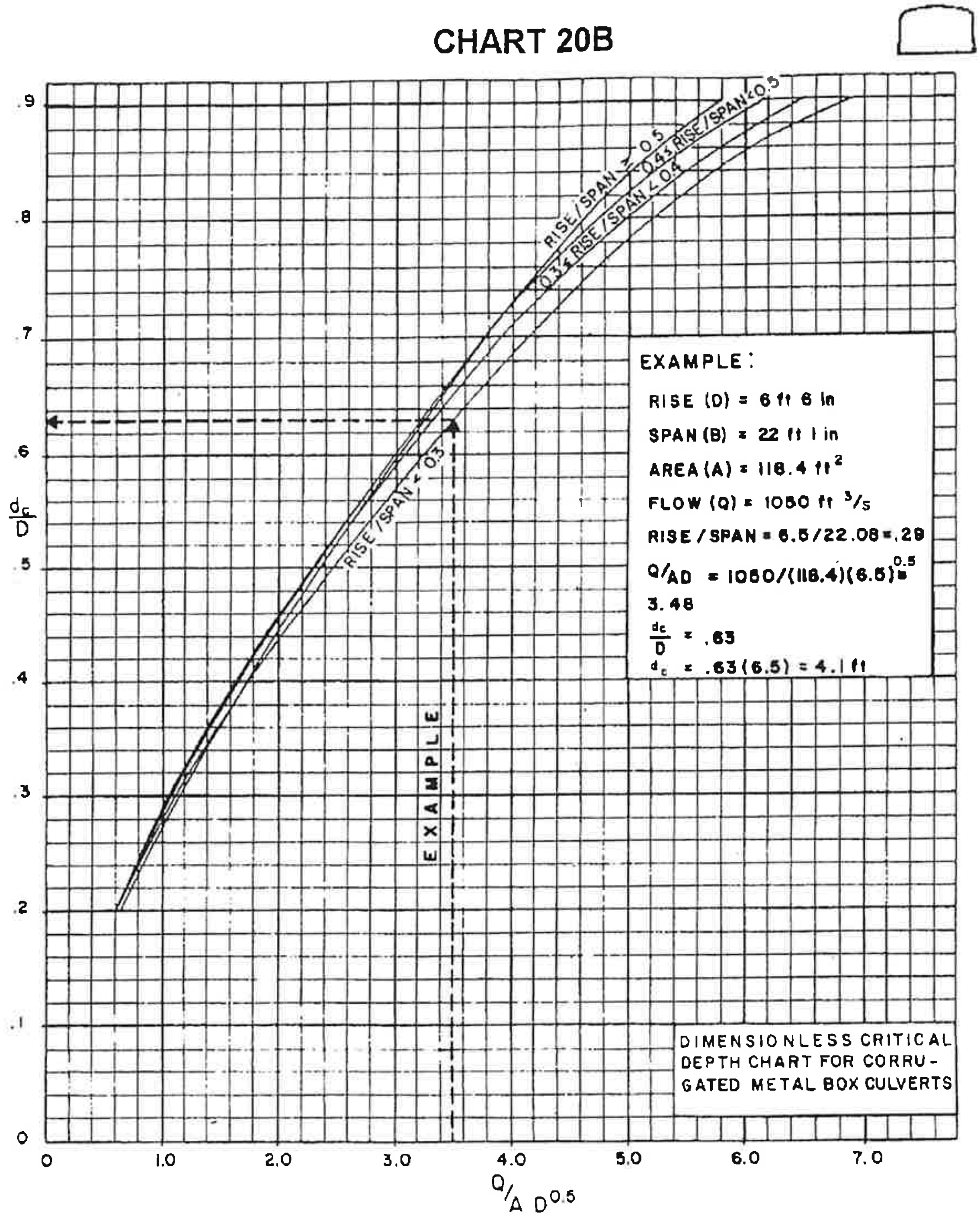
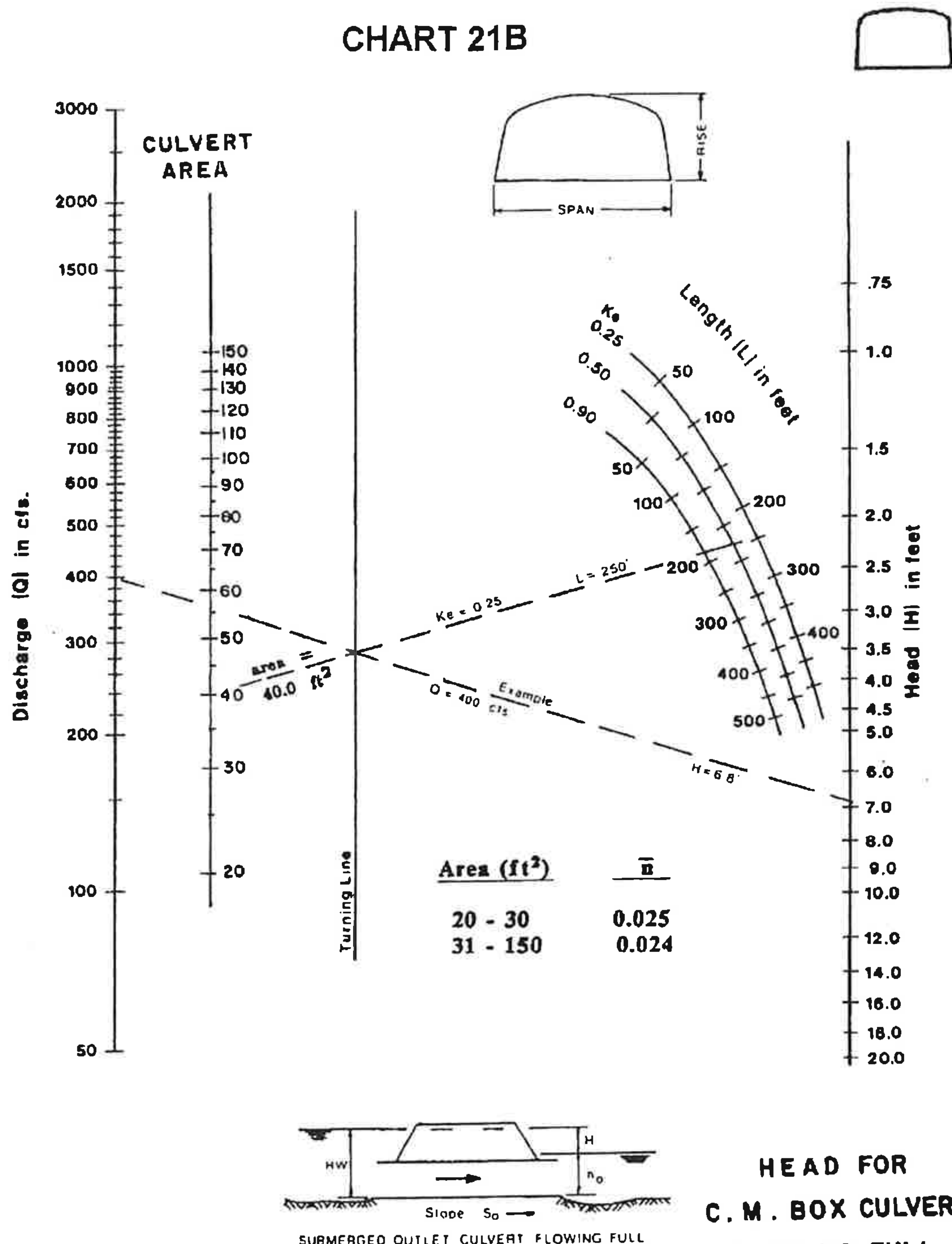

RISE / SPAN ≥ 0.5
0.4 ≤ RISE/SPAN < 0.5
0.3 ≤ RISE / SPAN < 0.4
RISE / SPAN < 0.3
EXAMPLE:
RISE (D) = 6 ft 6 in
SPAN (B) = 22 ft 1 in
AREA (A) = 118.4 ft²
FLOW (Q) = 1050 ft ³/s
RISE / SPAN = 6.5 / 22.08 = .29
Q/AD = 1050/(118.4)(6.5)^0.5 = 3.48
dc/D = .63
dc = .63 (6.5) = 4.1 ft
EXAMPLE
DIMENSIONLESS CRITICAL DEPTH CHART FOR CORRUGATED METAL BOX CULVERTS
dc/D
Q/A D^0.5
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
2.0
3.0
4.0
5.0
6.0
7.0

