CHAPTER 8 - WATER QUALITY ENHANCEMENT

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8.1 INTRODUCTION

As part of the National Urban Runoff Program conducted by the Environmental Protection Agency (EPA), Denver Regional Council of Governments (DRCOG) prepared a regional study of the nature of urban runoff, the influence on receiving waters, and possibilities for control of non-point sources of pollution. This study determined that detention and rapid infiltration were effective measures for stormwater runoff pollution control.

This study and others are:

a. To prevent excessive euthrophication of the reservoir, phosphorous loadings must be controlled to keep algal growths within acceptable levels.

b. A significant source of phosphorous was from stormwater runoff.

c. To achieve an overall non-point phosphorous removal of 50% for the entire basin, detention and rapid infiltration treatment of runoff from developed areas was recommended.

This section of the CRITERIA was prepared as the Best Management Practice (BMP) for control of non-point phosphorous from urban runoff in Douglas County. If required by the Town, all future development and any redevelopment shall provide detention and rapid infiltration or filtration treatment whenever stormwater runoff is tributary to a creek or basin, any drainageway entering a water supply reservoir, and any other watershed designated by State or County in accordance with this section of the CRITERIA. The consolidation of stormwater detention and phosphorous control facilities by all development and redevelopment projects is encouraged by the Town. Regionalized or basinwide facilities offer advantages regarding economics of scale and improved potential for adequate operation and maintenance.

8.2 MANAGING URBAN RUNOFF

BMP's can be classified as either structural or non-structural. Structural controls are usually "effect-oriented" such as detention systems, while non-structural controls are usually "cause-oriented" such as erosion control ordinances. Because non-point source pollution is varied in nature and impact, no individual BMP may fit all situations. The BMP's must be tailored to fit the needs of particular sources and circumstances. A cost-effective approach to controlling pollution from urban stormwater runoff is a combination of structural and non-structural control measures.

8.2.1 Structural Controls

The urban runoff structural controls which are judged to be most effective for removing pollutants are detention followed by rapid infiltration or filtration type of treatment. Ponds with long detention times (greater than 12 hours) were found to be effective in reducing pollutants such as Total Suspended Solids (TSS), Lead, Phosphorous, Nitrogen, Biochemical Oxygen Demand (BOD), and others (References-3, -13, -20, -22, and -24). The effectiveness of the pond is dependent on many variables such as rainfall/runoff characteristics, shape, volume, depth and area, detention times, and pollutant characteristics. The removal effectiveness varies from as little as 10% to as much as 95% depending on the pollutant and other variables. Design standards and criteria for the control of phosphorous using detention followed by filtration or infiltration are set forth in Section 8.3 of this document.

8.2.2 Non-Structural Controls

The non-structural controls which were found to be effective in reducing non-point pollutant loads are erosion and sedimentation control during construction activities and the maintenance of drainage facilities.

Erosion control is an effective BMP for controlling non-point pollution in the region. Sediment production from construction activities can be controlled through a number of temporary and permanent measures. Planning for erosion control is an important element in an erosion control program. Costs for developing an erosion control plan as a part of the initial planning process for a proposed development are small and will not add significantly to the total project costs. Much of the information necessary for erosion control planning will be generated as data is developed for other aspects of the project.

The key to a successful erosion control program is local government enforcement. This includes adoption of an ordinance, reviewing plans, construction inspection, and enforcement of monitoring and maintenance requirements. Maintenance, which is often neglected for drainage facilities, is essential to assure long-term effectiveness of drainage facilities and erosion control measures. Effective maintenance operations can reduce repair costs, flooding, lengthen the life span of facilities, improve water quality and provide aesthetic benefits. A complete survey of existing drainage facilities should be conducted to identify the number of facilities and to assess the required maintenance to bring all facilities up to a good operational level.

8.2.3 General Planning and Design Guidelines

Based on the experiences of DRCOG and other water quality control agencies, general planning and design guidelines for non-structural and structural non-point source control have been established. The recommended guidelines are as follows:

1. Promote infiltration of urban runoff by minimizing on-site impervious areas and preserving natural, broad drainageways.

2. Minimize continuous impervious areas by providing grassed or gravel buffer zones between impervious surfaces. Divert runoff from impervious area to pervious surfaces before the flows enter surface drainageways.

3. Locate detention and infiltration in areas that avoid creating a nuisance and the need for increased maintenance.

4. Provide multiple access to facilities to improve maintenance capabilities.

5. Direct off-site stormwater flow around the on-site facilities.

6. Revegetate and/or stabilize all areas distributed by construction activities and all storm drainageways created as a part of the development.

7. Construction contracts should include landscaping performance guarantees to ensure that plantings and grass cover become firmly established before the contractor's obligation is released and maintenance efforts begin.

8.3 DESIGN STANDARDS AND CRITERIA FOR PHOSPHOROUS REDUCTION

8.3.1 Detention

The recommended treatment of urban storm runoff for the reduction of phosphorous is a combination of detention followed by filtration or rapid infiltration. Other systems with equivalent or better phosphorous removal capability (minimum of 50% removal of total phosphorous for a detention/filtration system and 90% removal of total phosphorous for a detention/infiltration system) may be considered by the Engineering representative of the Town on a case-by-case basis.

The filtration/infiltration systems may utilize (a) native soils (infiltration) provided they have the appropriate permeability and phosphorous removal characteristics or (b) a prepared filter media (filtration) in those areas where the natural permeability is too low, resulting in excessively large infiltration areas, or it is too high, resulting in poor treatment. Removal of soluble phosphorous will be better with infiltration,a dn designers are encouraged to use native soils wherever possible. Infiltration capabilities of soils should be the prime factor in the siting or rapid infiltration facilities. However, rapid infiltration design requires a substantial amount of soils and subsurface hydrologic data and will only be considered by the county when accompanied by a detailed, site-specific, design report prepared by a licensed geotechnical engineer with experience in this type of work.

All stormwater detention facilities within the Town shall be designed in accordance with Chapter 5, "Detention" with modifications as presented in this section. A Water Quality Design Decision Flowchart is presented in Figure 802 to aid in the design of water quality enhancement modifications to the facilities required by Chapter 5.

1. Water Quality Storage Volume

The water quality storage volume required in addition to the detention storage requirements (see Section 5.3.1) shall be calculated using the following equation:

$$V_{WQ} = \frac{IA}{2400} \qquad \text{Equation 801}$$

where V_{WQ} = Water Quality Volume (acre-feet)
A = Total area tributary to water quality pond (acres)
I = Imperviousness of area A (percent)

The area tributary to the pond shall also include any off-site area which would flow through the pond. The designer is encouraged to route all off-site flows around the water quality pond, otherwise the pond will be larger than is necessary to treat runoff from the developed site only.

2. Water Quality Detention Basin Width/Length

The ration of the water quality enhancement detention basin length to the basin width shall be at least 2 to 1 (see Figure-803).

3. Water Quality Basin Average Depth

The minimum average depth in wet pond for the water quality volume shall be 3.5 feet. There is no minimum depth requirement for a dry pond.

4. Water Quality Basin Baffle

To prevent short-circuiting of flow between the inlet and outlet of the pond, a baffle shall be constructed at the upstream end of the detention facility (see Figure 802). The baffle shall be located at 1/4 of the distance from the basin in;let to the basin outlet. The length of the baffle (see Figure 803) shall be approximately 1/3 the basin width. The baffle shall be constructed of redwood or other materials suitable for long-term use in an alternating wet and dry environment.

8.3.2 Water Quality Outlet

1. Dry Pond

The water quality outlet shall be constructed to release the total water quality storage volume over a time period of approximately 40 hours. A typical outlet configuration is presented in Figure 805 and consists of a riser pipe with several rows and one or more columns of drainage holes. The design in these CRITERIA has been standardized using a riser with the rows of drain holes spaced uniformly at 4-inches for the entire height of the riser. The riser pipe shall be galvanized steel meeting ANSI/ASTM A-120 with a minimum diameter of four inches.

The outlet holes in the riser pipe are sized by setting the design depth at the water quality volume and then determining the maximum allowable open area per row of drain holes using Figure 807. Then, the size of the holes and the number of riser pipes may be selected using Table 801. An example water quality outlet design is presented in Section 8.6.

2. Wet Pond

For a wet pond, the total water quality volume is to be stored below the bottom-most holes of the water quality riser pipe (refer to Figure 806). The water quality riser pipe then extends above the water surface of the water quality volume an amount that is dictated by flow routing to the filter media, but no less than 1-foot above the normal water surface of the water quality volume. The outlet holes in the riser pipe may be sized using the same procedure as for a dry pond; however, the size of the filter bed will dictate the maximum allowable rate of discharge. To simplify this design the designer is allowed to use up to 45% of the 10-year stormwater routing volume as required in Chapter 5, for the routing of the water quality surcharge to the filter whenever a "wet pond" configuration is used. No such use of the 10-year stormwater routing volume will be allowed when using the "dry pond" configuration. Example No. 9 illustrates how the 10-year stormwater volume is utilized to route the flows through the outlet to the sand filter. If a designer wishes to route the water quality surcharge in a wet pond (which is equal to the volume required by Equation 801) using other design procedures that permit faster drainage, then the size of the filter bed has to be increased. The filter bed needs to be sized using Equation 802 on the basis of peak outflow rate from the outlet, regardless of the design procedure used.

8.3.3 Infiltration Basins

As previously noted, infiltration basins are encouraged because of the ability of most native soils to remove more soluble and total phosphorous than a sand filtration media. Infiltration basins are also considered to be more economical due to the lesser material requirements than a filtration basin, especially for the larger developments or where regional facilities are designed to serve two or more developments.

However, because of the design complexity for infiltration basins, site-specific soils and subsurface hydrologic investigations are required as part of the design process. The investigation work must be performed by a licensed geotechnical engineer experienced in this type of work. A detailed design report shall be submitted to the Engineering representative of the Town for approval prior to submittal of construction drawings and specifications.

8.3.4 Filtration Basins

Filtration basins shall be sized using a hydraulic surface loading of 0.090 gallons per minute per square foot (gpm/ft.^{2}). This loading rate includes a factor of safety and is based on a 6-inch surcharge above the sand media to provide needed hydraulic gradient. considered in this rate is the "pre-treatment" effect of the extended detention which removes many of the particulates that can clog sand filter media. The specified design is expected to provide five to six years of operation before part of the sand bed has to be replaced.

1. Design Peak Inflow

The peak inflow to the filtration basin and for the sizing of the filtration piping system shall be computed using the following equation for the outlet configuration depicted in these CRITERIA:

$$Q_{WQ} = 37\,D^{1.4}\,(a) \qquad \text{Equation 802}$$

Q_{WQ} = Design peak inflow (gpm)

D = Maximum depth of water above the center of lowest row of drain holes in feet (see Figure 805 and 806)

a = Area of one row of holes in the water quality riser pipe (square inches)

2. Filtration Basin Dimensions

The minimum surface area of the filtration basin shall be computed using the following equation:

$$A_F = \frac{Q_{WQ}}{.090} \qquad \text{Equation 803}$$

A_F = Surface area of filter (ft.^{2})

Q_{WQ} = Design peak inflow (gpm), from Equation 802

3. Underdrain Requirements

The perforated underdrain pipe shall be PVC as per ASTM D2729 with a minimum nominal inside diameter of 4-inches. Each pipe shall gave two rows of evenly spaced 3/8-inch diameter perforations, 120° apart, providing a minimum number of holes of 16 per foot (total of both rows). Underdrains shall be designed for gravity flow such that they drain completely free of water after each use.

Perforated underdrain pipe shall be sloped at a minimum of one percent (1%) to drain towards the header pipe. The drain pipe spacing shall be based on the number of square feet of filter area the pipe is allowed to serve; but the spacing between pipes shall not exceed 20-feet, and the spacing between the outermost pipe and the edge of the filter bed shall not exceed 10 feet.

The filter area that each perforated drain pipe may serve shall not exceed 900 square feet. Also, the maximum length of individual perforated pipe runs shall not exceed 100 feet. If the drain pipes exceed 100 feet in length, an additional header pipe to intercept the perforated drain pipes shall be required.

The underdrain pipe shall be connected to a PVC header pipe. The header pipe shall be sloped at two percent (2%) to drain towards the outfall or major drainageway. The header pipe shall be sized to flow one-half (1/2) full at the maximum inflow rate for one header, or at a rate of 0.09 gallons per minute per each square foot of filter area the header is designed to serve in the case of multiple headers.

4. <u>Sand Filtration Medium</u>

The sand filtration medium to be used in the filtration basin shall meet the following sieve characteristics:

U.S. STANDARD SIEVE SIZE	PERCENT PASSING (BY WEIGHT)
No. 4	100
No. 8	95 - 100
No. 16	85 - 100
No. 30	50 - 90
No. 50	15 - 60
No. 100	0 - 25
No. 200	0 - 10

A verification of gradation of these materials, prepared by an independent testing laboratory within 30 days of submittal of plans shall be provided. Materials meeting gradation for "mortar" or "masonry sand" will generally satisfy the above criteria.

5. <u>Gravel Filtration Medium</u>

The washed gravel filter medium shall meet the gradation requirements of Class B Filter Materials (Colorado Department of Highways, Specification 703.09) as follows:

U.S. STANDARD SIEVE SIZE	PERCENT PASSING (BY WEIGHT)
1 1/2 inch	100
No. 4	20 - 60
No. 16	10 - 30
No. 50	0 - 10
No. 200	0 - 3

A verification of gradation of these materials, prepared by an independent testing laboratory within 30 days of submittal of plans shall be provided.

6. Filter Fabric

Filter fabric shall consist of a non-woven, polypropylene geotextile, with the following minimum properties:

PROPERTIES	MEASURE	UNITS
Equivalent Opening Size (EOS)	U.S. Standard Sieve (COE-CW-02215077)	100
Coefficient of Permeability	cm/sec	1.0×10^{-2}
Water Flow Rate	gal/min/sf	285

Manufacturer certificate shall be provided by the contractor through the supplier within 30 days of the submittal of plans.

8.4 MONITORING

Flow and phosphorous removal monitoring requirements may eventually be required after the Clean Water Plan Amendment is completed and approved. To facilitate future monitoring activities, provisions must be made for future installation of flow metering and recording equipment. To measure the total water volume entering the detention pond, the design has allowed for addition of a system to monitor and record the depth of water in the detention pond at the concrete outlet pit (see Figure 805) or detention outlet (Figure 806). The flow into the filtration area can also be measured at this location or at the point where it enters the filter bed. However, a measuring facility is required in the latter case.

Future water quality sampling points will be at the inlet to the detention pond, the water quality outlet structure, and the rapid infiltration effluent. The design shall ensure that future access to these points will be readily available and can be accomplished without significant construction modifications to the detention ponds and filtration basin.

8.5 MAINTENANCE

The general types of maintenance anticipated at this time are noted below.

8.5.1 Detention Ponds

The operations and maintenance requirements for detention ponds shall be as set forth in the Policy Section and in Section 5 of this CRITERIA. In addition, the silt shall be removed when the water quality volume has been reduced by 10%, which is expected to occur approximately once every five years.

8.5.2 Filtration Basins

Access must be provided for heavy equipment necessary to remove and replace the surface 6-inches of the sand filter media surface at a frequency of once every five to six years. Periodic scarification (once every year) of the sand filter surface using a tractor and disk harrow may also be required for filtration areas.

8.5.3 Infiltration Basins

As with the filtration basins, infiltration designs must provide for vehicular access to periodically scarify the basins and to mow (once every month from May through September) both the vegetative cover and emergent weeds. heavy equipment access shall also be provided in case a portion of the top surface of the basin must be replaced because it has permanently lost the permeability or phosphorous removal capacity.

8.6 DESIGN EXAMPLE

Example No. 9: Water Quality Detention Design - Dry Pond

Given: A basin that has the following characteristics:

Basin Area (A) = 100 acres (including offsite area)
Basin Imperviousness (I) = 50%
Basin Soils: Type B
Detention may be a dry or wet pond. A dry pond is chosen for this example.

Required: Determine water quality modifications to the detention facility with a filtration basin requiring a sand filter medium and underdrains.

Step 1: Determine storage and release parameters for detention facility without water quality modifications (see Section 5 of the Criteria).

V_{100} = 8.04 acre-feet
V_{10} = 4.56 acre-feet
Q_{100} = 85 C.F.S.
Q_{10} = 23 C.F.S.

Step 2: Determine additional storage volume for water quality enhancement using the criteria presented in Section 15:

$$V_{WQ} = \frac{IA}{2400} \qquad \text{Equation 801}$$

$$= \frac{50 \times 100}{2400}$$

$$= 2.08 \text{ acre-feet } (90{,}750 \text{ ft.}^3)$$

Therefore the total storage volume required will be the sum at V-sub 100 and V-sub WQ or 10.12 AF.

Step 3: The designer, after examining various geometric configurations, decides that a depth of 4.5-feet at the outlet riser will achieve the desired water quality detention volume.

Step 4: The outlet riser pipe(s) holes are sized to release the water quality storage volume over a period of approximately 40 hours. Using a water quality storage volume of 2.08 acre-feet and a depth of 4.5-feet, the maximum allowable opening area per row of holes is found to be 1.75 square inches when using Figure 807. Referring to Table 801, the options are:

OPTIONS	PIPE DIA.	NO. OF COLUMNS	HOLE DIA. (INCHES)	HOLE AREA PER ROW (IN^2)	COMMENTS
A	4"	2	1.0	1.57	Too low
B	4"	3	7/8	1.80	Okay
C	4"	3	1.0	2.35	30% high

For this example, use 3 columns of 7/8" diameter holes in a 4"-diameter riser pipe, a = 1.80 square inches.

Step 5: Determine peak design inflow to filtration basin:

$$Q_{WQ} = 37\,D^{1.4}\,(a) \qquad \text{Equation 802}$$

$$= 37 \times 4.5^{1.4} \times 1.80$$

$$Q_{WQ} = 547 \text{ gpm}$$

Step 6: Determine surface area of filtration basin:

$$A_F = \frac{Q_{WQ}}{0.090} \qquad \text{Equation 803}$$

$$= \frac{547}{0.090}$$

$$A_F = 7077 \text{ square feet (use 6100 square feet)}$$

Step 7: Assuming the 6100 square feet filter basin is 80-feet wide and 76-feet long, determine the number of rows of perforated pipe. Using part 3 of Section 8.3.4, determine that:

$$\text{Number of rows drain pipe} = \frac{6100}{900} = 6.78$$

Therefore, use 7 rows of perforated drain pipe spaced at 10-feet. Since the length of the filter bed is only 76-feet, only one 10-inch header pipe will be required (based on 1/2 full flow at 547 gpm). Figure 809 illustrates the filter drain pipe layout, and Figure 810 shows the design details.

Step 8: Select sand and gravel filter medium from commercially available sources in accordance with specifications in Sections 8.3.4.4 and 8.3.4.5. Select a filter fabric in accordance with specifications of Section 8.3.4.6.

Step 9: For a dry pond, a gravel pack (see Figure 805) is required around the riser pipe to prevent clogging of the riser pipe holes. To account for the blockage of the riser pipe holes by the gravel pack, the required hole area (a) per row shall be increased by 20 to 30%. As a result, for this example, three columns of 1-inch holes (option C in step 4) is specified for the manufacture of the riser pipe.

Example No. 10: Water Quality Detention Design - Wet Pond

Given: Same as example No. 9 except that a wet pond is chosen for this example.

Required: Determine water quality modifications to the detention facility and a filtration basin requiring a sand filter medium and underdrains.

Step 1: Determine storage and release parameters for detention facility without water quality modifications (see Section 5 of these Criteria)

V_{100} = 8.04 acre-feet
V_{10} = 4.56 acre-feet
Q_{100} = 85 C.F.S.
Q_{10} = 23 C.F.S.

Step 2: Determine storage volume for water quality enhancement using the criteria presented in Section 8:

$$V_{WQ} = \frac{IA}{2400} \qquad \text{Equation 801}$$

$$= \frac{50 \times 100}{2400}$$

$$= 2.08 \text{ acre-feet } (90{,}750 \text{ ft.}^3)$$

By depressing the water quality volume below the bottom of the stormwater detention volume for the 10-year storms (i.e., V_{10}) by excavation, the net land area for the detention/water quality pond should remain essentially the same as is required by Chapter 14 (i.e., Step 1 in this example). Only a part of the stormwater detention pond bottom need be used for the "wet pond", as long as an average wet pond depth of 3.5 to 4 feet is provided.

Step 3: The designer next determines the depth of outlet riser pipe above the normal maximum water surface (NMWS) to establish distance "D" (see Figure 806). To set this distance, the area-capacity of the stormwater detention pond must be known. The depth which results in a volume of 45% of the 10-year detention storage above the normal water surface is selected.

From Step 1, the 10-year detention volume = 4.56 AF which results in:
45% x 4.56 AF = 2.05 AF surcharge water quality volume

Using this surcharge water quality volume and a table of depth-volumes for the detention area, the distance D is determined to be 2.4 for this example. See table below:

VOLUME
DEPTH TABLE

DEPTH ABOVE NMWS (FT.)	SURFACE AREA (ACRE)	ACCUM. VOLUME (AF)
0	.7	0
1	.8	.75
2	1.1	1.7
2.4	1.2	2.05
3	1.3	2.5

STEP 4: Size outlet riser pipe holes to release the surcharge water quality volume over a period of approximately 40 hours. Using Figure 807, a volume of 2.05 acre-feet and a depth of 2.4-feet, the maximum allowable opening area per row of holes is 4.4 square inches. Referring to Table 801, we see that a 3/4-inch diameter hole has an area of 0.442 and ten (10) columns of holes will just exceed the required orifice area per row of holes of 4.4 square inches.

For this example use 10 columns of 3/4-inch diameter holes in a 10-inch riser pipe with a total row area of 4.42 square inches (within 10%).

STEP 5: Determine peak design inflow to the filtration basin using actual row area of = 4.42 square inches.

$Q_{WQ} = 37\,D^{1.4}\,(a)$ Equation 802

$= 37 \times 2.4^{1.4} \times 4.42$

$Q_{WQ} = 557$ gpm

STEP 6: Determine surface area of filtration basin:

$A_F = \dfrac{Q_{WQ}}{0.090}$ Equation 803

$= \dfrac{557}{0.090}$

$A_F = 6190$ square feet (use 6200 square feet)

STEP 7: Determine underdrain spacing, assuming a filtration basin dimensions of 62-feet wide and 100-feet long (see Step 7 of Example No. 9).

STEP 8: Select sand and gravel filter medium from commercially available sources in accordance with specifications in Section 8.3.4.4 and 8.3.4.5. Select a filter fabric in accordance with specifications of Section 8.3.4.6.

WATER QUALITY OUTLET CRITERIA

(a) Riser Pipe Limitations

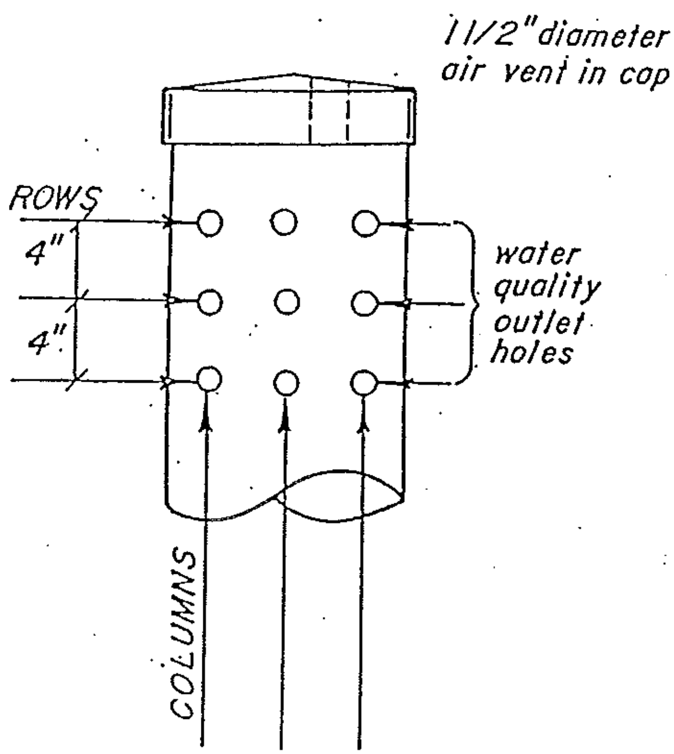
Minimum Number of Holes per Outlet Structure - 8
Maximum Number of Holes per Outlet Structure - None
Minimum Hole Size - 1/8" Diameter
Maximum Hole Size - 1" Diameter

Spacing between rows is a constant 4-inches

(b) Column Limitations

Riser Dia. (Inches)	Maximum Number of Columns Hole Diameter 1/4"	1/2"	3/4"	1"
4	8	8	6	4
6	12	12	9	6
8	16	16	12	8
10	20	20	14	10
12	24	24	18	12

(c) Riser Pipe Definition Sketch



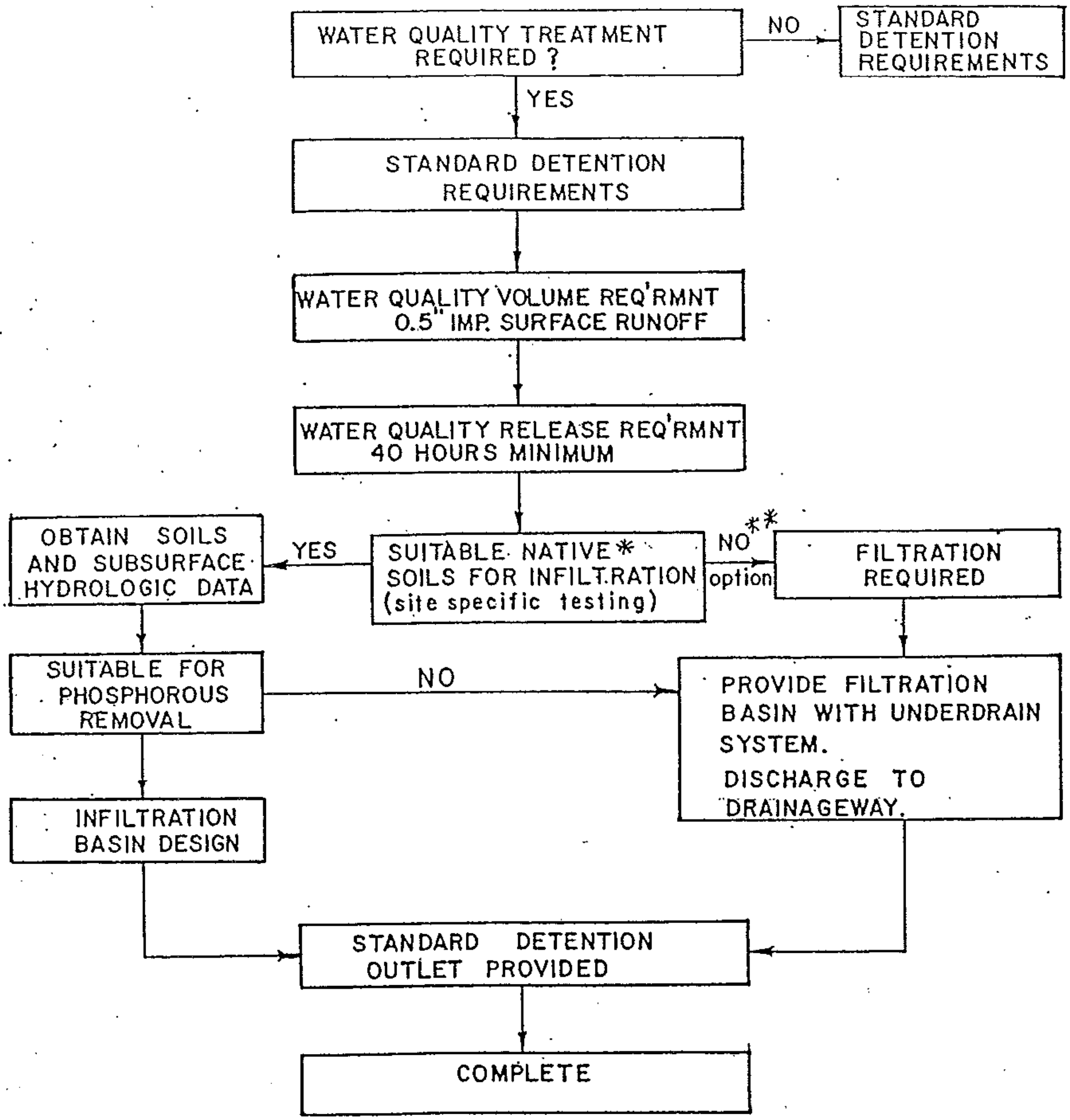
(d) AREAS OF CIRCULAR DRAIN HOLES

DIAMETER (INCHES)	AREA (SQUARE INCHES)
1/8	.013
1/4	.049
3/8	.110
1/2	.196
5/8	.307
3/4	.442
7/8	.601
1	.785

Date:
Rev:

REFERENCE:

WATER QUALITY DESIGN FLOWCHART



* Infiltration rates may be acceptable if they measure between 2 inches/hour and 20 inches/hour.

** No means either soils are not suitable or designer elects not to do site specific testing required for infiltration basin.

Date:	REFERENCE:
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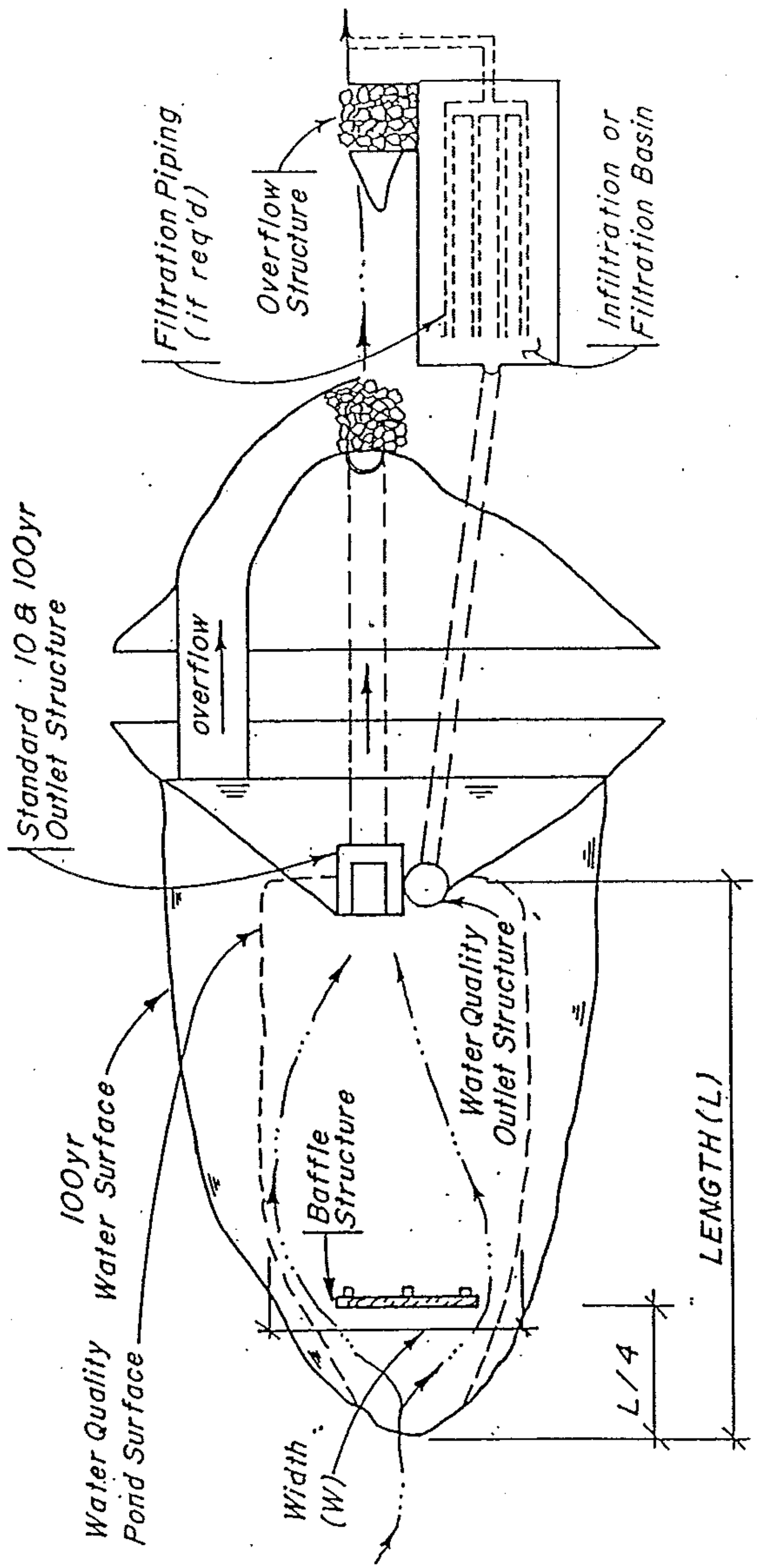
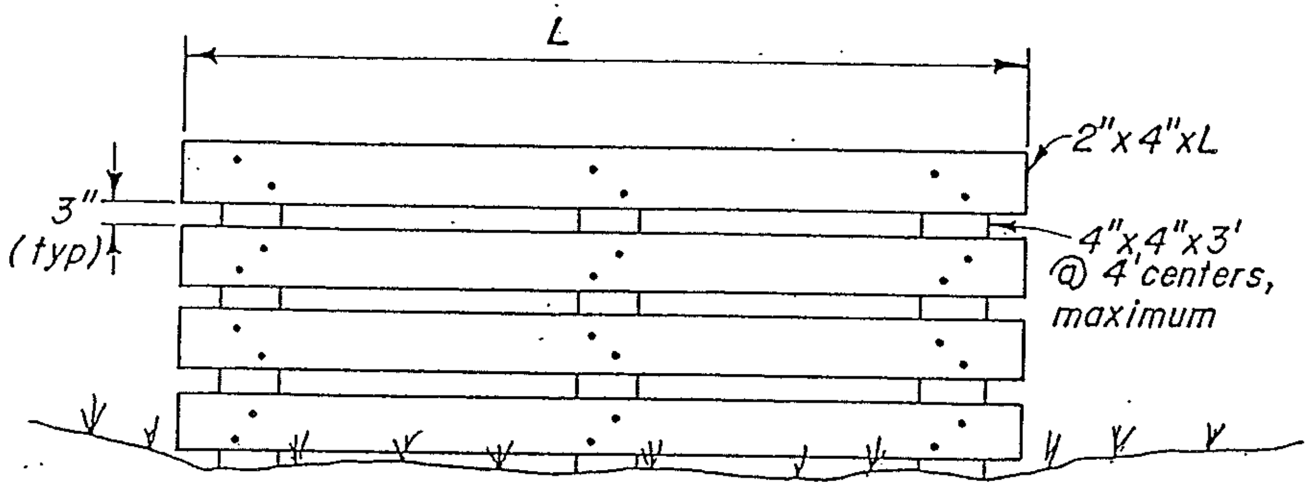
DETENTION POND WITH WATER QUALITY ENHANCEMENT FEATURES



NOTES: 1. LENGTH / WIDTH > 2.0

DETENTION BAFFLE DETAIL



L = approximately 1/3 maximum basin width W. Baffle to be constructed of redwood or other materials suitable for long-term use in an alternating wet and dry environment.

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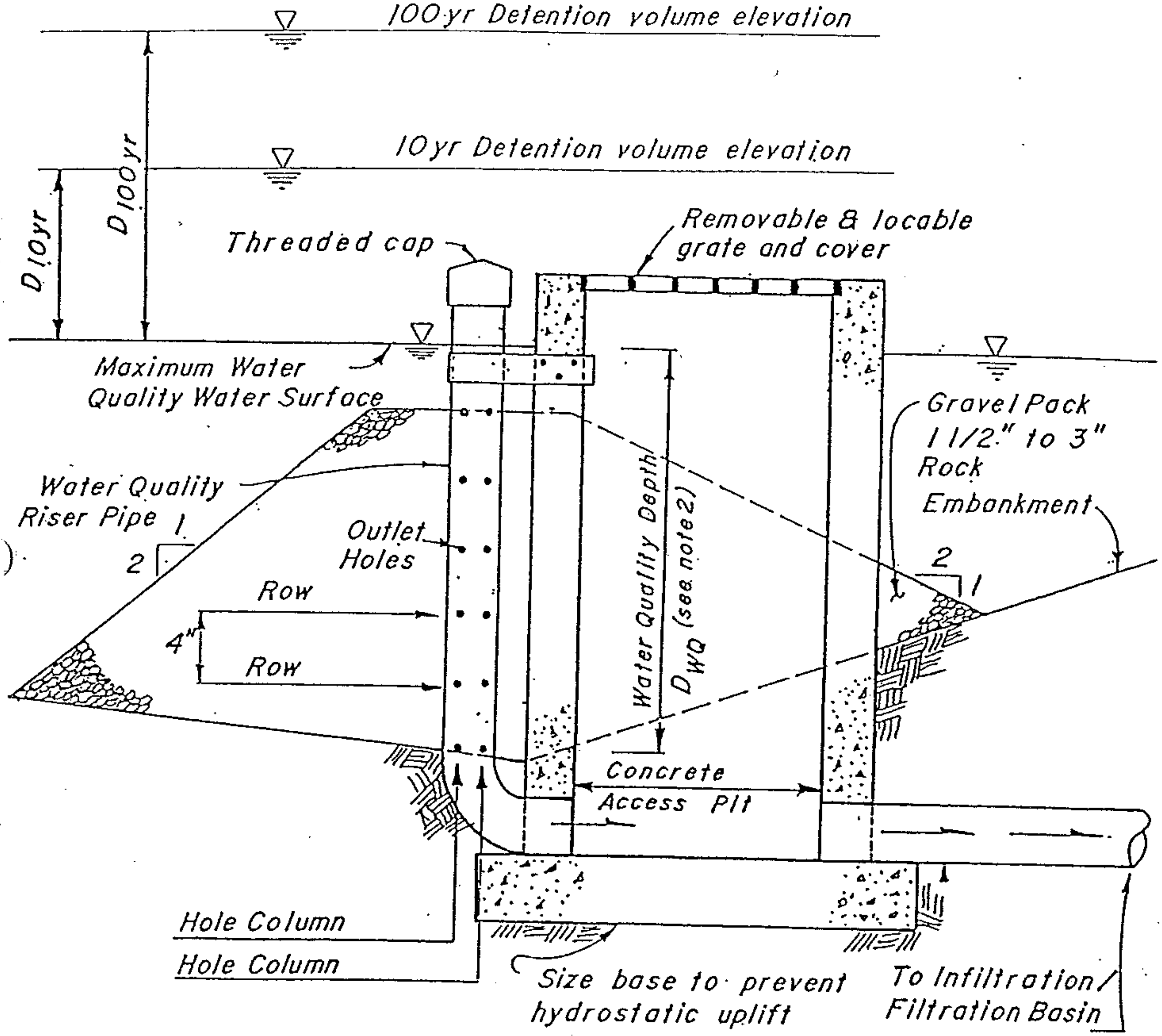
WATER QUALITY OUTLET FOR DRY POND



Note: 1. Riser pipe to be galvanized steel

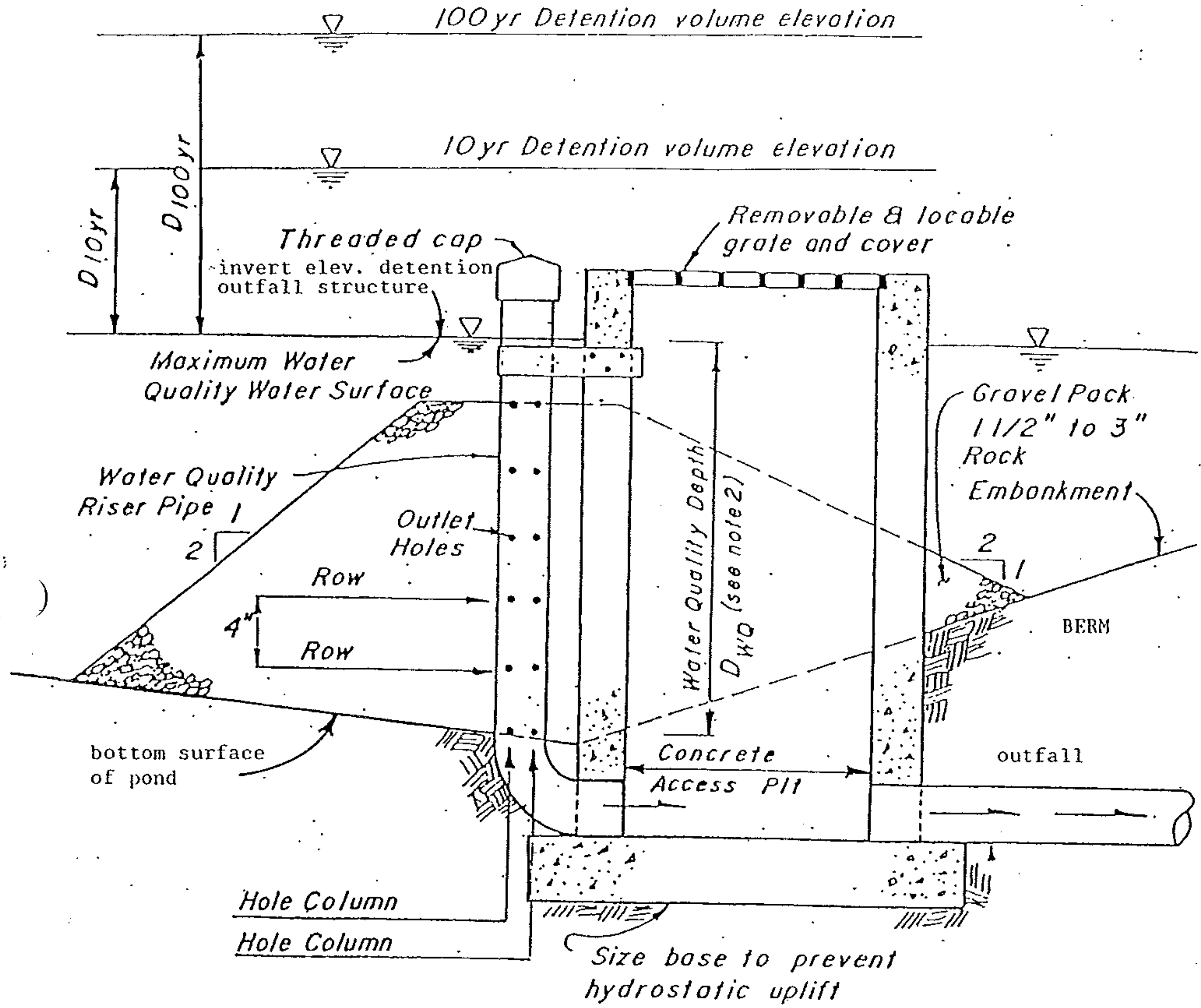
2. Depth "D" is used in equation 802 to compute loading rate for filtration area

3. Design must provide for permanent access to the outlet structure at all times

DATE:
REV:

REFERENCE:

WATER QUALITY OUTLET

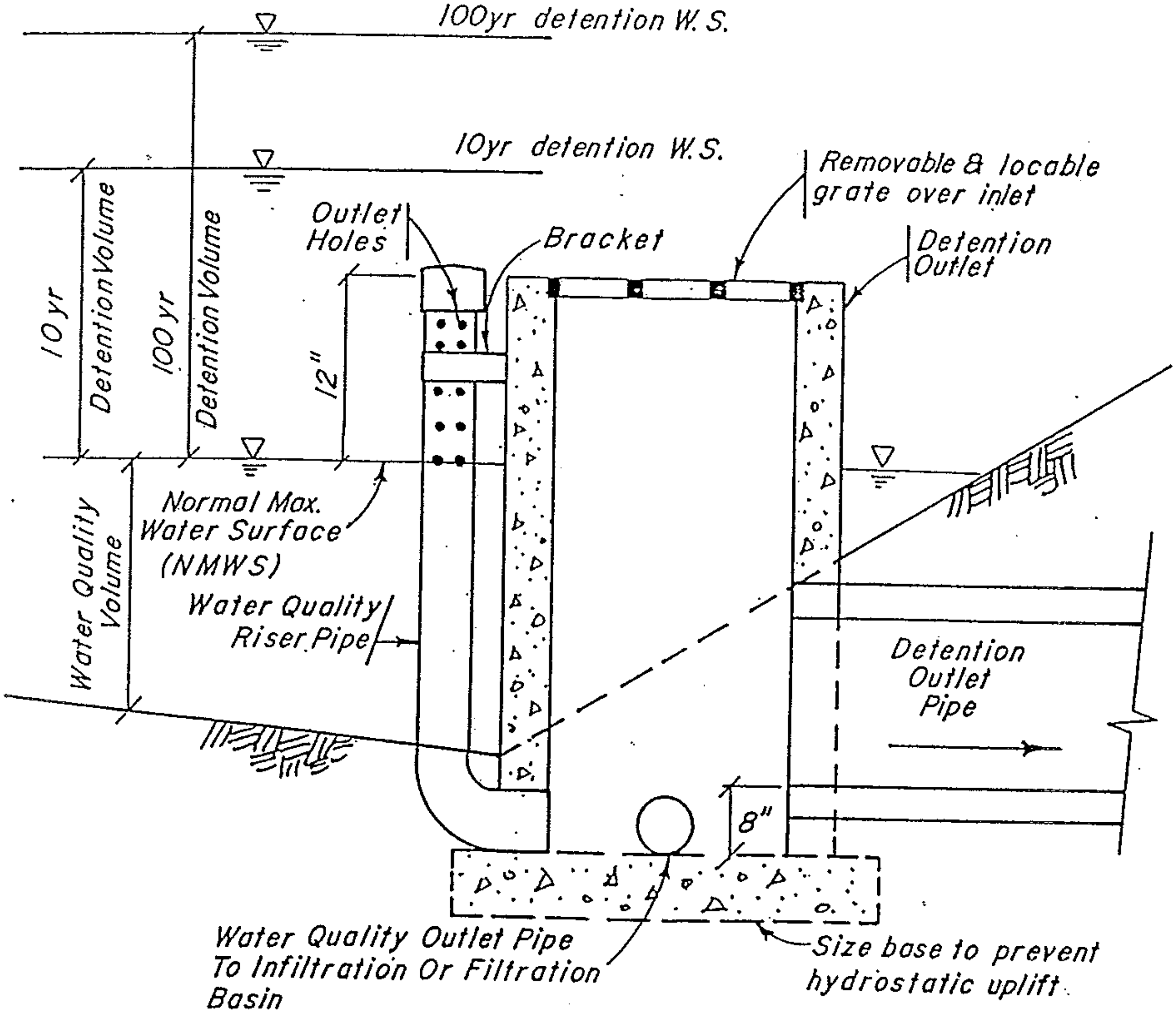


Note: 1. Riser pipe to be galvanized steel

2. Depth "D" is used in equation 802

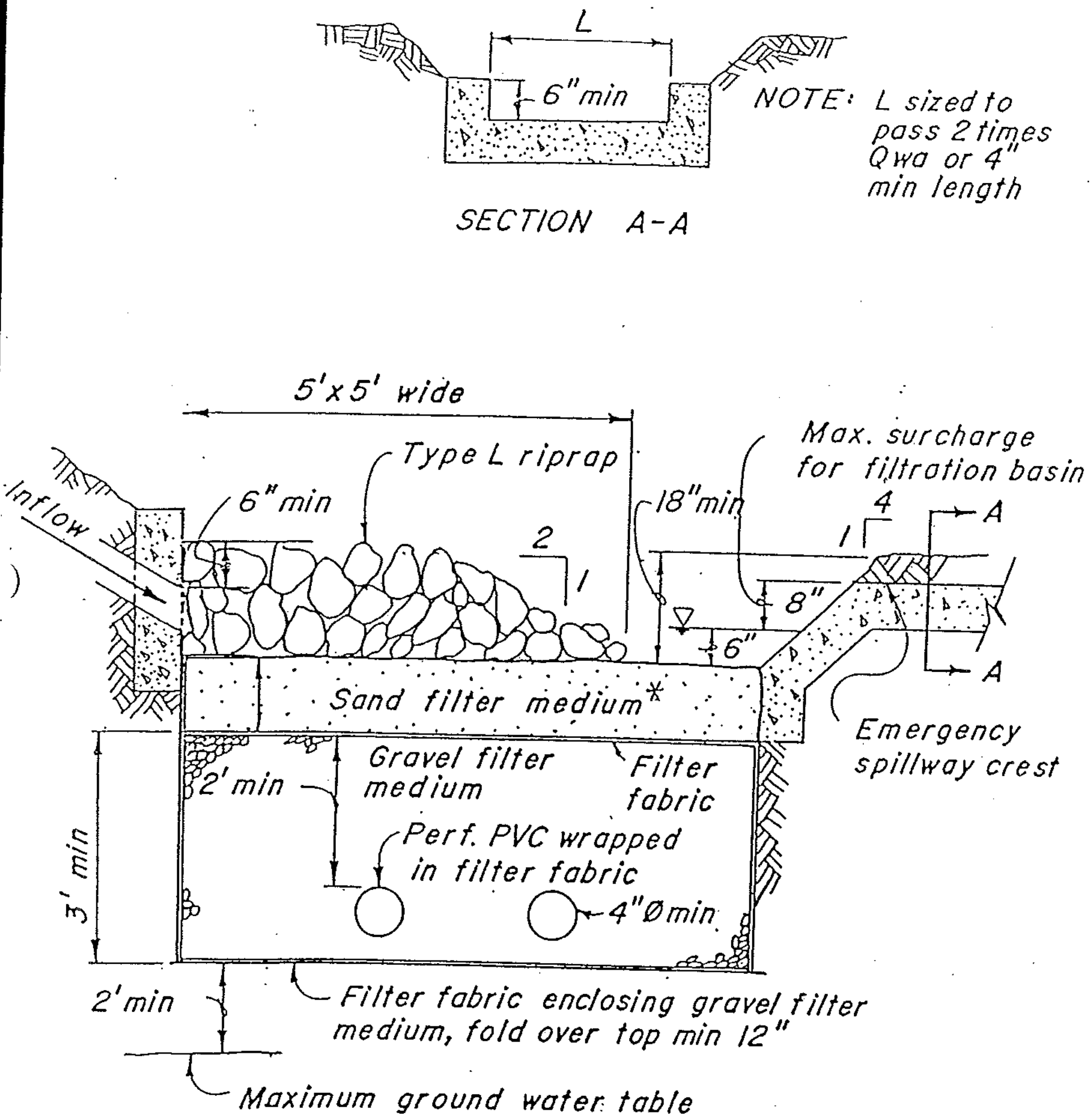
3. Design must provide for permanent access to the outlet structure at all times

WATER QUALITY OUTLET FOR WET POND



Note: Depth "D" is used in equation 802 to compute loading rate for filtration area. For wet ponds, D can utilize up to 45 percent of the volume used to route the 10-year storm runoff (i.e., 45% at V_{10})

FILTRATION BASIN CONFIGURATION



*NOTE: Top of sand filter and gravel are to be built to achieve a level surface.

DATE:
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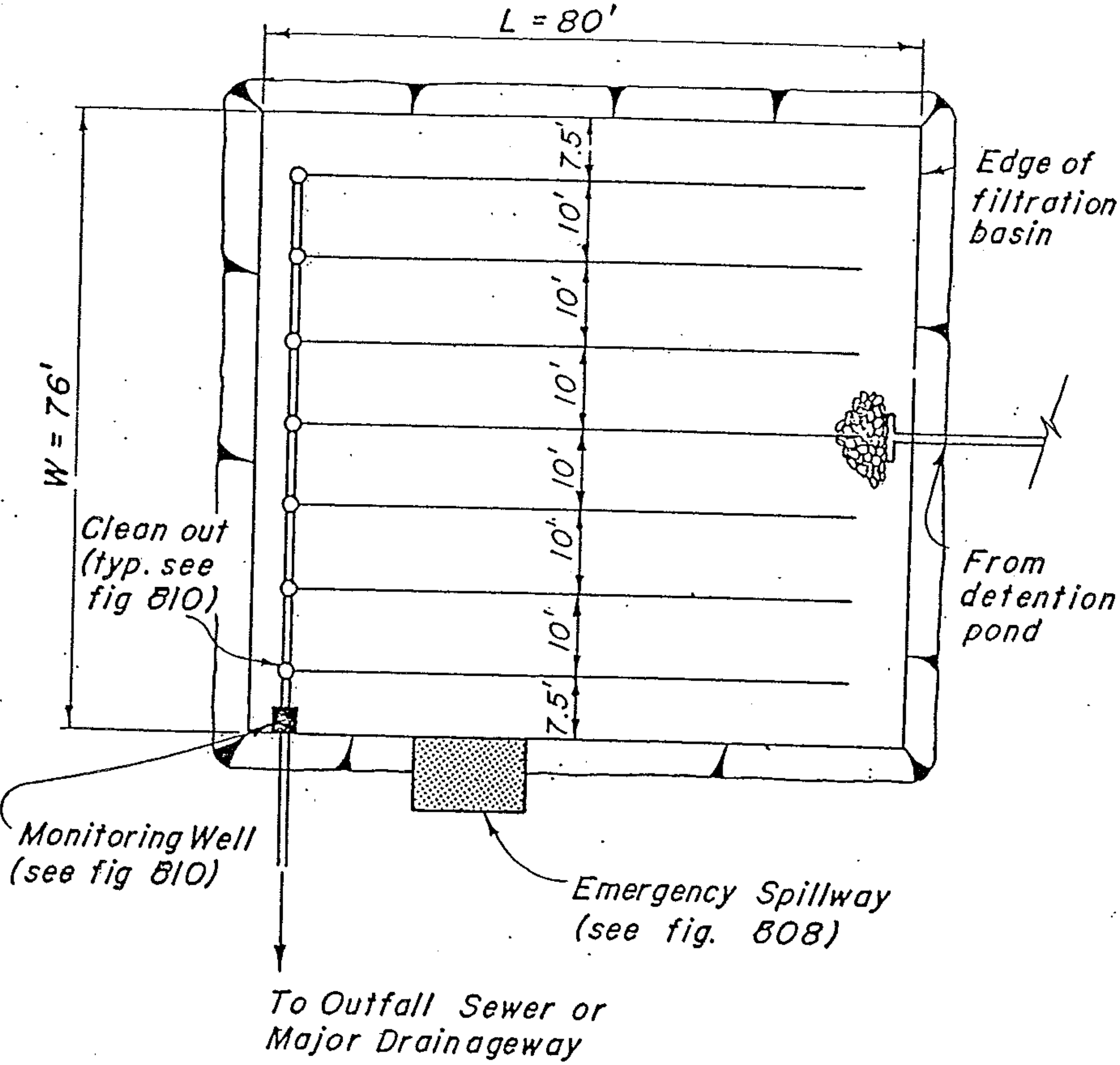
REFERENCE:

FILTER DRAIN PIPE LAYOUT EXAMPLE FOR 10" HEADER



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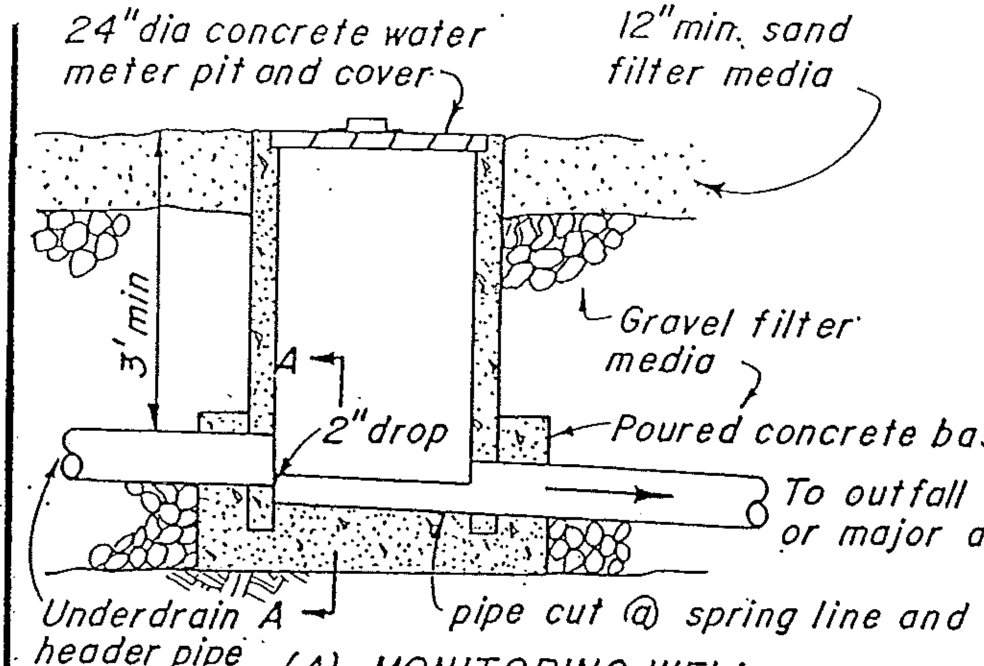
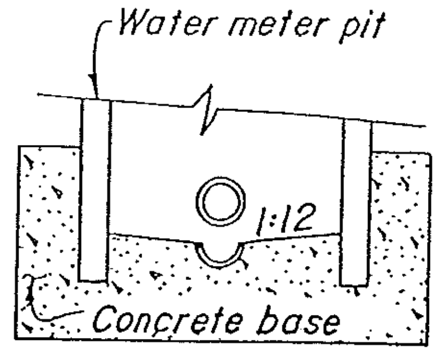
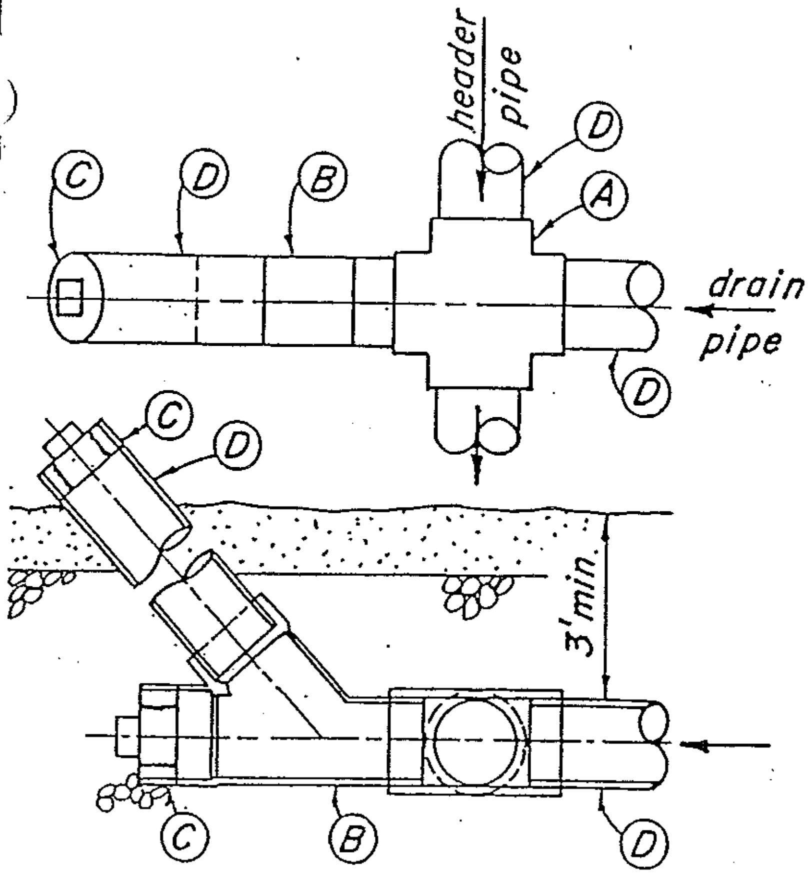
FILTER DRAIN PIPE LAYOUT DETAILS



(A) MONITORING WELL



SECTION A-A



(B) CLEANOUT

BILL OF MATERIALS		
Symbol	Name	Quantity
A	cross	1 each
B	45°wye	1 each
C	cleanout adaptor & plug	2 each
D	pipe	as req'd

DATE:
REV:

REFERENCE: