SECTION 11.0 – DETENTION
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SECTION 11.0 DETENTION

11.1 INTRODUCTION

The criteria presented in this section shall be used in the design and evaluation of all detention facilities for the City. The review of all planning submittals (refer to Section 2) shall be based on the criteria presented in this section.

Detention facilities store excess runoff associated with an increase in basin imperviousness and discharge this excess at a rate similar to the rate experienced from the basin without development. It is intended that the detention facility protect downstream property and improvements, and avoid the overloading of storm drainage facilities located further downstream. If special design conditions exist that cannot be defined by this criteria, the designer shall bring these up with the City during the review process.

The various detention methods are defined on the basis of where the facility is constructed: open space, parking lot, underground. The City permits all methods of detention except for rooftop detention.

Detention facilities shall not be constructed within public right-of-way. The design high water level of detention ponds shall not encroach upon public right-of-way. For additional information see Section 1.2.

11.2 WATER QUALITY ENHANCEMENT

Refer to Section 12 – Stormwater Quality Enhancement - for guidelines to incorporate water quality considerations within the design and construction of detention ponds

11.2.1 DRAINAGE MAINTENANCE

The property owner shall be responsible for maintenance of all drainage facilities installed pursuant to the development agreement and/or drainage easement agreement. Requirements include, but are not limited to maintaining the specified storm water detention/retention volumes, maintaining outlet structures, flow restriction devices and facilities needed to convey flow to said basin.

Long term operation and maintenance of detention ponds can be found in these Criteria in Section 12 – Stormwater Quality Enhancement.

11.3 STORAGE REQUIREMENTS

11.3.1 AREAS WITHOUT MASTER DRAINAGE PLANS

In basins where a master drainage plan has not been approved, the City may require detention storage in accordance with this section to protect irrigation structures or downstream development. Stormwater runoff shall not be released from developments at a rate greater than the 5-year historical runoff. The amount of runoff detained on-site shall be the difference between the 100-year developed runoff and the 5-year historical runoff. In all cases, detention is required unless proven otherwise.

11.3.2 AREAS WITH MASTER DRAINAGE PLANS

Stormwater runoff shall be released from developments in accordance with the master drainage plan for the area. The release rates may vary from the 5-year historic to the 100-year developed rate. Historic runoff is runoff which occurred under the physiographic conditions prior to any proposed development.

In cases where master drainage plans are approved but the improvements have not been constructed (i.e., an adequate outfall to protect downstream property) detention may be required until such time that the outfall is constructed.

11.3.3 VARIANCES

For any release rate greater than specified in either Sections 11.3 or 11.4, the Design Engineer requesting the variance shall analyze the downstream conditions in detail and show that no adverse effects will occur. This analysis shall include any and all information required by the City. All calculations pertaining to the analysis shall be submitted for review (such as the volume and peak discharge calculations). This analysis shall be submitted to the City in the preliminary and final drainage reports.

Examples of when detention requirements may be varied are:

(a) if development occurring on the site decreases the percentage of impervious area already present,

(b) if the latter phase of a subdivision is submitted and the previous phases have already met the detention requirements for the entire site

(c) if a Regional Pond capable of accepting the minimum required detention and water quality capture volume exists AND a conveyance element with sufficient capacity meeting City standards exists or is proposed with the development to convey site runoff to the Re-gional Pond.

(d) if the project is located in the Redevelopment District, AND adds 5,000 SF of impervious area or less, AND does not create an immediate flooding hazard for downstream property or facilities.

(e) if the project is not located in the Redevelopment District, adds 1,000 SF of impervious area or less, and does not create an immediate flooding hazard for downstream property or facilities.

Drain time criteria is not eligible for variance requests, as drain time release rate is governed by State law. A Water Quality Control Measure, such as WQCV detention, must be implemented for any development in which one acre or more of disturbance results with the project, per the City's MS4 permit.

To be considered eligible, variance requests must be thoroughly analyzed by the designer to show that no hazards will be created downstream. Detention variance requests are not guaranteed to be approved and must be approved in writing by the City Public Works Department Stormwater Manager. The City has standard variance approval forms for this purpose.

Retention ponds are not acceptable unless there is no feasible method for draining the pond by gravity. If a retention pond is foun d to be the only alternative, the minimum volume of the facility must be adequate to retain the storm runoff from twice the 100-year developed storm event. Percolation/evaporation alone may be an accepted method for draining the pond, but percolation will not be acceptable in situations where an increase in groundwater flow as a result of pond percolation could cause an adverse impact upon structures with basements down gradi-

ent of the pond site. For any storm event, if the pond cannot be drained within 72 hours, permanent pumping facilities shall be required to drain the pond.

11.4 DESIGN CRITERIA

11.4.1 VOLUME AND RELEASE RATE

The minimum required volume shall be determined using either: (a) the Rational Formula Method; or (b) the CUHP method as documented in the USDCM Volume 2 "Storage" or the UD SWMM computer program. Utilization of the Rational Formula Method is restricted to basins less than or equal to 5 acres. For basins larger than 5 acres, detention volumes should be determined using the CUHP method or the UD SWMM computer program. Alter- native computer programs for routing flows through detention facilities must be reviewed and approved by the City prior to utilization.

For all detention facilities within the City, the minimum volume of the facility must be adequate to detain the storm runoff from the 100-year developed storm event. Off-site flows may pass through the detention facility but not by over-sizing the orifice. Adequate spill- way/outlet capacity shall be provided to safely pass these flows to downstream conveyance elements. Additional information related to minimum storage volumes and maximum release rates from detention ponds can be obtained from the master drainage plans for each major drainage basin.

Procedures for the determination of the required detention volume using the Rational For- mula Method are presented below.

Rational Formula Method

The cumulative runoff volume entering a detention pond is estimated by:

$$V_{in} = CiAT \qquad \textbf{Equation 11.4.1(1)}$$

Where V_{in} = cumulative runoff volume, ft^3
C = runoff coefficient (per Urban Drainage)
i = storm's intensity taken from IDF curve at time T, inches per hour
A = tributary area, acres
T = storm duration, seconds

The cumulative volume leaving the basin is estimated by:

$$V_{out} = kQ_{out}T \qquad \textbf{Equation 11.4.1(2)}$$

in which T is defined above and

V_{out} = cumulative volume of outflow, ft^3

Q_{out} = maximum outflow rate, cfs
k = outflow adjustment coefficient from Figure 11-1

In Figure 11-1, Qpin (peak inflow rate) is determined from the Rational Method Formula (Q=CiA).

The required detention volume is the maximum difference between the cumulative inflow and the cumulative outflow volumes or

$$V = \max (V_{in} - V_{out}) \qquad \text{Equation 11.4.1(3)}$$

As per Urban Drainage Design Guidelines, if the procedure results in an increasing storage volume at the end of two hours, use the 2-hour storage volume.

This procedure assumes a constant outflow rate which is the rate of discharge when the detention pond is full. Discharge varies, however, with the depth of water. This fact is partially compensated for by the outflow adjustment factor k.

11.4.2 DESIGN FREQUENCY

All detention facilities are to be designed to release not greater than the 5-year historical (prior to any development) peak runoff during the 100-year storm event.

11.4.3 HYDRAULIC DESIGN

Hydraulic design procedures for sizing a detention facility's outlet works are described below.

11.4.3.A WEIR FLOW

The general form of the equation for horizontal crested weirs is:

$$Q = CL(H)^{3/2} \qquad \text{Equation 11.4.3.A(1)}$$

Where Q = discharge (cfs)
C = weir coefficient (see Table 11-1)
L = horizontal length (feet)
H = total energy head (feet)

Another common weir is the v-notch, whose equation is as follows:

$$Q = 2.5 \tan (\Theta/2) H^{5/2} \qquad \text{Equation 11.4.3.A(2)}$$

Where Θ = angle of the notch at the apex (degrees)

When designing or evaluating weir flow, the effects of submergence must be considered. A single check on submergence can be made by comparing the tail water to the headwa- ter depth. The example calculation for a weir design on Figure 11-2 illustrates the sub- mergence check.

11.4.3.B ORIFICE FLOW

The equation governing the orifice opening and plate is the orifice flow equation:

$$Q = C_d A (2gh)^{1/2} \qquad \textbf{Equation 11.4.3.B}$$

Where Q = flow (cfs)
C_d= orifice coefficient
A = area (ft^2)
g = gravitational constant = 32.2 ft/sec^2
h = head on orifice measured from centerline (ft)

An orifice coefficient (Cd) value of 0.65 shall be used for sizing of all square edged orifice openings and plates (see Figure 11-4).

11.5 DESIGN STANDARDS FOR OPEN SPACE DETENTION

11.5.1 STATE ENGINEER'S OFFICE

Any dam constructed for the purpose of storing water, with a surface area, volume, or dam height as specified in Colorado Revised Statues 37-87-105 as amended, shall require the approval of the plans by the State Engineer's Office. Those detention storage facilities sub- ject to state statutes shall be designed and constructed in accordance with the criteria of the State.

11.5.2 GRADING REQUIREMENTS

Slopes on earthen embankments shall not be steeper than 4H:1V.

For grassed detention facilities, the minimum bottom slope shall be 1.0 percent, measured perpendicular to the trickle channel.

11.5.3 FREEBOARD REQUIREMENTS

The minimum required freeboard for detention facilities is one foot above the computed 100-year water surface hydraulic grade line elevation. The invert of the emergency spillway shall be placed at or above the computed on-site 100-year water surface elevation. The computed 100-year water surface hydraulic grade line elevation is defined as follows:

A flow situation for which the emergency spillway is passing the 100-year developed on-site flow plus the 100-year off-site flows (if they exist) based on an assumed plugged orifice condition.

All state dam safety criteria must be carefully considered when determining the freeboard capacity of ponds which incorporate high embankments or large areas and storage volumes.

11.5.4 TRICKLE FLOW CHANNELS

All grassed bottom detention ponds shall include a concrete lined trickle channel. A perforated under drain shall be required if the soils report indicates close proximity to groundwater or groundwater is encountered during construction. Minimum longitudinal slope of trickle channel shall be 0.4%. Trickle flow channel criteria are presented in Section 5.2.2.

11.5.5 OUTLET CONFIGURATION

Presented in Figure 11-3 are two examples of a detention pond outlet configuration (see Section 12 for outlet requirements for stormwater quality enhancement). A Type 1 outlet consists of a grated drop inlet, outlet pipe, and an overflow weir in the pond embankment. The outlet will be designed to release the peak discharge associated with the 5-year historical runoff during the 100-year developed runoff. The control for the 100-year peak discharge shall be at the throat of the outlet pipe under the head of water as defined on

Figure 11-3.
The trash rack must be designed to pass the 5-year historical storm flow with a minimum of 50 percent blockage. Since the minimum size of the outlet pipe is 12 inches, then a control orifice plate at the entrance of the pipe shall be required to control the discharge of the design flow. An example orifice plate is shown in Figure 11-4.

A Type 2 outlet consists of a depressed inlet with an outlet pipe and an overflow weir in the pond embankment. Again, an orifice plate at the entrance shall be required to control the release rate to the 5-year historical peak flow. The control for the 100-year developed condition discharge occurs at the throat of the outlet pipe as shown on Figure 11-3. The outlet pipe must have an adequate slope to ensure throat control in the pipe.

For both outlet types, flows in excess of the developed condition 100-year discharge are released through the overflow weir or spillway. The control orifice plate shall not be oversized to pass release flows from off-site (upstream) detention facilities. The overflow weir or spillway shall be oversized to pass other off-site flows through the pond. Size the spillway to pass the 100-year developed on-site flow plus the 100-year off-site flows based on an assumed plugged orifice condition. The maximum trash rack-opening dimension shall be equal to 6".

Other outlet configurations will be allowed provided they meet the requirements of the permitted release rates at the required volume and include proper provisions for maintenance and reliability. The outlet shall be designed to minimize unauthorized modifications which affect proper function.

Additional storage shall be required to incorporate water quality considerations into the design and construction of a detention pond. Minimum requirements for the implementation and use of detention ponds for stormwater quality control are provided in Section 12.0-Stormwater Quality Enhancement. For information and design guidelines related to the construction of detention ponds that promote stormwater quality control, the reader is referred to the Urban Storm Drainage Criteria Manual (USDCM), Volume 3, "Best Management Practices".

11.5.6 EMBANKMENT PROTECTION

Whenever a detention pond uses an embankment to contain water, the embankment shall be protected from catastrophic failure due to overtopping. Overtopping can occur when the pond outlets become obstructed or when a larger than 100-year storm occurs.

Failure protection for the embankment may be provided in the form of a 24" deep, Type M, buried riprap layer on the entire downstream face of the embankment or a separate emergency spillway having a minimum capacity equal to the 100-year developed storm event for the basin.

Detention facilities in major drainage channels shall have a spillway capacity equal to the 100-year peak discharge associated with fully developed conditions in the basin. Structures shall not be permitted in the path of the emergency spillway or overflow. The invert of the emergency spillway should be set equal to or above the 100-year water surface elevation.

11.5.7 VEGETATION REQUIREMENTS

All detention ponds shall be vegetated by either irrigated sod or irrigated native dry land grasses. Refer to Section 14 – Vegetation and Irrigation for these specifications.

No more than one or two deciduous trees, small leaf, maintainable to a single stem, and not inherent to suckering, shall be allowed per 4500 square foot of pond. These trees shall be planted as far away from the outlet structure as possible to prevent plugging the outlet and WCCV holes.

No evergreens shall be allowed in a pond.

11.5.8 MAINTENANCE ACCESS

To assure that the detention facility performs as designed, maintenance access shall be provided, and shown on the Final Plat. Regional detention ponds are usually dedicated to the City for operation and maintenance. For privately maintained facilities such as commercial, residential, or industrial sites, an easement shall be granted to the City to allow access and to assure that the facility continues to function as intended. The City has standard easement agreement forms for this purpose.

11.6 DESIGN STANDARDS FOR PARKING LOT DETENTION

11.6.1 DEPTH LIMITATION

The maximum allowable design depth of ponding is 18 inches for the 100-year flood and 6 inches for the initial storm runoff event. Calculations shall be provided to the City indicating the depth of ponding for the 10-year storm event. Signs shall be posted within parking lots warning users of high water during significant storm events.

11.6.2 OUTLET CONFIGURATION

Where a drop inlet is used to discharge to a storm drain or drainage way, the minimum pipe size for the outlet pipe is 12 inches in diameter. Where a weir and a small diameter outlet pipe through a curb are used, the size and shape are dependent on the discharge and storage requirements. In this case, a minimum pipe diameter of 4 inches is required.

11.6.3 MAINTENANCE ACCESS

To assure that the detention facility performs as designed, maintenance access, especially to outlet structures, shall be provided. The outlet shall be designed to minimize unauthorized modifications, which affect function. Any repaving of the parking lot shall be evaluated for impact on volume and release rates and is subject to approval by the City prior to proceeding with the repaving. A sign shall be attached or posted in accordance with Section 11.6.4.

11.6.4 FLOOD HAZARD WARNING

All parking lot detention areas shall post a minimum of two signs identifying the detention pond area. The sign shall have a minimum area of 1.5 square feet and contain the following message:

"WARNING"

This area is a detention pond and is subject to periodic flooding depths ranging from a depth of __(provide the design depth) for the initial storm runoff event to (provide the design depth) for the 100-year storm."

Any suitable materials and geometry of the sign are permissible, subject to approval of the City.

11.7 DESIGN STANDARDS FOR UNDERGROUND DETENTION

11.7.1 MATERIALS

Underground detention shall be constructed using reinforced concrete pipe (RCP) or other sys-tem approved by the City. The pipe thickness, cover, bedding, and backfill shall be designed to withstand HS-20 loading. The minimum diameter of pipe allowed shall be 48”.

A Water Quality Vault shall be required for the water quality capture volume requirement for all underground detention facilities. See Section 6.8.

11.7.2 CONFIGURATION

Pipe segments shall be sufficient in number, diameter, and length to provide the required minimum storage volume for the 100-year design. As an option, the initial design storm runoff volume can be stored in the pipe segments and the difference for the 100-year runoff volume stored above the pipe in an open space detention pond, or in parking lot detention.

The pipe segments shall be placed side by side and connected at both ends by elbow tee fit- tings and across the fitting at the outlet (see Figure 11-5). The pipe segments shall be con- tinuously sloped at a minimum of 0.4 percent to the outlet. Manholes for maintenance ac- cess (see Section 11.7.4) shall be placed in the tee fittings and in the straight segments of the pipe, when required.

Permanent buildings or structures shall not be placed above the underground detention.

11.7.3 INLET AND OUTLET DESIGN FOR UNDERGROUND DETENTION

The outlet from the underground detention shall consist of a short (maximum 25 feet) length of RCP with a 12-inch minimum diameter. The outlet pipe(s) shall discharge into a standard manhole or into a drainage way with erosion protection provided per Sections 9.3.2, 10.2, and 10.3. If an orifice plate is required to control the release rates, the plate shall be hinged to open into the detention pipes to facilitate back flushing of the outlet pipe.

Channel rundowns down the slope of detention ponds shall be designed as per Section 5.0, Open Channels, Part 5.5 Channel Rundowns.

11.7.4 INLET AND OUTLET DESIGN FOR UNDERGROUND RETENTION

Should gravity draining not be feasible by outfall to a storm drain or open channel, the storage facility shall be considered a retention pond and be subject to conditions set forth in Section 11.3.3. An approved variance request by the Stormwater Manager shall be required for any retention facility.

Underground retention facilities relying on a pump shall require a primary pump, a back-up pump, and an alarm to alert the facility operator in the event of failure of both pumps. A back-up power source shall be required sufficient to operate pumping facilities to the capacity of draining the full retention facility.

The facility owner shall conduct routine maintenance on the pumping facilities and report the result of these maintenance activities to the Stormwater Management Division a minimum of once annually. A City inspector may request a demonstration of the facility operator that pumps are in good working order, and the facility owner shall supply a sufficient volume of water to demonstrate acceptable operation of the facility. These requirements shall be recorded in a Development Agreement, Maintenance Agreement or other legal recorded document.

The discharge point and orientation shall ensure discharge is conveyed off the subject parcel in a safe manner and shall be approved by the Stormwater Manager. The discharge flow rate shall be no greater than 10 feet per second.

Channel rundowns down the slope of detention ponds shall be designed as per Section 5.0, Open Channels, Part 5.5 Channel Rundowns.

11.7.5 MAINTENANCE ACCESS

Access easements to the detention site shall be provided. To facilitate cleaning of the pipe segments, 3-foot diameter maintenance access ports shall be placed according to the following schedule:

MAINTENANCE ACCESS REQUIREMENTS		
Detention Pipe Size	**Maximum Spacing**	**Minimum Frequency**
48" to 54"	150'	Every pipe segment
60" to 66"	200'	Every other pipe segment
Greater than 66"	200'	One at each end of the battery of pipes

Manholes shall be constructed in accordance with Figure 11-5.

11.8 DESIGN STANDARDS FOR SHEEP DRAW FLOODPLAIN DETENTION

The City of Greeley has, in the past, allowed on-site detention ponds associated with new development to be constructed within the 100-year floodplain along Sheep Draw. The most recent proposed detention pond in the floodplain is located at Northview Estates just south of C Street – Pond # 1. This issue is discussed in the new updated Comprehensive Drainage Plan (Comp Plan) for Sheep Draw, dated March 8, 2006, section VI. – Miscellaneous Hydrologic and Hydraulic Issues, Page 6.9, paragraph 6.3 – Construction of On-Site Detention Ponds in the 100-year Sheep Draw Floodplain. The following is the discussion presented in the Comp Plan.

The recent construction of several of these ponds, combined with the anticipation of future proposals for more ponds of this nature, prompted an evaluation of this practice. At issue are both the effectiveness and the potential adverse impacts associated with on-site detention ponds located where Sheep Draw flows would inundate the ponds during flood events. The effectiveness of the ponds to provide the required attenuation of the peak runoff in this situation, as well as potential stability issues with respect to detention pond embankments exposed to Sheep Draw flood flows are both of specific concern. Additional concerns relate to potential impacts to flood levels along Sheep Draw and the stability of the Sheep Draw channel itself.

Based on consideration of hydraulic conditions associated with 100-year flows along Sheep Draw, local versus regional hydrologic response within the basin, and potential erosion issues within the Sheep Draw channel and floodplain, on-site detention ponds may be constructed in the 100-year floodplain along Sheep Draw provided the following six conditions can be satisfied.

1. Considering no impacts from inundation of Sheep Draw flows, the proposed detention pond must reduce the 10-year developed condition peak runoff from the site to no more than the 5-year existing condition peak runoff rate, while reducing the 100-year developed condition peak runoff from the site to no more than the 100-year existing condition peak runoff rate.
2. The proposed detention pond must be hydrologically analyzed using the City of Greeley's current CUHP/EPA SWMM model for the Sheep Draw Basin to demonstrate that during the 100-year event, Sheep Draw flows will not enter or overtop into the on- site detention pond until on-site runoff from the 100-year event (assuming developed conditions) has dropped below the 100-year existing condition peak runoff rate.
3. Any pond embankments that are exposed to flood flows along Sheep Draw must be pro- tected from riverine erosion by these flow, as evidenced by appropriate analyses

to demonstrate stability of the proposed embankment protection measures in the context of 100-year hydraulic conditions along Sheep Draw.

4. Any pond embankments that would be subject to overtopping by Sheep Draw flood flows must be protected from erosion due to embankment overtopping either by structural or engineered measures, or by demonstrating through rigorous hydrologic and/or hydraulic analyses that embankment erosion potential due to these overtopping flows in minimal.
5. The grading for the pond and any of its attendant facilities, features or protection measures may not obstruct in any manner 100-year flood flows within the floodway of Sheep Draw.
6. No adverse impact to the stability of the Sheep Draw channel must be demonstrated us- ing a combination of hydraulic, sediment transport and channel bank stability analyses that are appropriate for the specific situation.

11.9 DESIGN EXAMPLE - DETENTION VOLUME

GIVEN:

Basin area = 5 acres
Single family residential site, Percent Impervious = 40%
Historical 5-year release rate = 2 cfs
Developed 100-year peak inflow rate = 16.5
cfs 100-year Runoff Coefficient = 0.6

FIND: Determine size of detention pond to limit developed 100-year peak inflow rate to histori- cal 5-year release rate of 2 cfs.

SOLUTION:

STEP 1: Determine Q_{out}/Q_{pin} to be

0.12 STEP 2: From Figure 11-1, k =

0.96

STEP 3: At intervals of 5 minutes, determine the rainfall intensity (from IDF

curves) Runoff volume (Vin from Equation 11.4.1(1))

Outflow volume (Vout from Equation 11.4.1(2))

Storage volume (V_{in} - V_{out})

The calculating procedure is illustrated in Table 11-2. The required detention volume from Table 11-2 is determined to be 0.53 acre-feet.

DETENTION OUTLET STRUCTURE

GIVEN:
Detention pond with the following characteristics.

Maximum 100-year release rate = 23.0 cfs
Maximum 5-year release rate = 6.9 cfs

Type 2 outlet (refer to Detail 11-3)
100-year water surface elevation = 105.0
5-year outlet pipe invert elevation = 100.0
18-inch diameter outlet pipe

FIND: 5-year outlet sizing

SOLUTION: (see Figure 11-6)

STEP 1: Determine maximum discharge from the outlet pipe. Depth to centerline of the outlet pipe = 4.25 ft.

$Q = C_d A(2gh)^{1/2}$ (Equation 11.4.3.B)
$= 0.65\ (1.76)\ [2(32.2)(4.25)]^{1/2}$
$= 18.9$ cfs
$Q > Q_5$; requires orifice plate

STEP 2: Determine 5-year orifice opening size; estimate depth to centerline of orifice (try 4.5 ft)

$A = Q / [C_d\ (2gh)^{1/2}]$ (Rearranged Equation 11.4.3.B)
$= 6.9 / \{0.65\ [2(32.2)(4.5)]^{1/2}\}$
$= 0.62\ ft^2$

STEP 3: Determine 5-year orifice diameter

Diameter $= [4A/\pi]^{½}$
$= [4(0.62)/\pi]^{½}$
$= 0.9$ feet (10.7 inches)

Therefore, use an orifice opening with a 10.5-inch diameter hole at the entrance to the outlet box.

STEP 4: Check discharge through 5-year outlet for 100-year headwater and 10.5-inch orifice opening (h= 4.56 feet).

$Q = C_d A(2gh)^{½}$ (Equation 11.4.3.B)
$= 0.65(0.60)[2(32.2)(4.56)]^{½}$
$= 6.7$ cfs
$Q = 6.7$ cfs $< Q_5 = 6.9$ cfs

STEP 5: Check trash rack design area given orifice diameter of 10.5 inches.

Orifice area $= A_o = 0.6\ ft^2$
$A/A_o = 10$ (from Figure 11-4 for 10.5-inch orifice diameter)

$A = 10(A_o) = 10(0.6) = 6\ ft^2$
Maximum opening = 0.5(10.5) = 5.25 inches

Note: If maximum opening for trash rack is greater than 6" per this equation, use Maximum opening = 6".

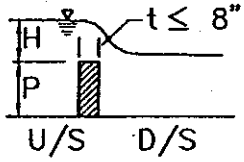
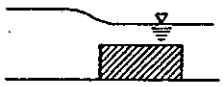
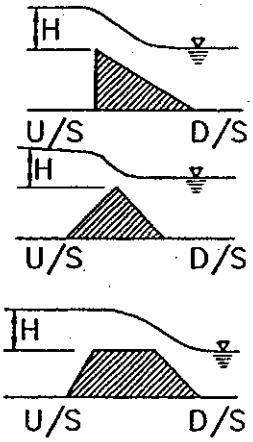
11.10 CHECKLIST

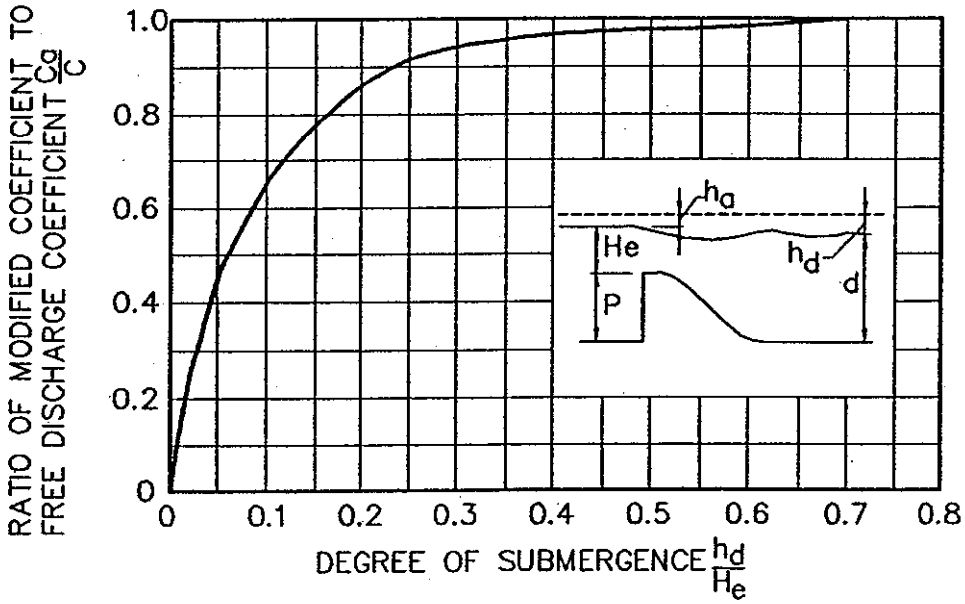
To aid the Designer and Reviewer, the following checklist has been prepared:

1. Earth slopes are to be 4:1 or flatter.
2. Minimum freeboard of 1 foot for the 100-year detention is required.
3. Open space detention areas shall include trickle channels. For the purpose of enhancing storm water quality, where practical, the trickle channel shall be grass lined with a buried perforated under drainpipe, surrounded by filter fabric and rock filter material. See Section 5.0 Open Channels, Figure 5-5, Trickle Channel Details.
4. Channel rundowns have been designed as per Sections 5.0, Open Channels, and 5.5 Channel Rundowns and Figure 5-7 Channel Rundown.
5. Protect embankment for overtopping condition by adding riprap or other acceptable erosion protection.
6. Provide trash racks where required.
7. Provide signs as required.
8. Provide maintenance access.

11.11 CITY ACCEPTANCE OF STORMWATER DETENTION/RETENTION FACILITIES

The City will not accept maintenance of local detention facilities or any detention facilities located within a Metropolitan District. The City may accept maintenance of sub-regional and regional detention facilities. These will be considered on a case-by-case basis and must be negotiated and approved by the Stormwater Manager prior to final acceptance of design documents.

SHAPE	COEFFICIENT	COMMENTS	SCHEMATIC
SHARP CRESTED	–		
PROJECTION RATIO (H/P = 0.4)	3.4	H<1.0	
PROJECTION RATIO (H/P = 2.0)	4.0	H>1.0	
BROAD CRESTED	–		
W/SHARP U/S CORNER	2.6	MINIMUM VALUE	
W/ROUNDED U/S CORNER	3.1	CRITICAL DEPTH	
TRIANGULAR SECTION	–		
A) VERTICAL U/S SLOPE	–		
1:1 D/S SLOPE	3.8	H>0.7	
4:1 D/S SLOPE	3.2	H>0.7	
10:1 D/S SLOPE	2.9	H>0.7	
B) 1:1 U/S SLOPE	–		
1:1 D/S SLOPE	3.8	H>0.5	
3:1 D/S SLOPE	3.5	H>0.5	
TRAPEZOIDAL SECTION			
1:1 U/S SLOPE, 2:1 D/S SLOPE	3.4	H>1.0	
2:1 U/S SLOPE, 2:1 D/S SLOPE	3.4	H>1.0	
ROAD CROSSINGS			
GRAVEL	3.0	H>1.0	
PAVED	3.1	H>1.0	



ADJUSTMENT FOR TAILWATER

REFERENCE: KING & BRATER, HANDBOOK OF HYDRAULICS, McGRAW HILL BOOK COMPANY, 1963 – DESIGN OF SMALL DAMS, BUREAU OF RECLAMATION, 1977

City of Greeley Colorado
Great. From the Ground Up.

WEIR FLOW COEFFICIENTS

TABLE 11 -1

PUBLIC WORKS DEPARTMENT
STORMWATER MANAGEMENT DIVISION
1001 NINTH AVENUE GREELEY, COLORADO 80631

SCALE: NTS
REVISED AUG 1996

STORM DURATION T (min) [1]	RAINFALL INTENSITY *i* (IN/HR) [2]	RUNOFF VOLUME C*iA*T (FT) [3]	OUTFLOW VOLUME kQT (FT) [4]	STORAGE VOLUME* (FT) [5]	STORAGE VOLUME (AF) [6]
5	9.67	8,703	576	8,127	0.19
10	7.51	13,518	1,152	12,366	0.28
15	6.34	17,118	1,728	15,390	0.35
20	5.34	19,224	2,304	16,920	0.39
25	4.74	21,330 ^{3}	2,880 ^{3}	18,450 ^{3}	0.42
30	4.40	23,706	3,456	20,304	0.47
35	4.00	25,200	4,032	21,168	0.49
40	3.59	25,848	4,608	21,240	0.49
45	3.35	27,135	5,184	21,951	0.50
50	3.10	27,900	5,960	21,940	0.50
55	2.94	29,106	6,336	22,770	0.52
60	2.78	30,024	6,912	23,112	0.53**
70	2.47	31,122	8,064	23,058	0.53
80	2.16	31,104	9,216	21,888	0.50
90	2.00	32,400	10,008	22,392	0.51

* COLUMN [3] - COLUMN [4]

** REQUIRED DETENTION VOLUME

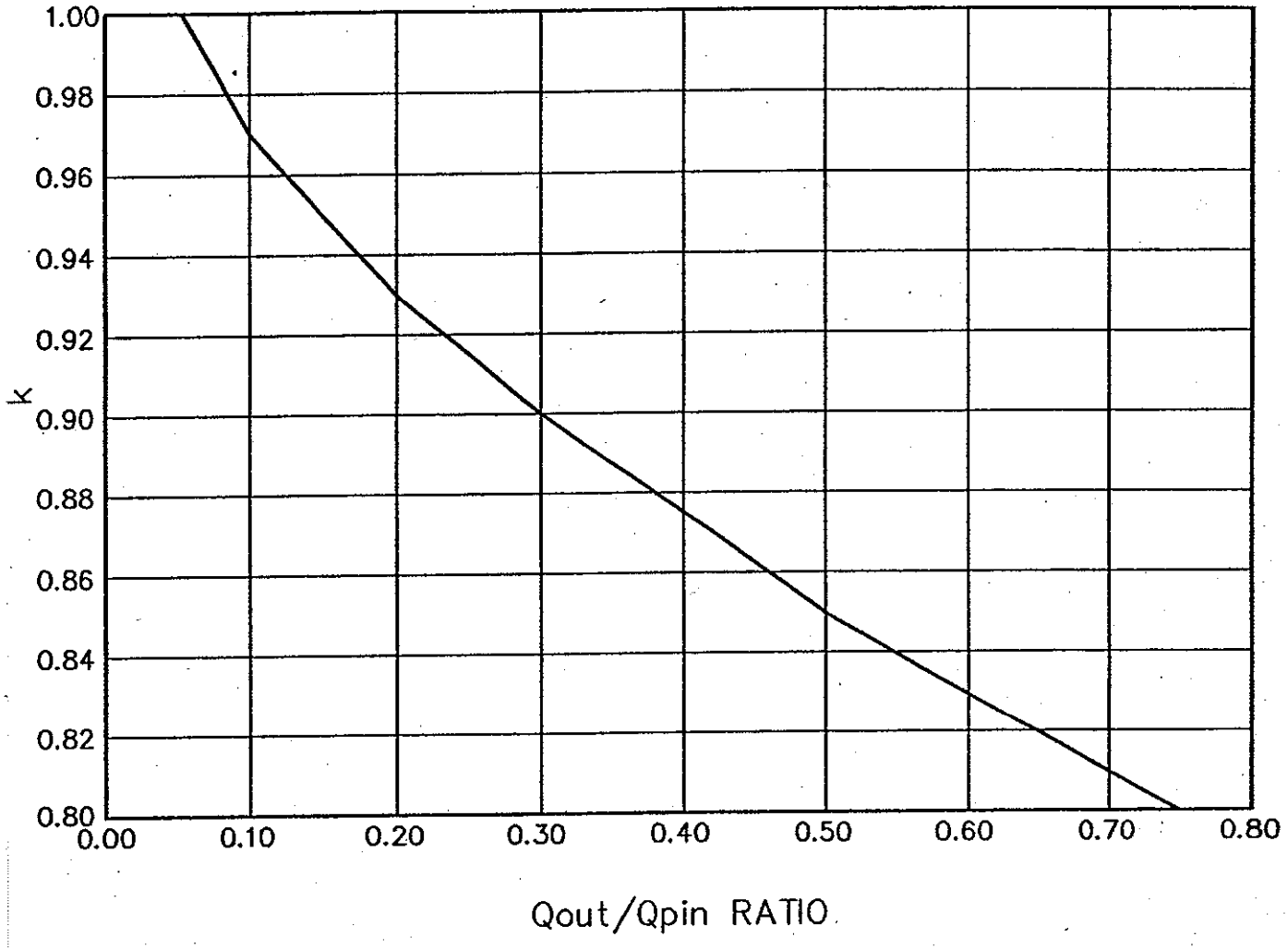
City of Greeley Colorado
Great. From the Ground Up.

RATIONAL FORMULA METHOD FOR DETENTION POND SIZING

TABLE 11-2

PUBLIC WORKS DEPARTMENT
STORMWATER MANAGEMENT DIVISION
1001 NINTH AVENUE GREELEY, COLORADO 80631

SCALE: NTS
REVISED MARCH 2007



OUTFLOW ADJUSTMENT FACTOR VERSUS OUTFLOW RATE / INFLOW PEAK RATIO

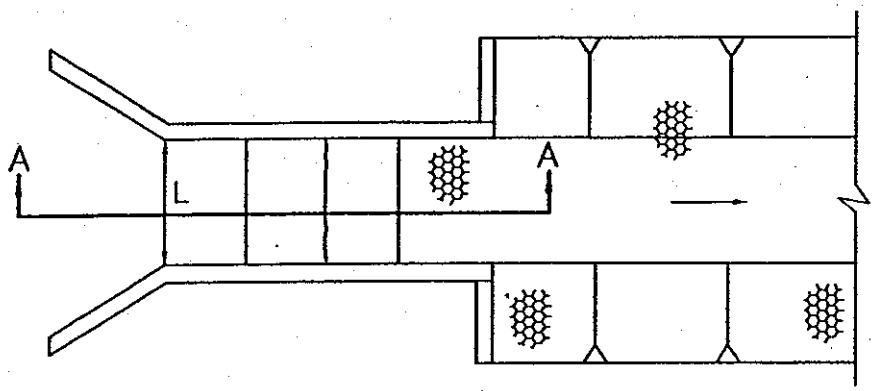
(UNIVERSITY OF COLORADO - DENVER, 1991)

FIGURE 11 -1

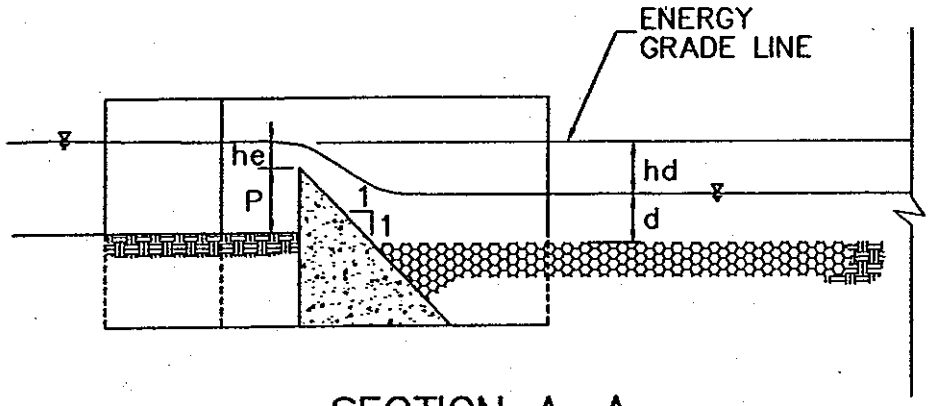
City of Greeley Colorado
Great. From the Ground Up.

PUBLIC WORKS DEPARTMENT
STORMWATER MANAGEMENT DIVISION
1001 NINTH AVENUE GREELEY, COLORADO 80631

SCALE: NTS
REVISED AUG 1996



PLAN



SECTION A–A

GIVEN: Q=100 CFS, TRIANGULAR WEIR WITH VERTICAL FACE, AND 1:1 DOWNSTREAM SLOPE, P=2', he =z', TAILWATER DEPTH = 4.5, hd = 1.5

FIND: L, AND CHECK SUBMERGENCE

SOLUTION: Cw = 3.8 (TABLE 11–1)

$L = Q/CH^{3/2} = (100)/[(3.8)(2)^{3/2}] = 9.3$ FT

SUBMERGENCE CHECK

$\frac{hd}{he} = \frac{1.5}{2.0} = 0.75$, THEN Ca/C = 1.0, (TABLE 11–1)
THEREFORE NO SUBMERGENCE ADJUSTMENT IS REQUIRED

City of Greeley Colorado
Great. From the Ground Up.

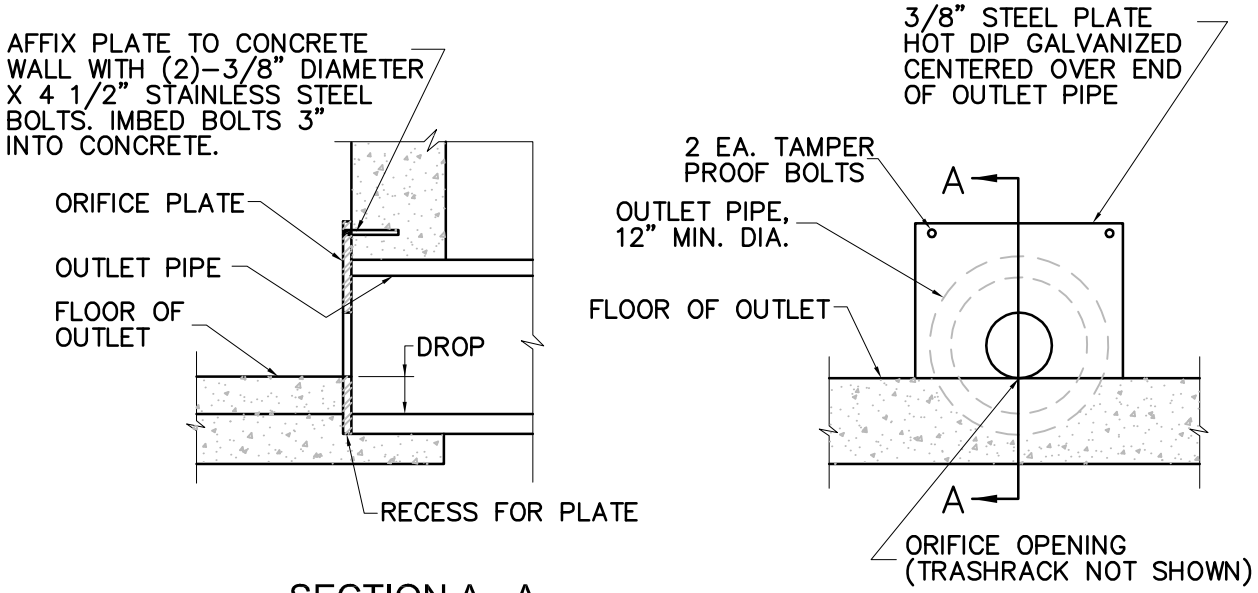
WEIR DESIGN EXAMPLE

FIGURE 11 -2

PUBLIC WORKS DEPARTMENT
STORMWATER MANAGEMENT DIVISION
1001 NINTH AVENUE GREELEY, COLORADO 80631

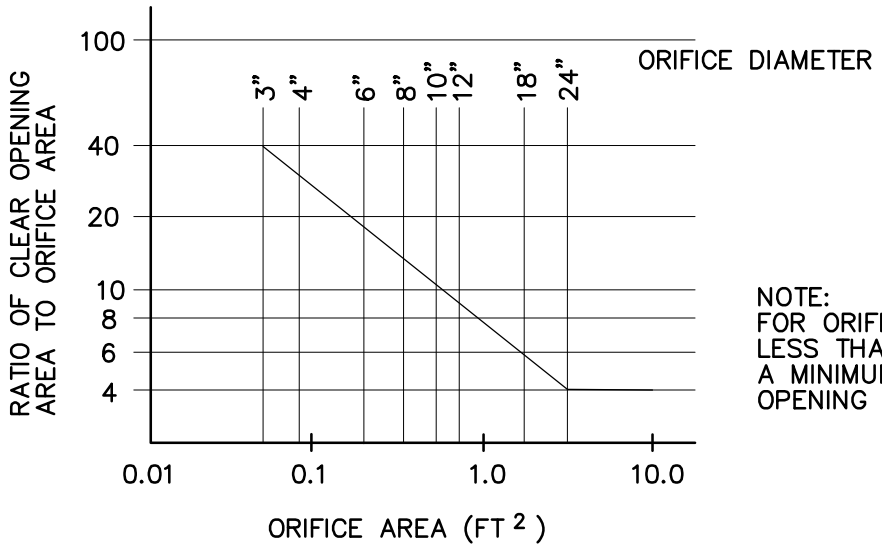
SCALE: NTS
REVISED NOV 1997

ORIFICE PLATE DETAIL



SECTION A - A

(B) TRASHRACK AREA REQUIREMENTS



NOTE:
FOR ORIFICE DIAMETER LESS THAN 3", USE A MINIMUM CLEAR OPENING OF 2 FT^2

DETENTION POND DETAILS

FIGURE 11-4

City of Greeley Colorado
Great. From the Ground Up.

PUBLIC WORKS DEPARTMENT
STORMWATER MANAGEMENT DIVISION
1001 NINTH AVENUE GREELEY, COLORADO 80631

SCALE: NTS
REVISED MARCH 2007

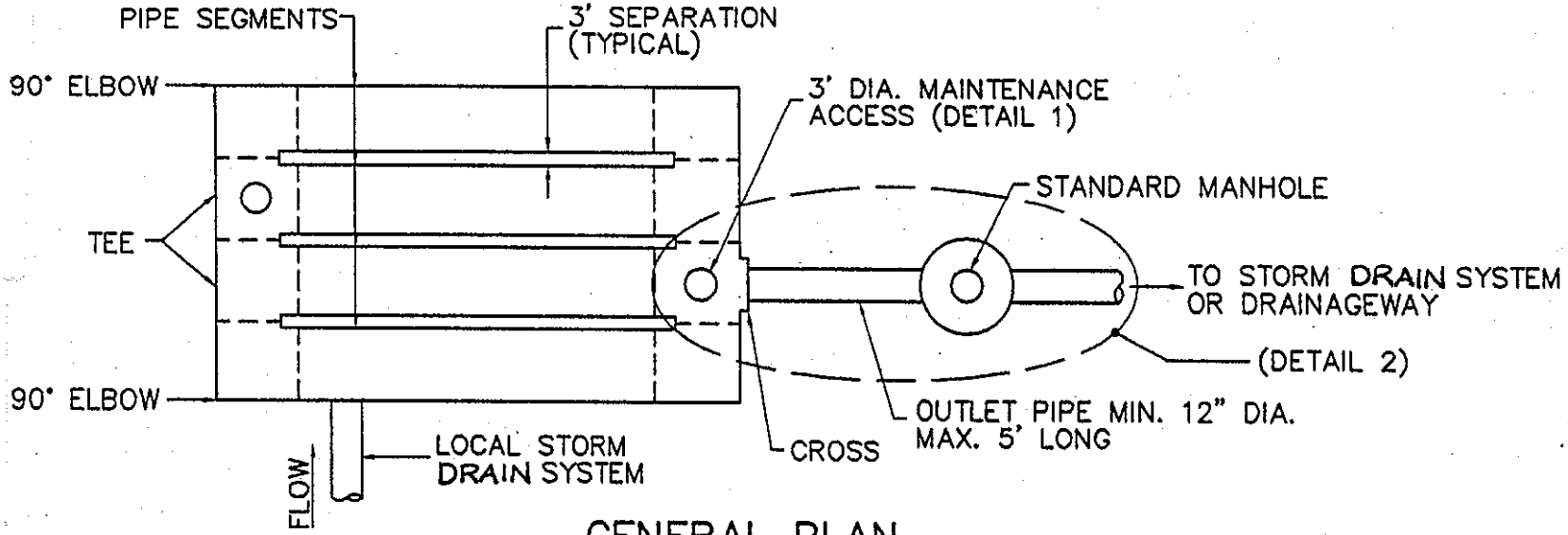
City of Greeley Colorado
Great. From the Ground Up.

PUBLIC WORKS DEPARTMENT
STORMWATER MANAGEMENT DIVISION
1001 NINTH AVENUE GREELEY, COLORADO 80631

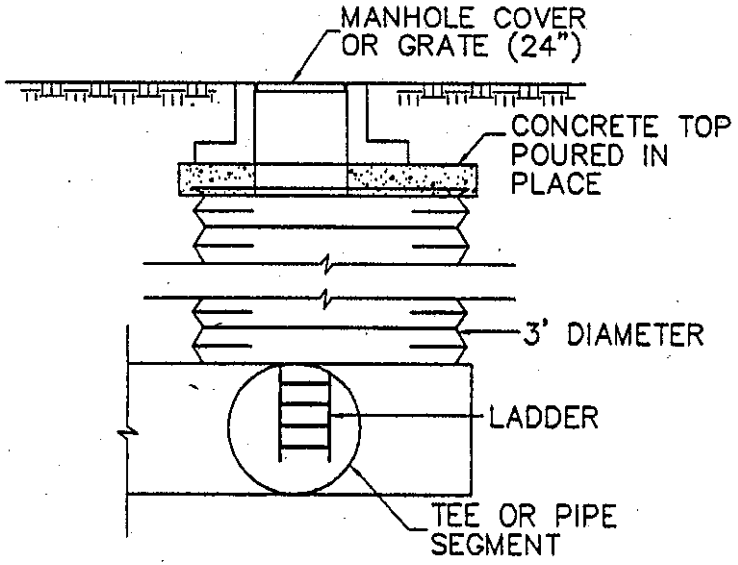
UNDERGROUND DETENTION

FIGURE 11 -5

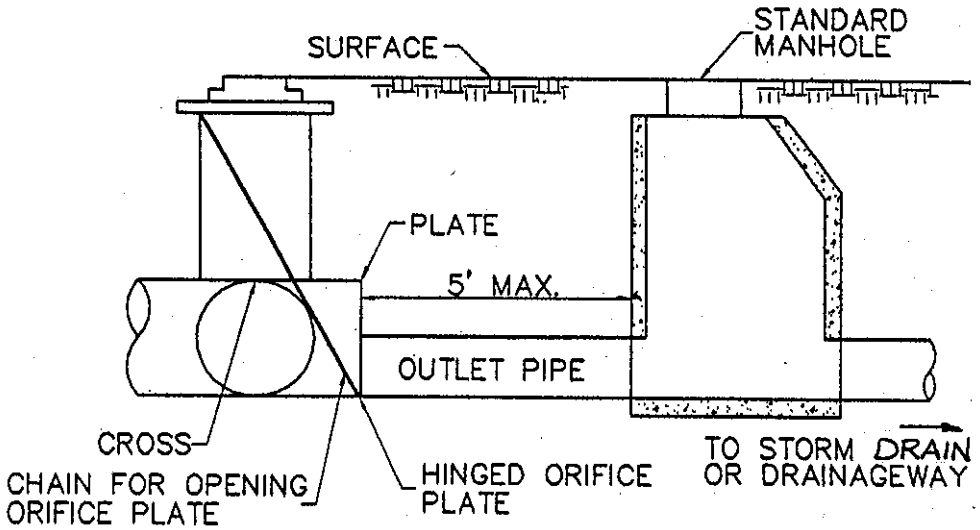
SCALE: NTS
REVISED AUG 1996



GENERAL PLAN



MAINTENANCE ACCESS DETAIL 1



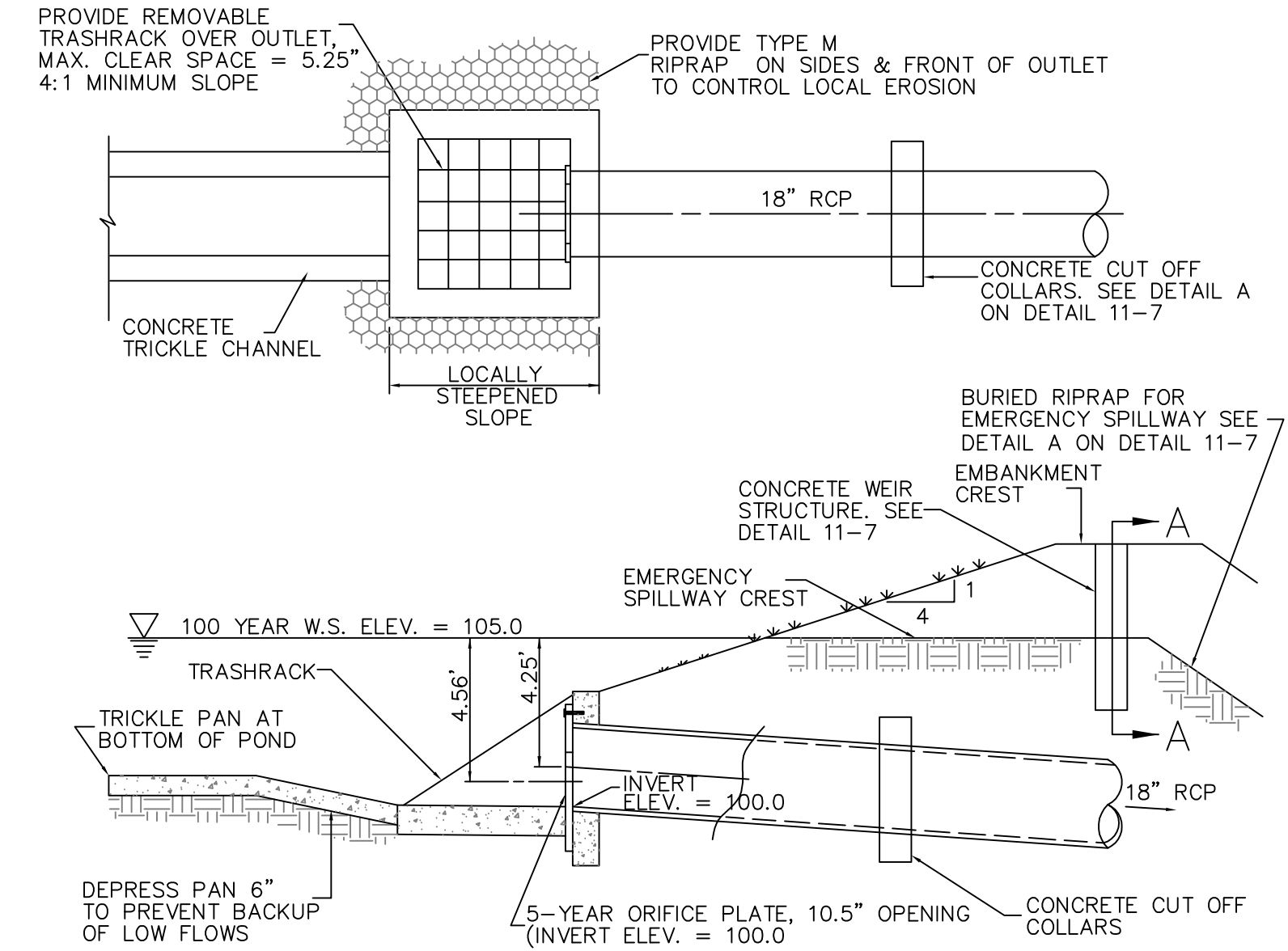
OUTLET DETAIL 2

City of Greeley Colorado
Great. From the Ground Up.

OUTLET DESIGN EXAMPLE

FIGURE 11-6

PUBLIC WORKS DEPARTMENT
STORMWATER MANAGEMENT DIVISION
1001 NINTH AVENUE GREELEY, COLORADO 80631



NOTE: TRASH RACK & 3/8" STEEL ORIFICE PLATE TO BE HOT DIP GALVANIZED ANCHOR WITH 3/8" DIA. X 4 1/2" STAINLESS STEEL BOLTS. EMBED BOLTS 3" INTO CONCRETE.

SCALE: NTS
REVISED MARCH 2007