CHART 21B

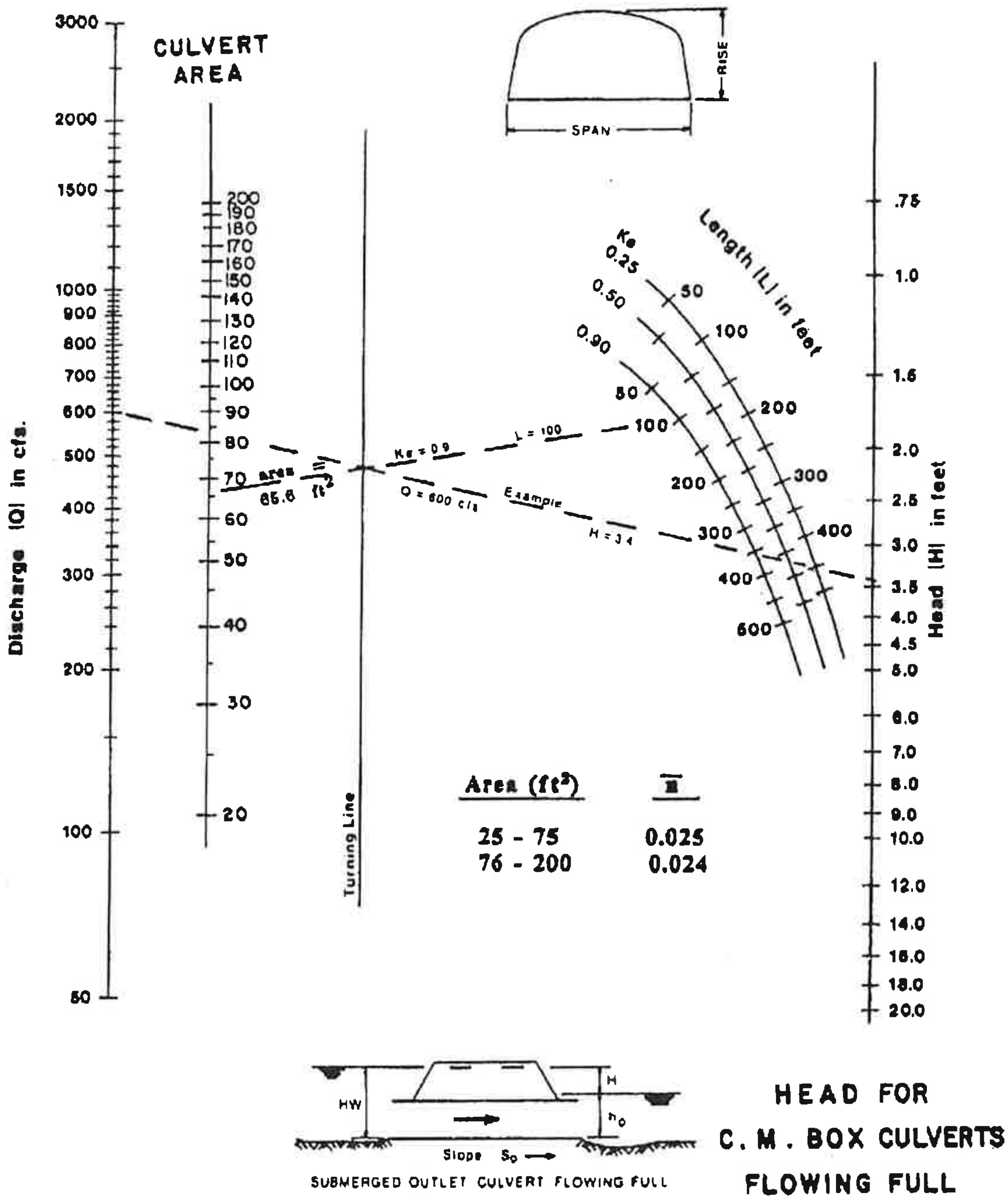


HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CONCRETE BOTTOM
RISE / SPAN < 0.3

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 22B



Area (ft²)	n
25 - 75	0.025
76 - 200	0.024

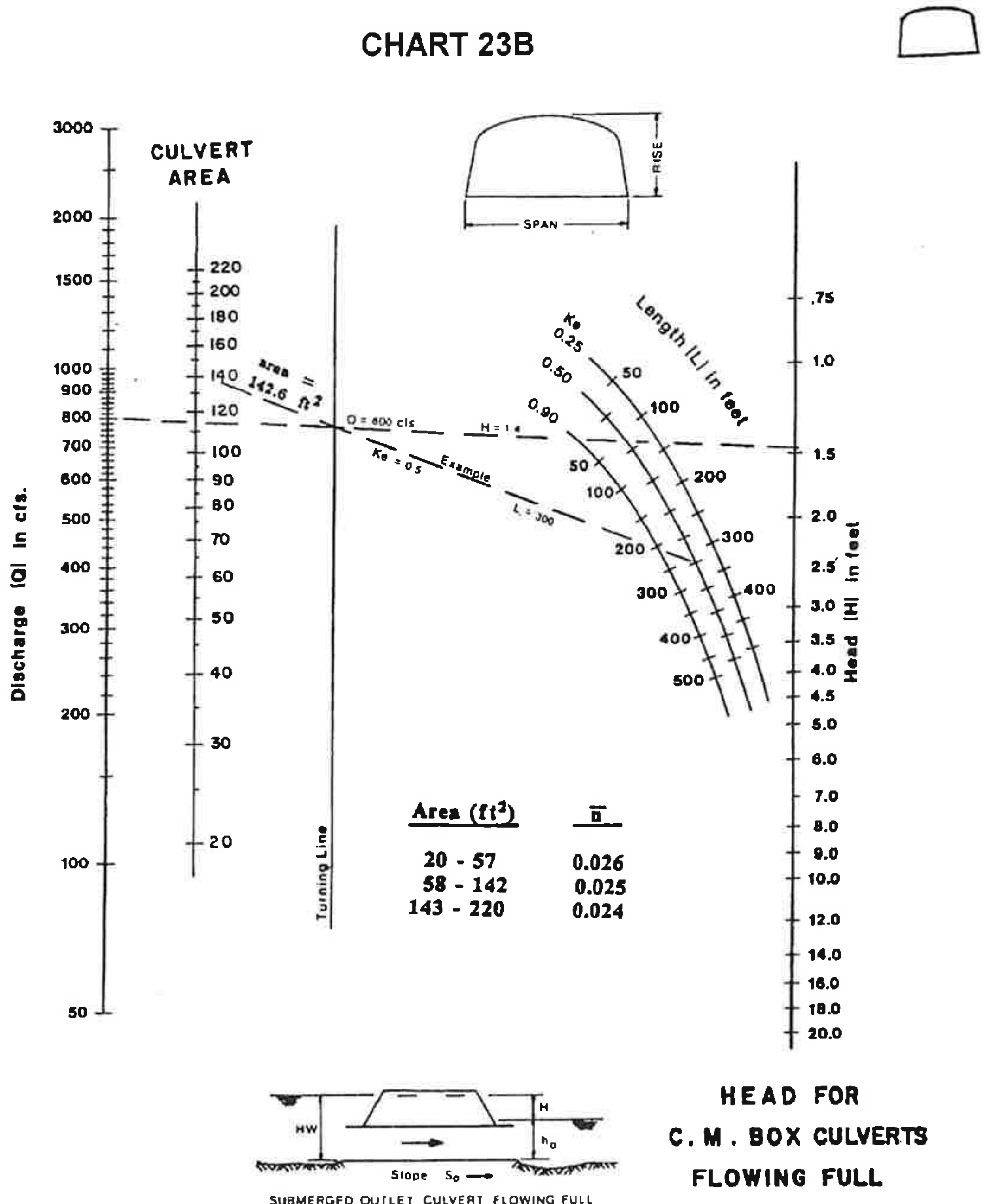
HEAD FOR C. M. BOX CULVERTS FLOWING FULL CONCRETE BOTTOM

0.3 ≤ RISE / SPAN < 0.4

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 23B



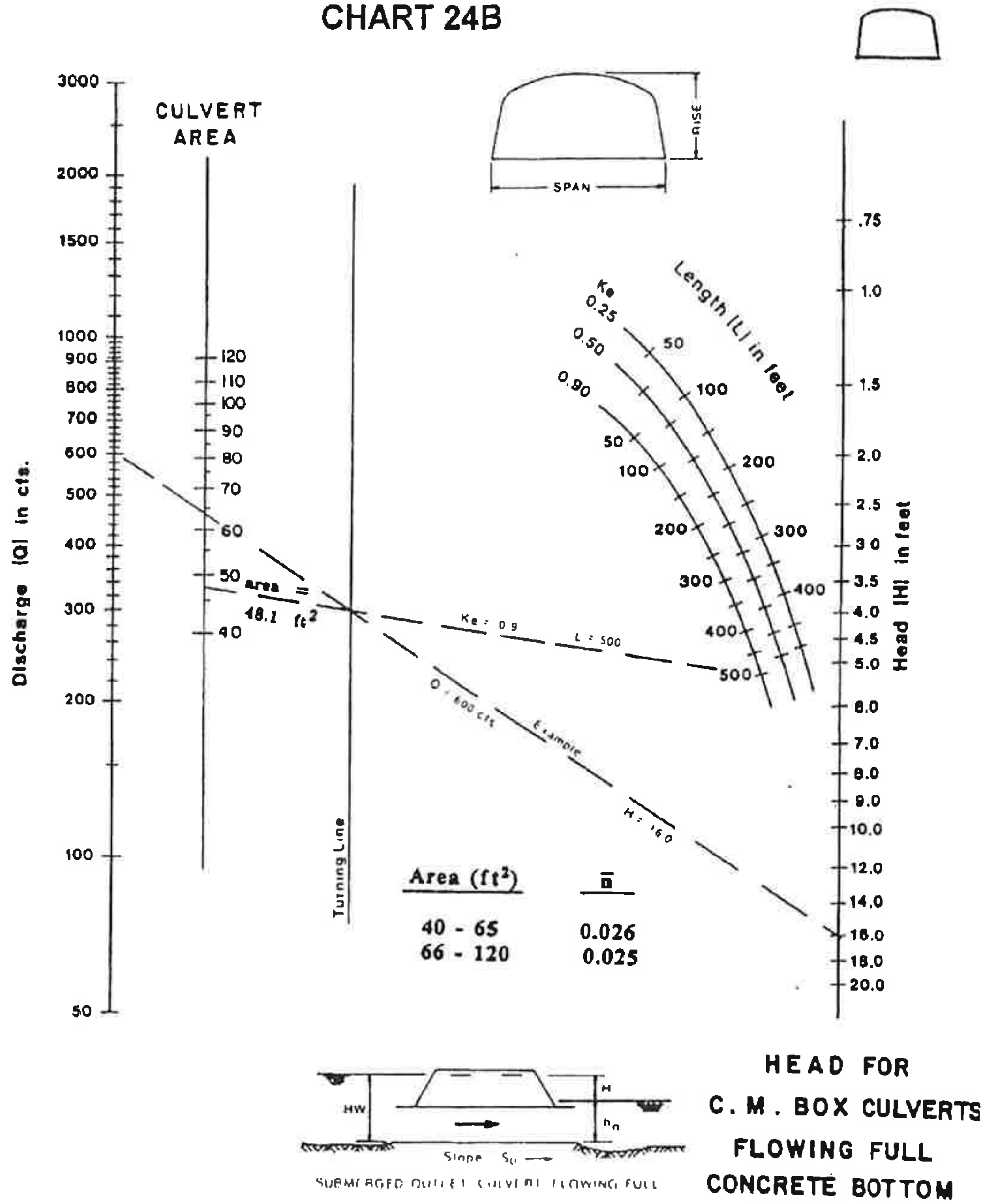
HEAD FOR C. M. BOX CULVERTS FLOWING FULL CONCRETE BOTTOM

0.4 ≤ RISE/SPAN < 0.5

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 24B



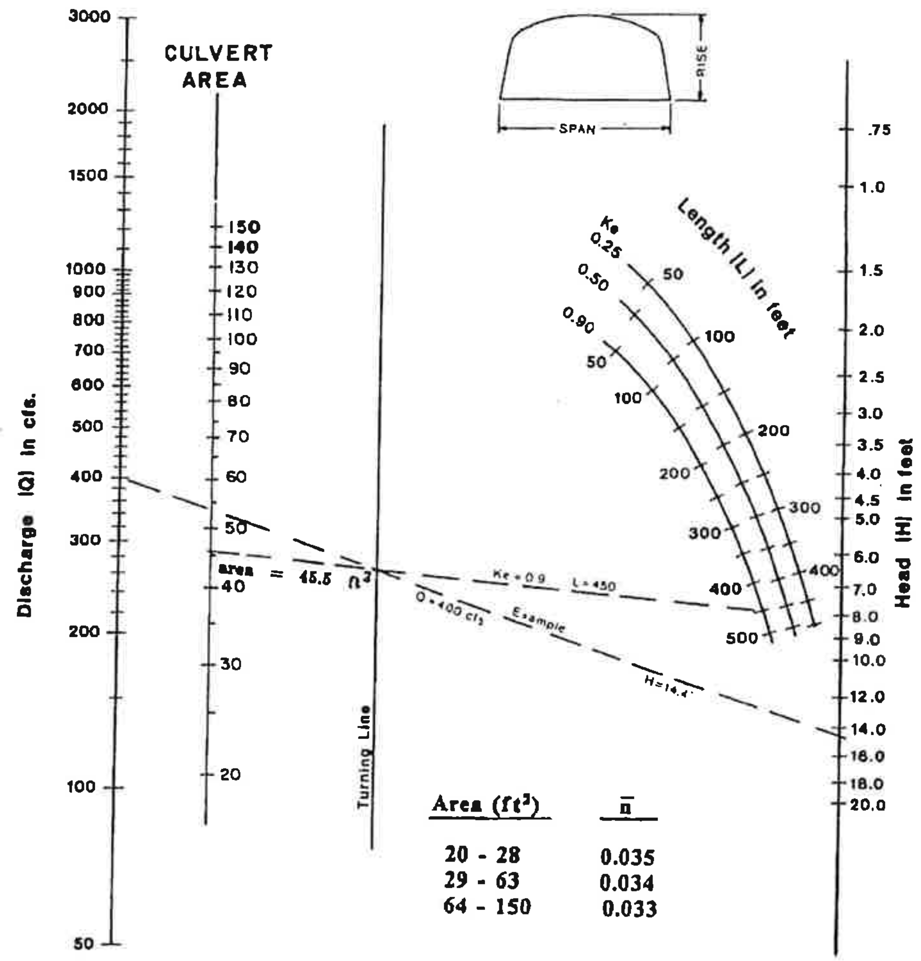
Area (ft²)	n̄
40 - 65	0.026
66 - 120	0.025

HEAD FOR C. M. BOX CULVERTS FLOWING FULL CONCRETE BOTTOM $0.5 \leq$ RISE / SPAN

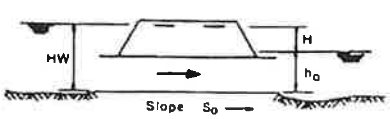
Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 25B



Area (ft²)	n
20 - 28	0.035
29 - 63	0.034
64 - 150	0.033



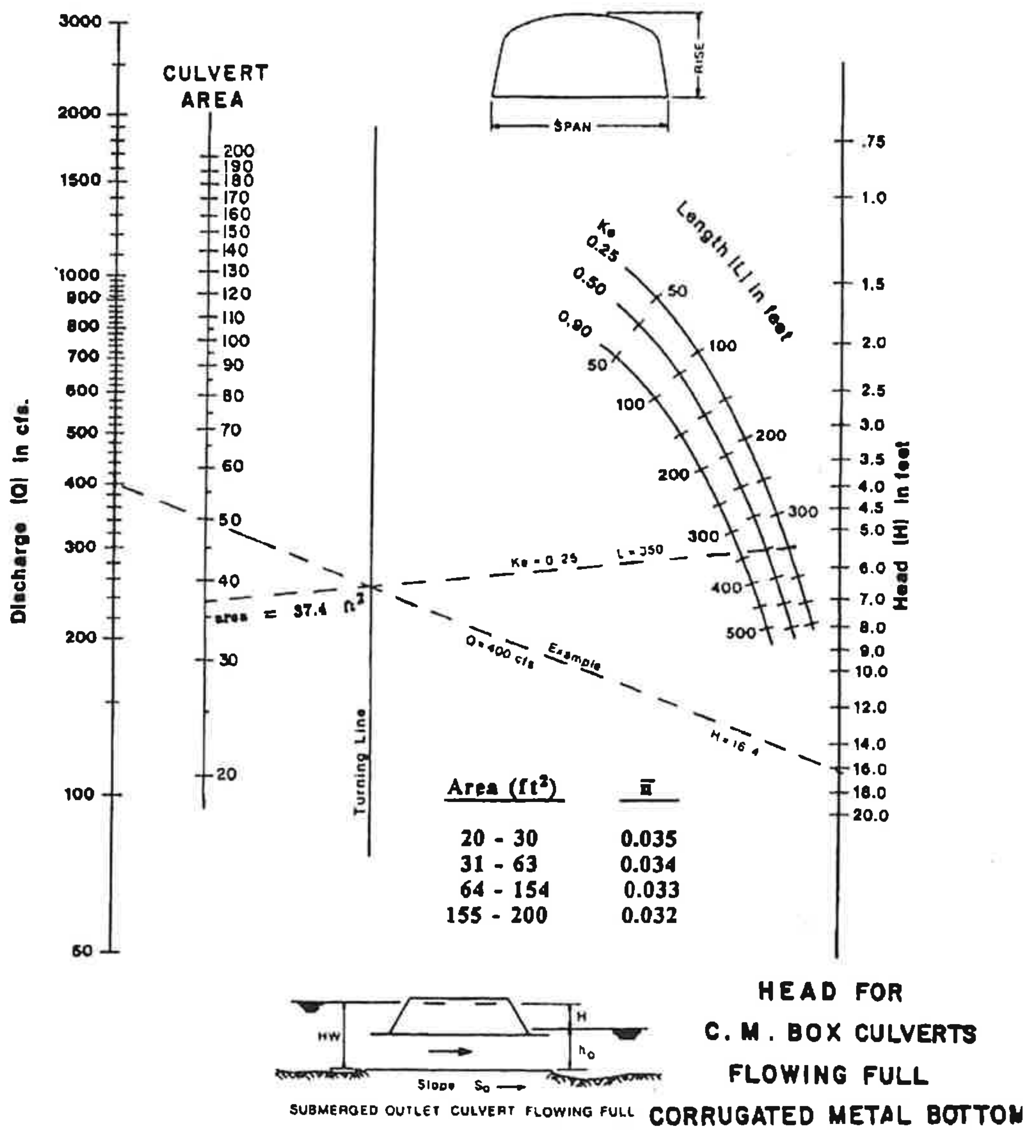
SUBMERGED OUTLET CULVERT FLOWING FULL

**HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CORRUGATED METAL BOTTOM
RISE / SPAN < 0.3**

Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 26B

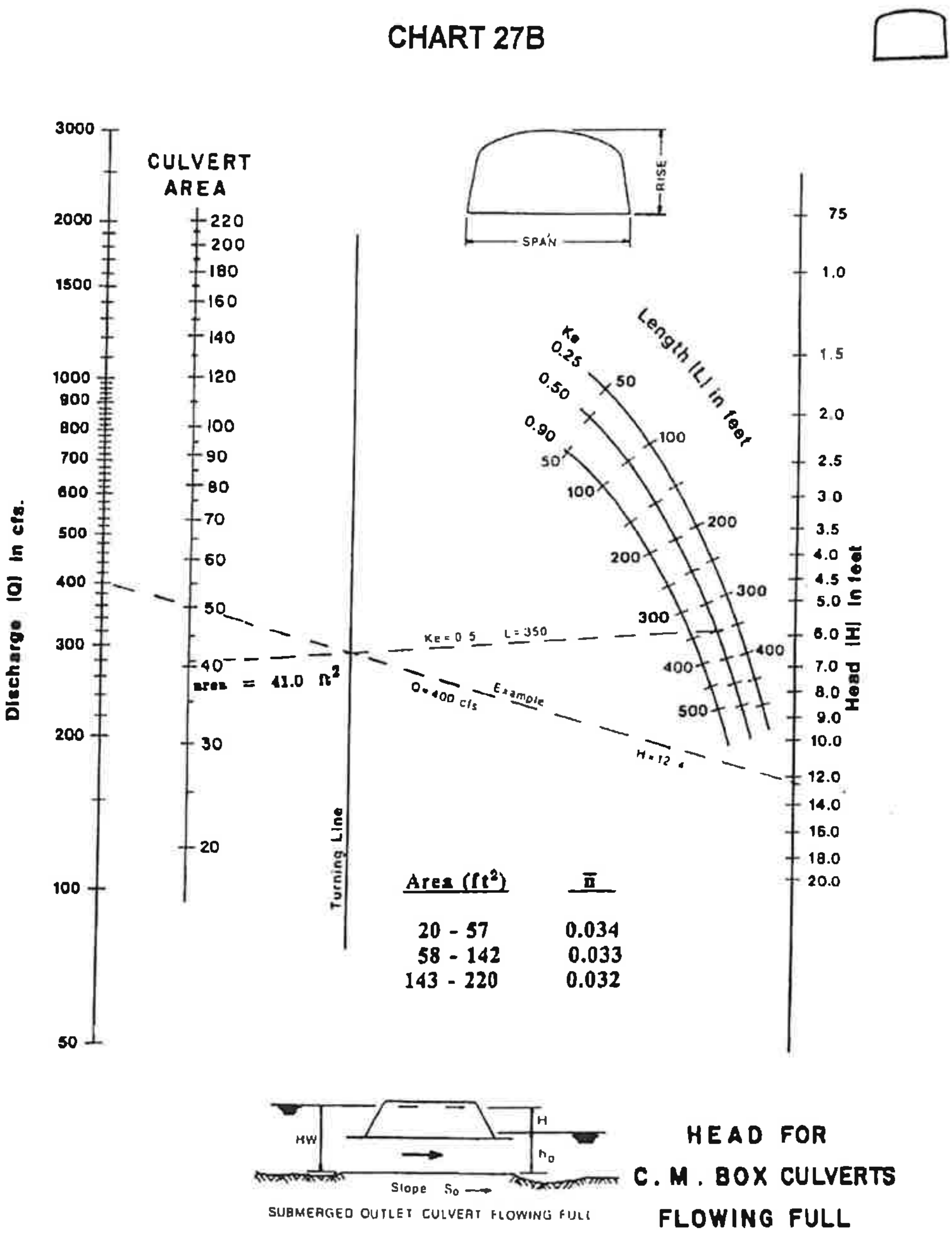


HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CORRUGATED METAL BOTTOM
$0.3 \le$ RISE / SPAN < 0.4

Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 27B



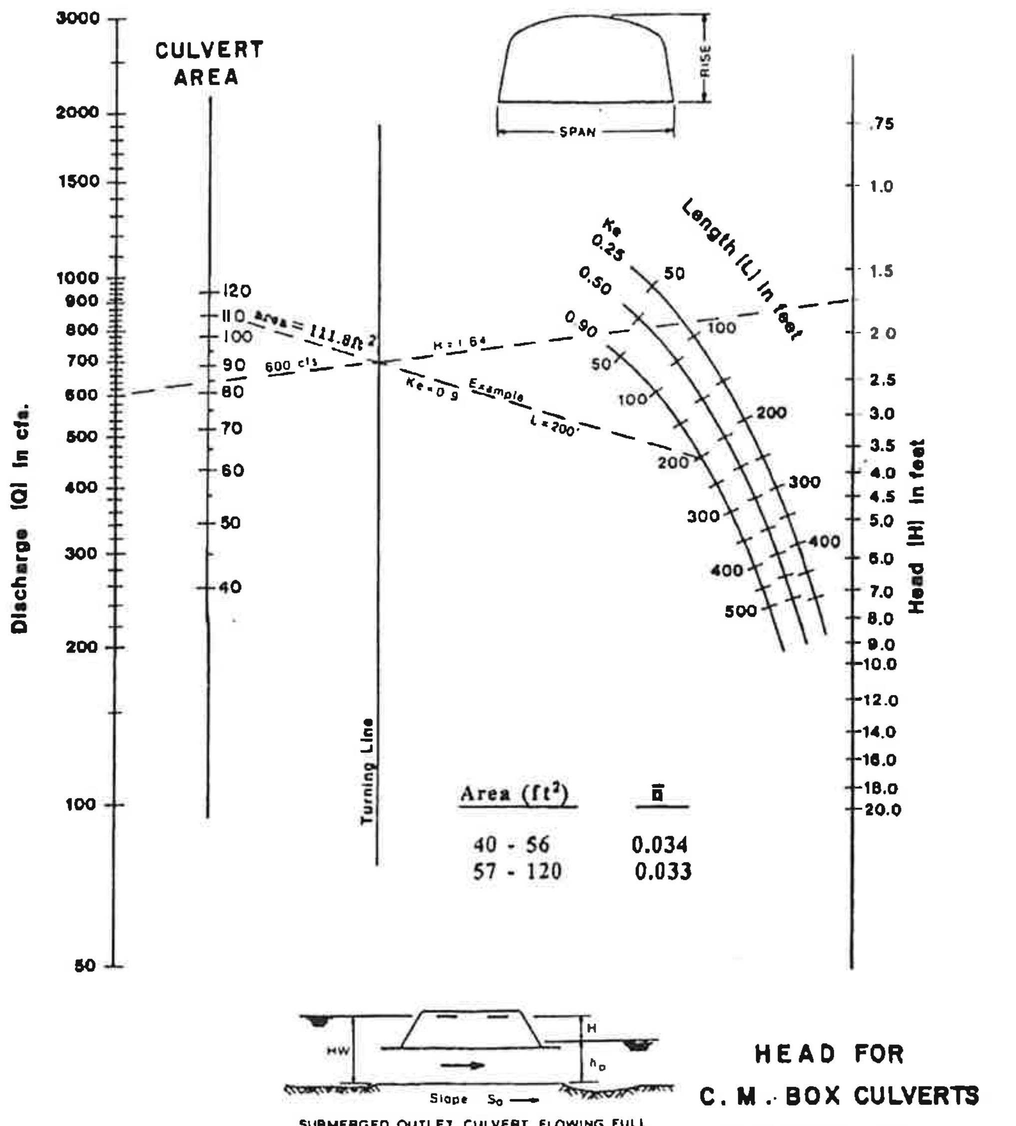
Area (ft²)	n
20 - 57	0.034
58 - 142	0.033
143 - 220	0.032

HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CORRUGATED METAL BOTTOM
0.4 ≤ RISE / SPAN < 0.5

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 28B

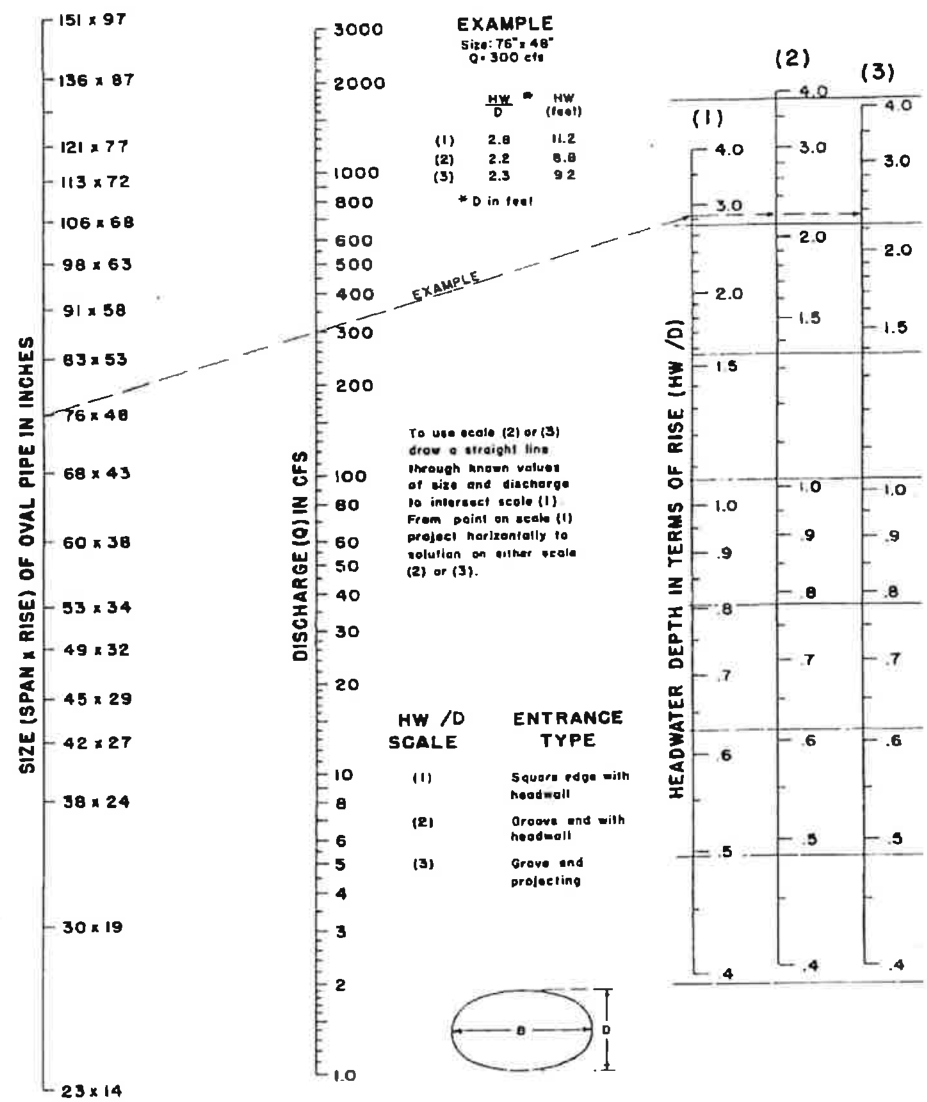


HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CORRUGATED METAL BOTTOM
0.5 ≤ RISE / SPAN

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

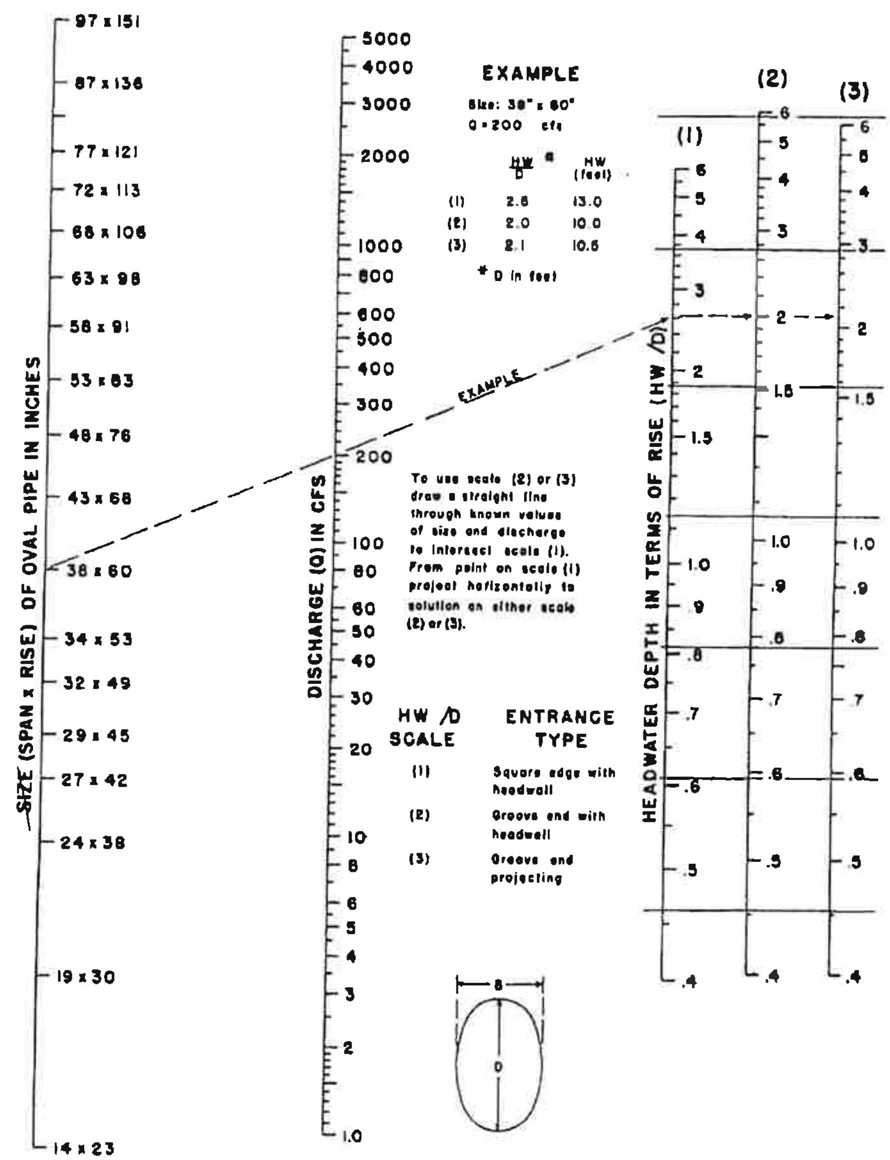
CHART 29B



HEADWATER DEPTH FOR
OVAL CONCRETE PIPE CULVERTS
LONG AXIS HORIZONTAL
WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN 1963

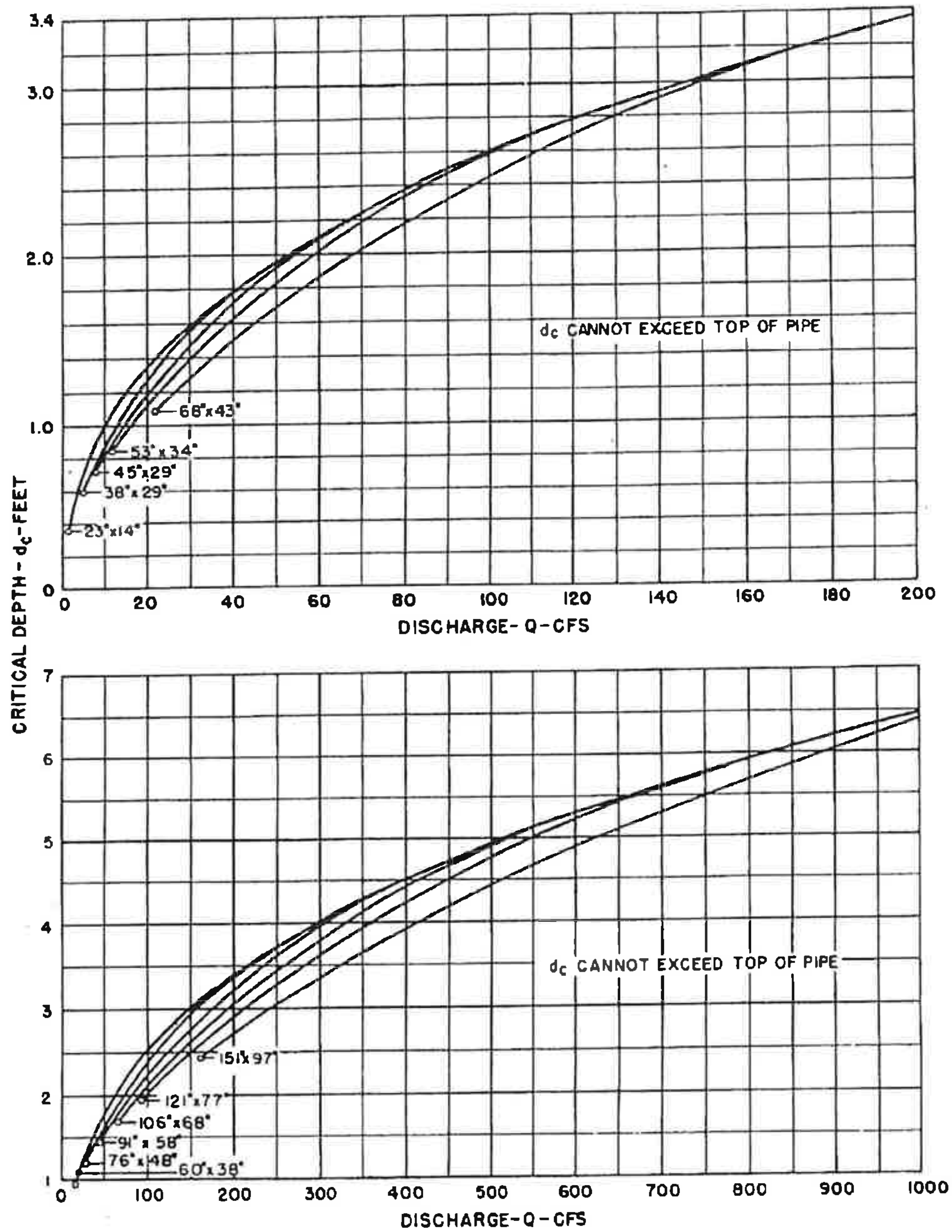
CHART 30B



HEADWATER DEPTH FOR
OVAL CONCRETE PIPE CULVERTS
LONG AXIS VERTICAL
WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN 1963

CHART 31B

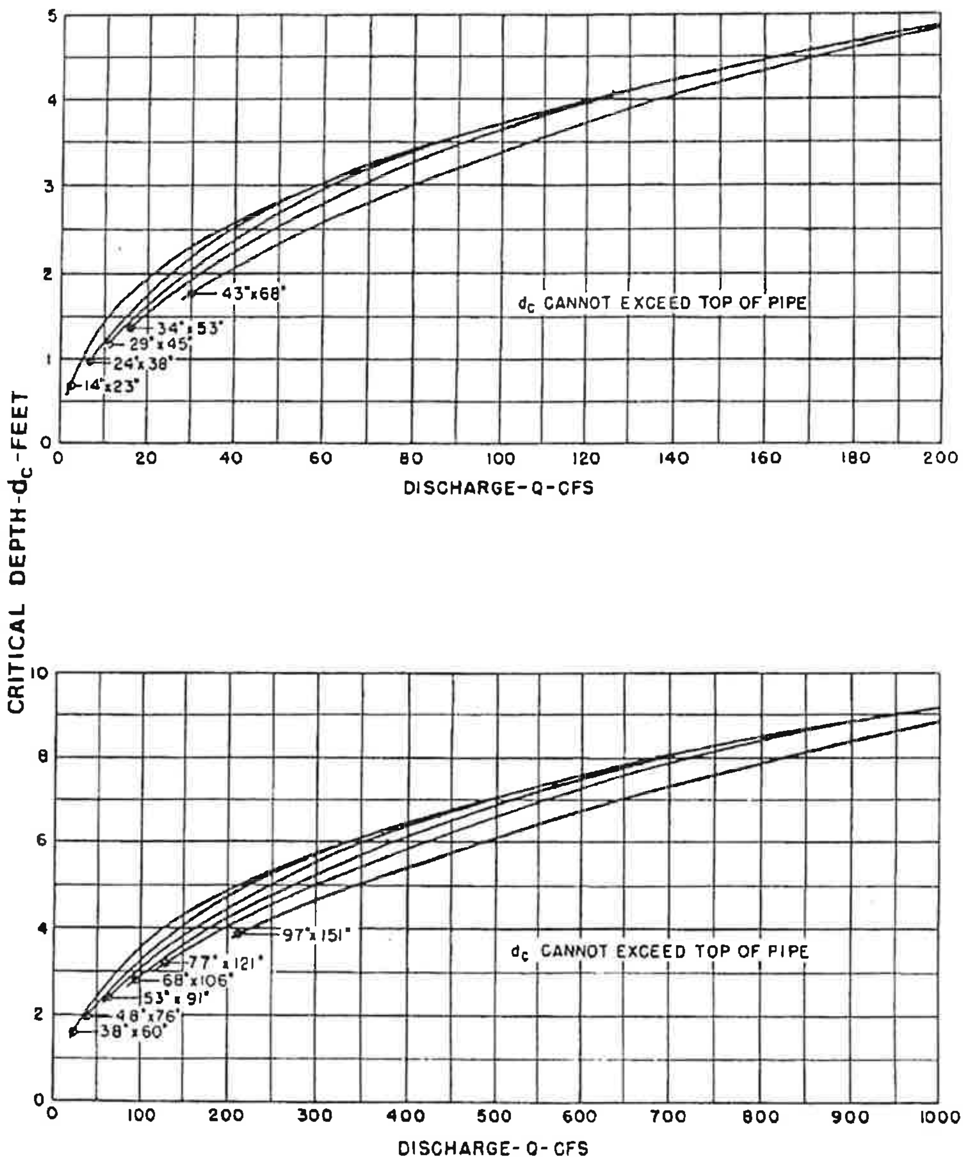


BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
OVAL CONCRETE PIPE
LONG AXIS HORIZONTAL

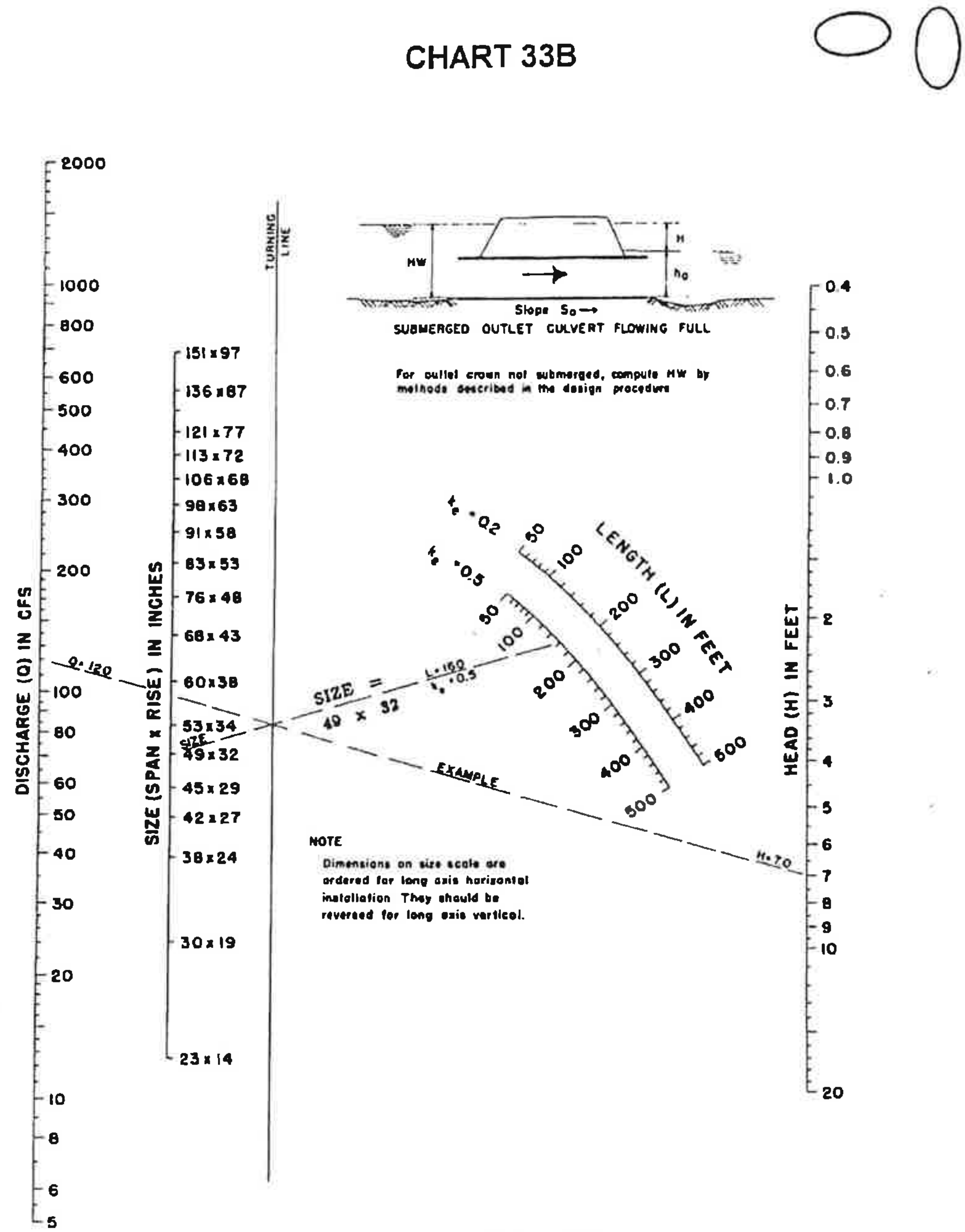
CHART 32B



BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
OVAL CONCRETE PIPE
LONG AXIS VERTICAL

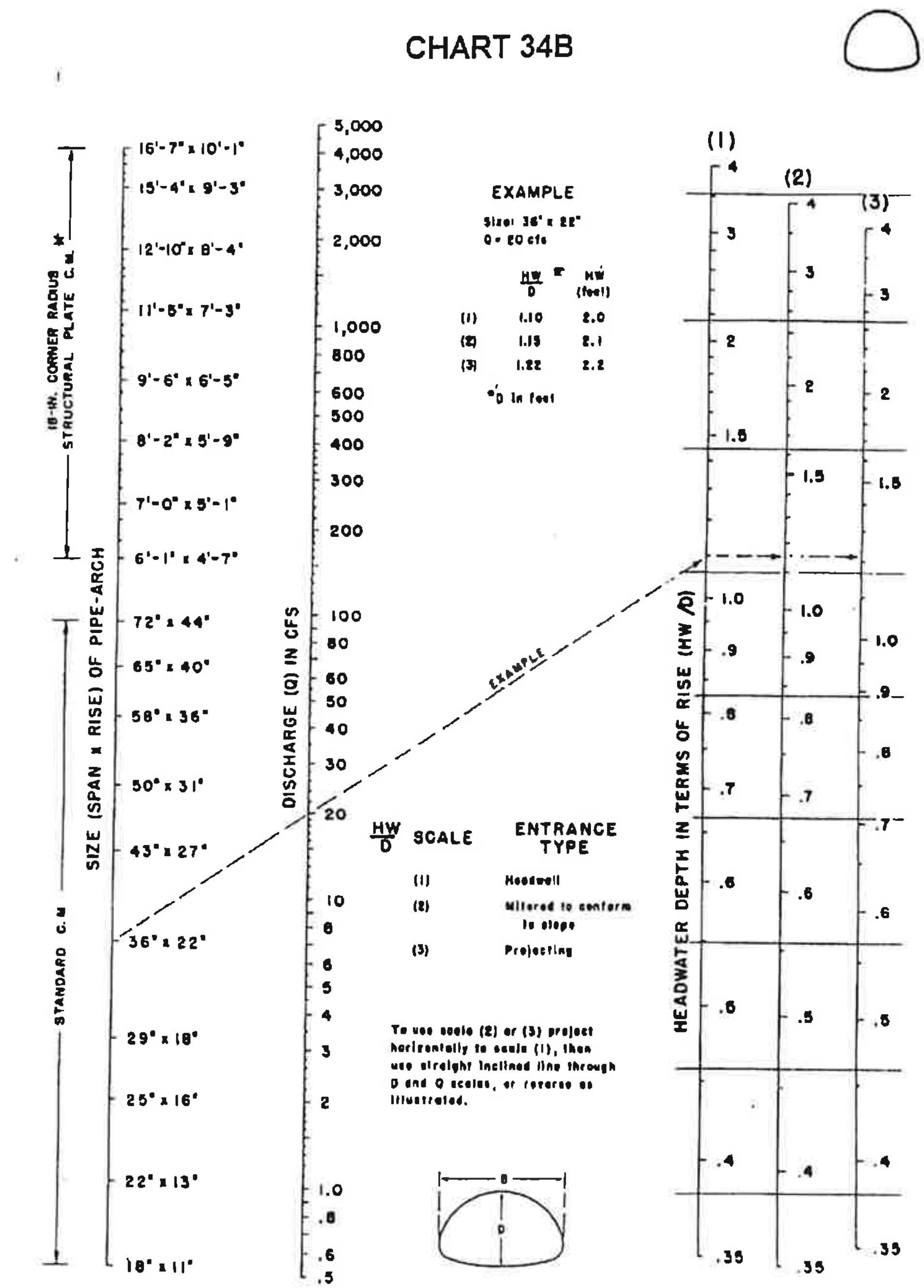
CHART 33B



HEAD FOR
OVAL CONCRETE PIPE CULVERTS
LONG AXIS HORIZONTAL OR VERTICAL
FLOWING FULL
$n = 0.012$

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 34B

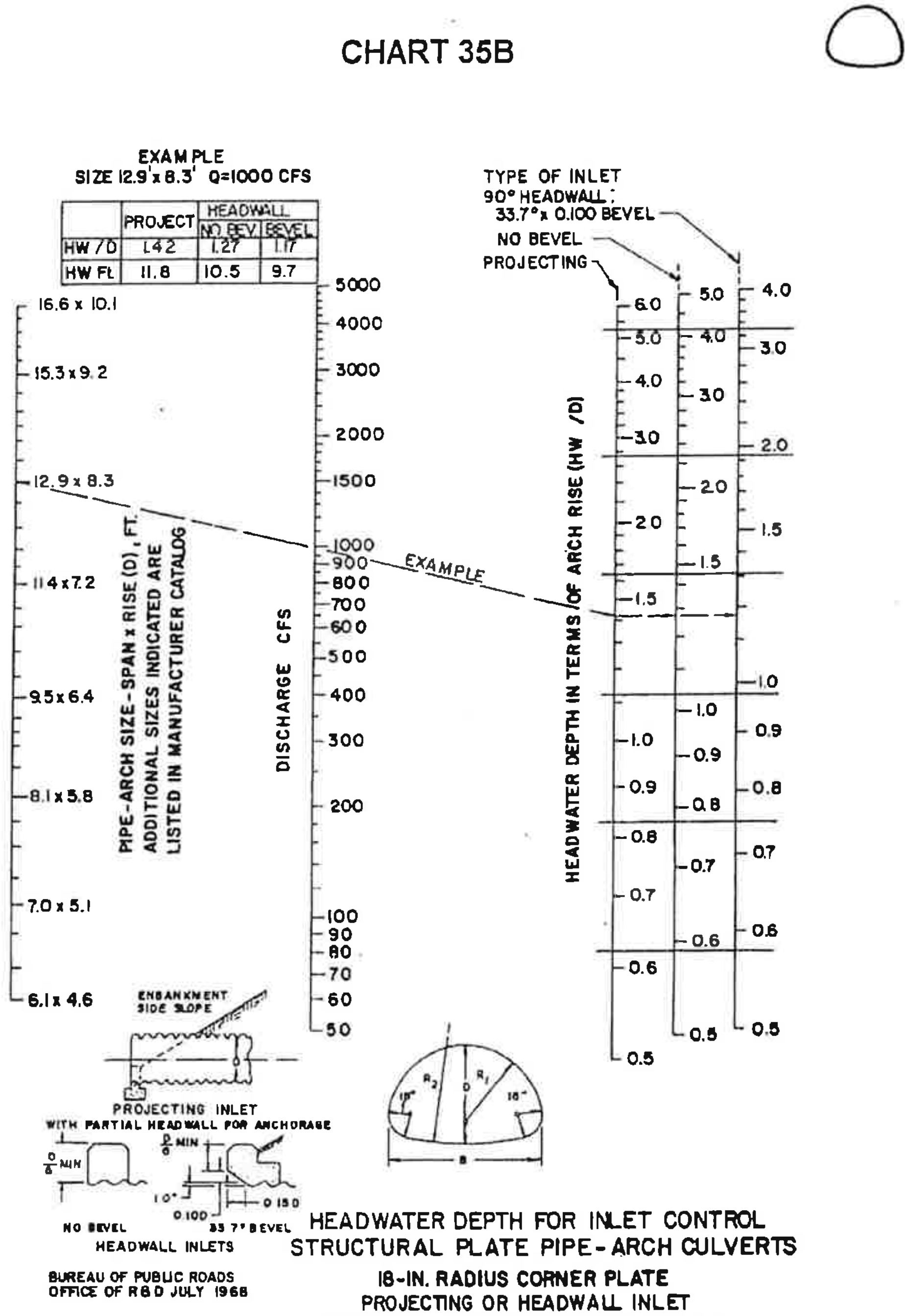


*ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

BUREAU OF PUBLIC ROADS JAN. 1963

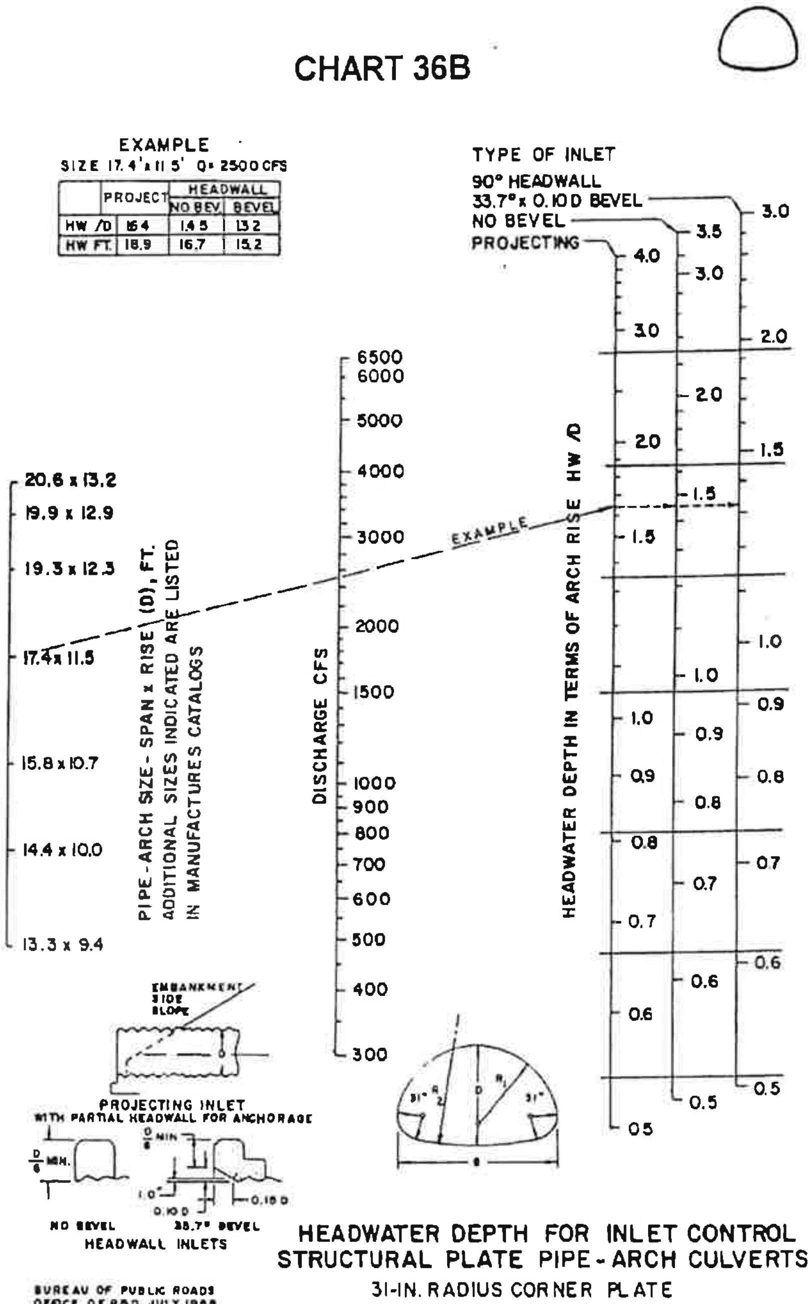
HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

CHART 35B



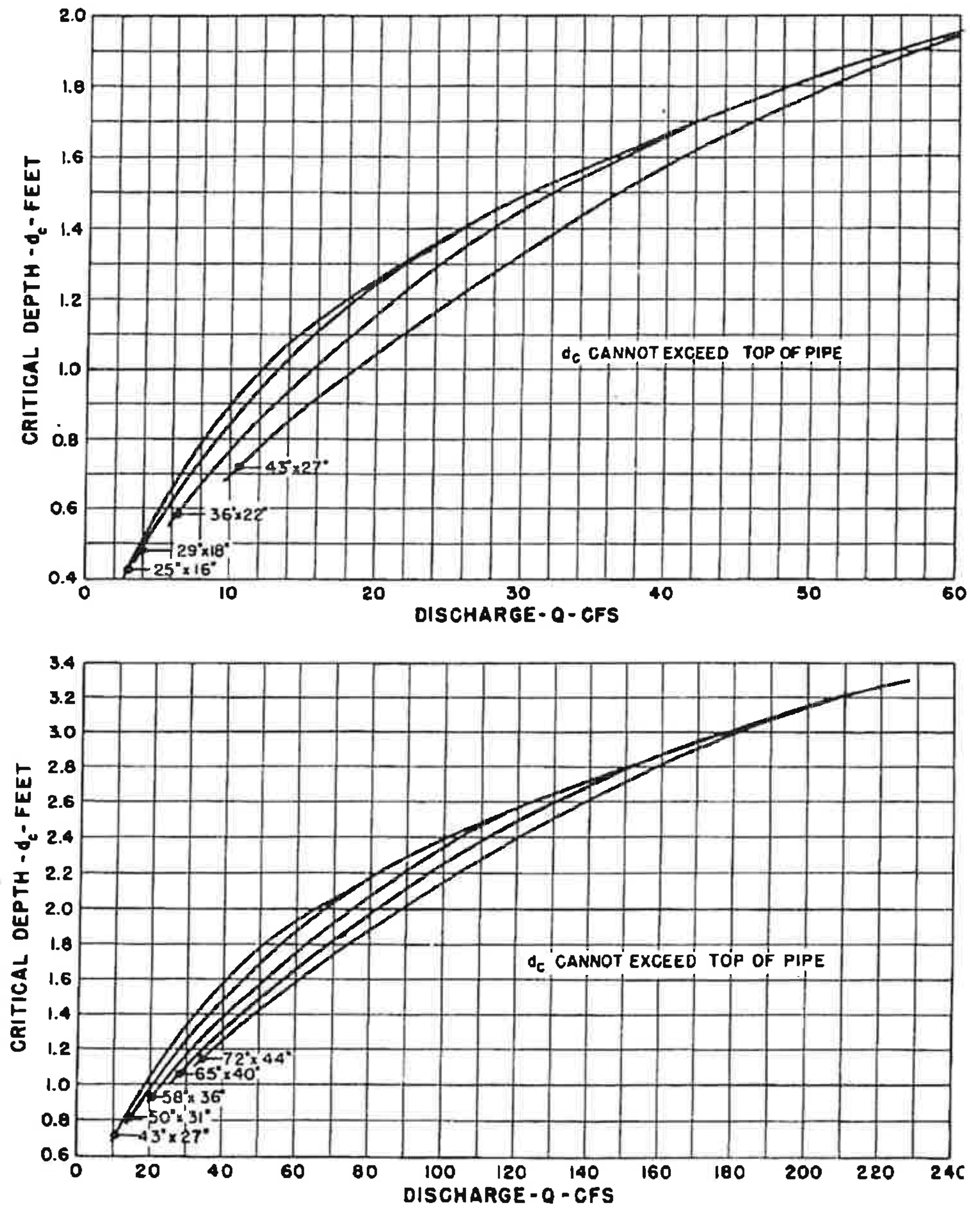
HEADWATER DEPTH FOR INLET CONTROL
STRUCTURAL PLATE PIPE-ARCH CULVERTS
18-IN. RADIUS CORNER PLATE
PROJECTING OR HEADWALL INLET
HEADWALL WITH OR WITHOUT EDGE BEVEL

CHART 36B



HEADWATER DEPTH FOR INLET CONTROL
STRUCTURAL PLATE PIPE-ARCH CULVERTS
31-IN. RADIUS CORNER PLATE
PROJECTING OR HEADWALL INLET
HEADWALL WITH OR WITHOUT EDGE BEVEL

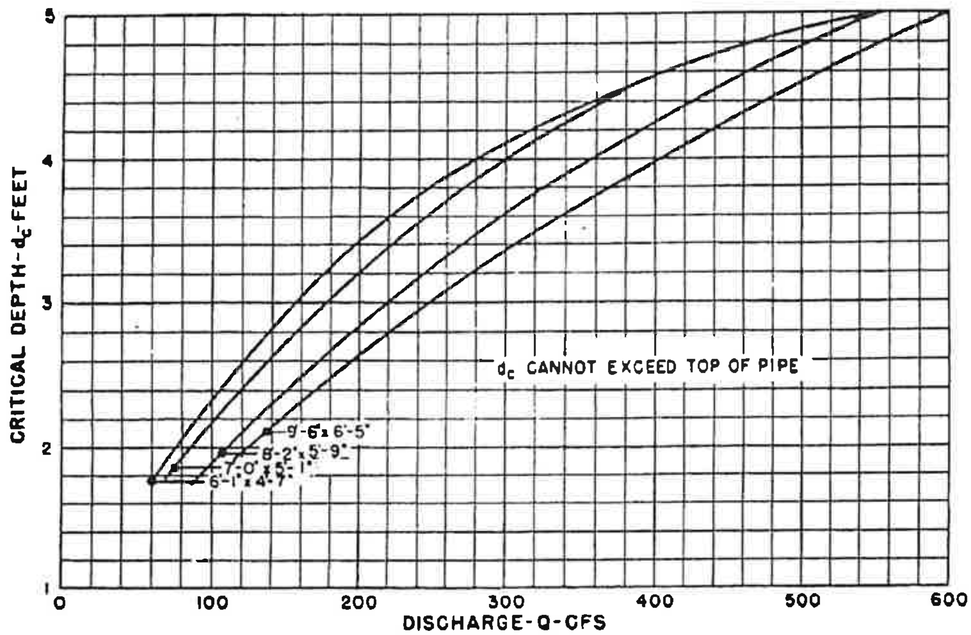
CHART 37B

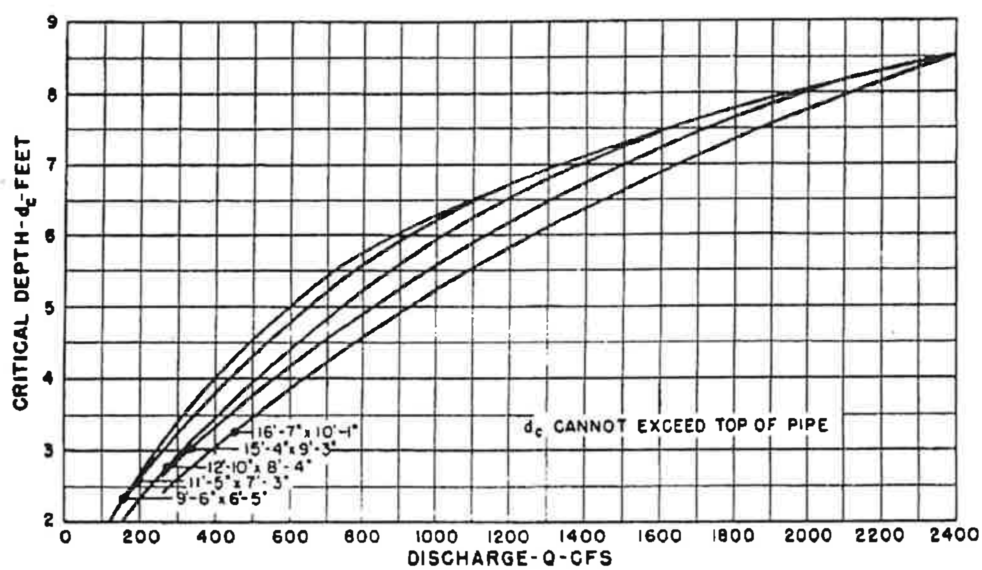


BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

CHART 38B

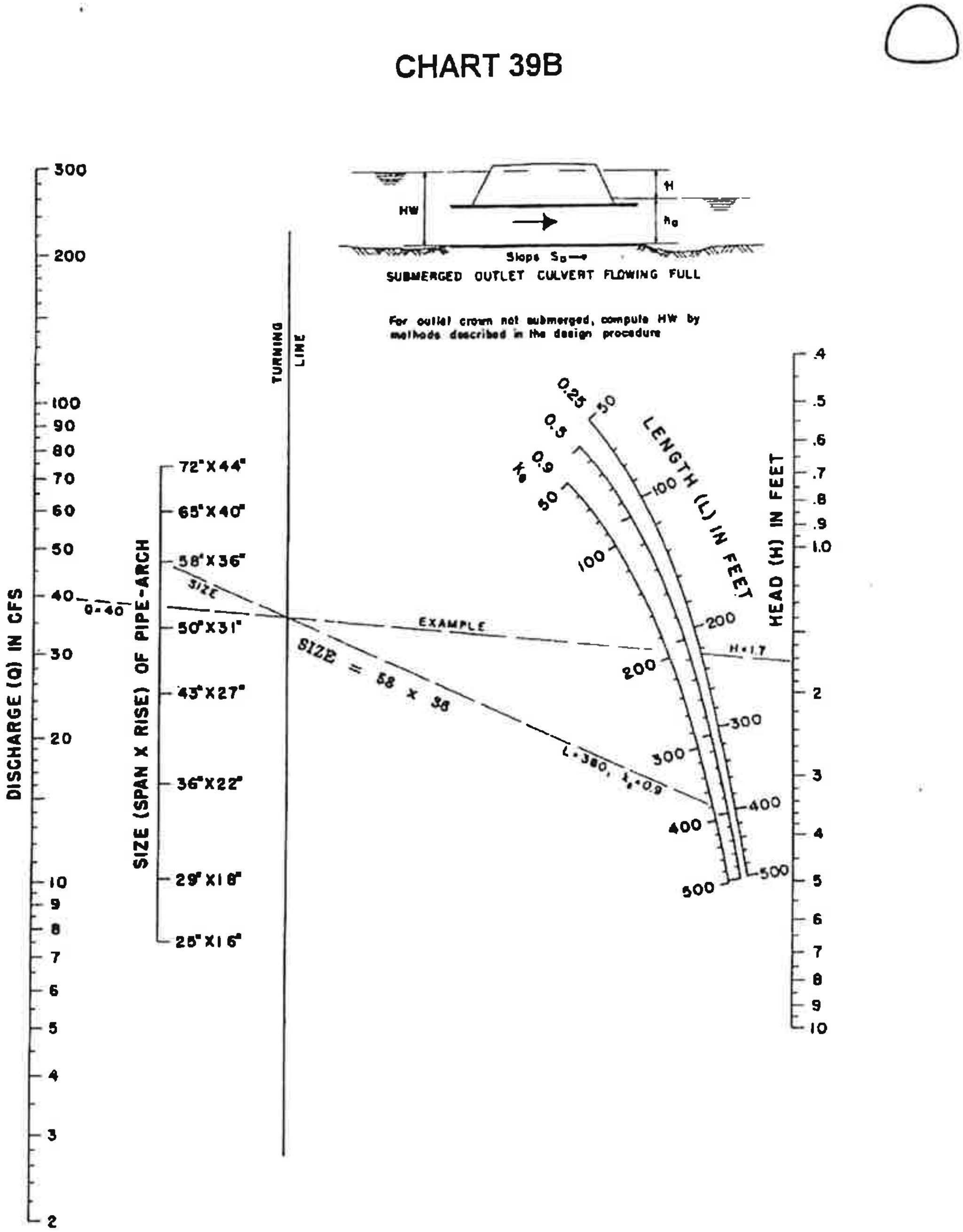




BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
STRUCTURAL PLATE
C. M. PIPE-ARCH
18 INCH CORNER RADIUS

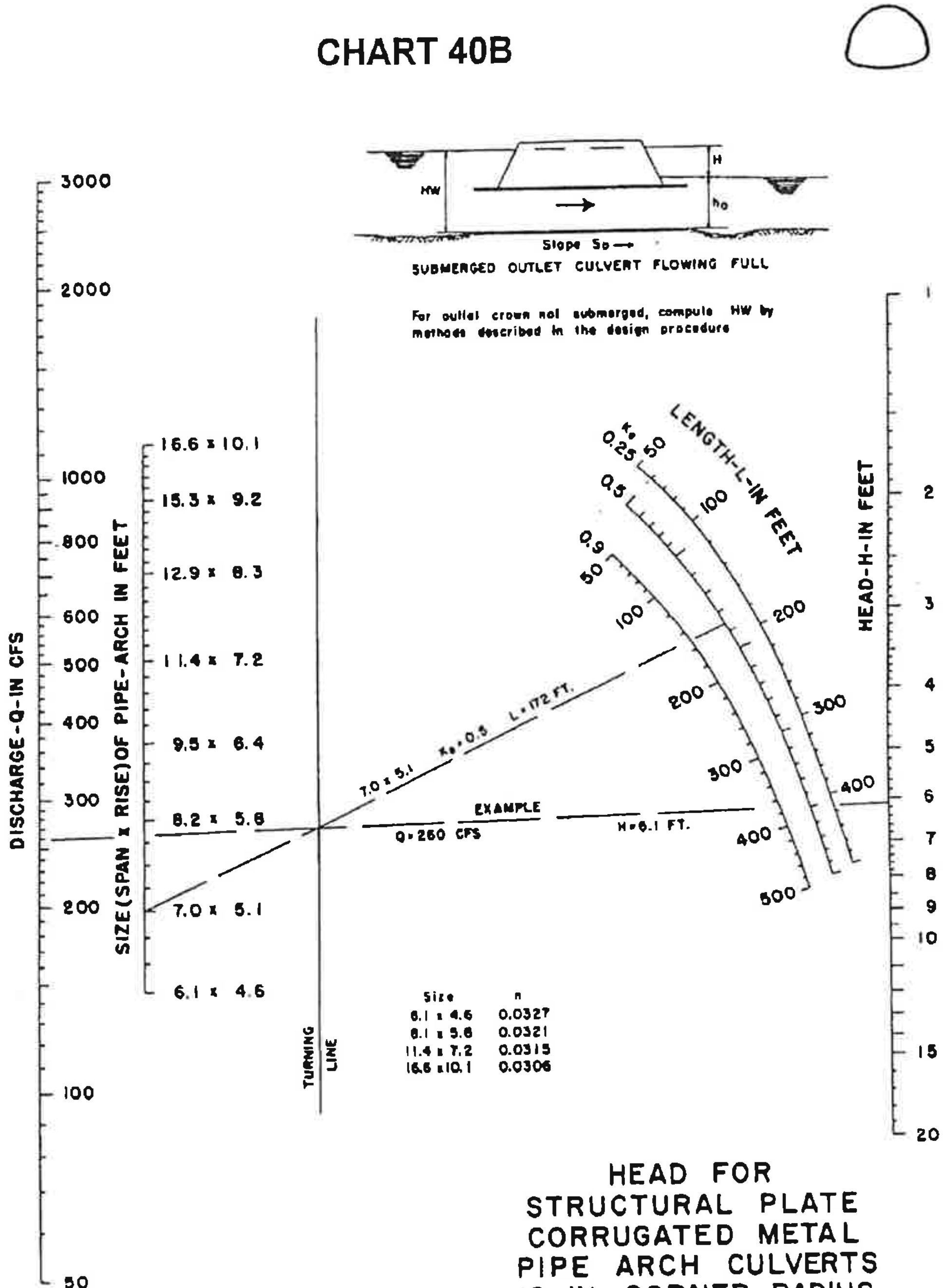
CHART 39B



HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n=0.024

BUREAU OF PUBLIC ROADS JAN. 1963

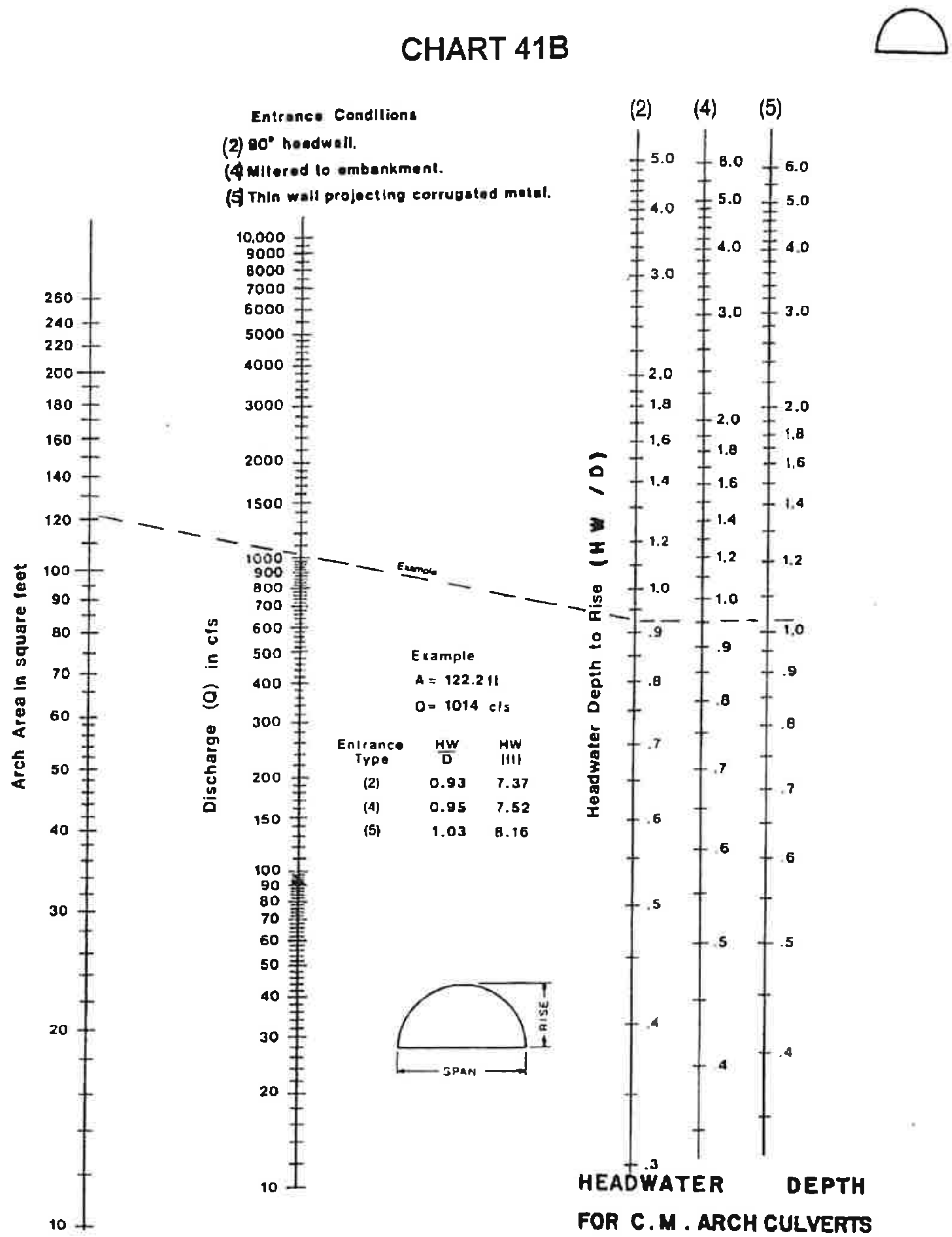
CHART 40B



HEAD FOR
STRUCTURAL PLATE
CORRUGATED METAL
PIPE ARCH CULVERTS
18 IN. CORNER RADIUS
FLOWING FULL
n=0.0327 TO 0.0306

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 41B



HEADWATER DEPTH
FOR C.M. ARCH CULVERTS
0.3 ≤ RISE / SPAN < 0.4
WITH INLET CONTROL

Duplication of this nomograph may distort scale

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation