RESOLUTION NO. 2008-02

A RESOLUTION ESTABLISHING STORMWATER MANAGEMENT DESIGN AND CONSTRUCTION POLICIES

WHEREAS, it is the desire of the City Council to adopt a policy relating to Stormwater Management Design and Construction to provide guidance and clarity to the professional community designing stormwater systems within the city of Post Falls, which in turn should reduce the amount of staff time required to address technical design questions.

NOW THERFORE BE IT RESOLVED by the mayor and city council of the city of Post Falls as follows:

That the attached STORMWATER MANAGEMENT DESIGN AND CONSTRUCTION POLICIES dated January 15, 2008 are hereby adopted as the policies and procedures for design and construction of stormwater systems within the city of Post Falls.

The City Engineer shall have the authority to execute these policies and take the necessary actions for the policy implementation.

PASSED by the City Council this 15 day of January 2008 and approved by the Mayor.

Mayor Clay Larkin

Clay Larkin, Mayor

Christene Pappas

Christene Pappas, City Clerk

CITY OF POST FALLS INCORPORATED MAY 26 1892 IDAHO

City of Post Falls
Stormwater Management Design & Construction Policies

General

All land developed within the City of Post Falls shall incorporate stormwater runoff treatment facilities. The purpose of the stormwater treatment facilities is to mitigate the potential for groundwater degradation and for the protection of the Rathdrum Prairie Aquifer and the Spokane River. The preferred treatment mechanisms are the infiltration of stormwater runoff through a Biofiltration swale ('208' swale design) or a Bioinfiltration swale (flush mount swale design). Alternative systems, which meet or exceed the contaminant removal levels contained in Table 1, may be used subject to approval of the City Engineer, the Stormwater Technical Advisory Committee, and the Idaho Department of Environmental Quality.

TABLE 1

Expected contaminate removal rates using grassed percolation areas:

Contaminant	% Removed
Total Suspended Solids	95%
Total Dissolved Solids	50%
Nutrients:	
Nitrate	20-50%
Total Nitrogen	80%
Phosphorus	90%
Metals	80%
Organic Chemicals	60%
Bacteria	99%

These policies shall be considered as minimum requirements to be used in design of the stormwater facilities.

Stormwater Management Design Standards

Considerable research has shown that approximately 90% of the contaminants from any runoff event are carried by the first one-half inch of runoff, therefore the stormwater treatment facility shall be designed to treat the first one-half inch of runoff from the impervious surface draining to the treatment facility. The stormwater treatment facility shall also be capable of either storing or disposing the stormwater runoff generated by a 25-year, 2-hour storm event. The two design methods accepted by the City of Post Falls and in accordance with the Idaho Department of Environmental Quality (IDEQ) Catalog of Stormwater Best Management Practices (BMP's) are BMP #38a – Biofiltration Swale ('208' swale design) and BMP #38b – Bioinfiltration Swale (flush mount swale design). Each of the above mentioned BMP's is designed to treat the first one-half inch of runoff from the impervious surface draining to the treatment facility as required. Stormwater

from roof runoff may be directly discharged into drywells and does not need to be treated prior to discharge. The drywells shall be sized accordingly using the Rational Method to handle the maximum runoff generated from the roof. The maximum runoff is determined by assuming the time of concentration is 5 minutes, resulting in a rainfall intensity of 2.8 inches per hour. Refer to the Hydrology section of these policies for an explanation of the Rational Method (page no. 3).

BMP #38a – Biofiltration Swale ('208' swale design)
Biofiltration swales are vegetated channels with a slope less than 6% and that maximizes flow residence time and promotes pollutant settling. Infiltration is not a major component of this BMP. Refer to the Idaho Department of Environmental Quality (IDEQ) Catalog of Stormwater BMP's for more information.

Biofiltration swales shall be designed to store the first ½ inch of runoff from a storm event. Using the concept of the storage volume as the basis for grassed percolation area design yields the following general equation:

$$\text{Volume of swale}_{\text{minimum}} = (\tfrac{1}{2} \text{ inch}) \text{ X } (1 \text{ ft} / 12 \text{ inches}) \text{ X (Impervious Area)}$$

The above equation assumes that the swale is flat (1% or less). In situations where the swale slope is greater than 2%, compensation must be made for the slope. Check dams shall be installed in the swale to slow the stormwater flow and to dissipate the stormwater evenly across the swale bottom.

The stormwater facilities shall be designed to treat and store or dispose of the 25-yr, 2-hr storm event. The Bowstring Method shall be utilized to determine the storage volume required to store the runoff generated by a 25-year, 2-hour storm event. The Bowstring Method takes into account the outflow capacity of the drywell. The capacities of a single depth drywell and a double depth drywell are 0.3 cubic feet per second and 1.0 cubic feet per second, respectively. Refer to the Bowstring Method design worksheet for detailed explanation of calculations (example spreadsheets attached). Another alternative for designing the stormwater facilities to dispose the 25-yr, 2-hr storm event is to utilize the Rational Method to determine the maximum runoff flow and provide sufficient drywell capacity to handle the maximum runoff. The maximum runoff is determined by assuming the time of concentration is 5 minutes, resulting in a rainfall intensity of 2.8 inches per hour. Refer to the Hydrology section of these policies for an explanation of the Rational Method.

The drywell rim shall be a minimum of 0.5 feet above the bottom of the swale and maximum of 0.67 feet above the bottom of the swale and 0.2 feet below the drainage curb cut or any other inlet invert elevation.

BMP #38b – Bioinfiltration Swale (flush mount swale design)
Bioinfiltration swales are vegetated channels with a slope less than 4% and intended to infiltrate the first half-inch of stormwater runoff from impervious surfaces through a grass or vegetative root zone. The minimum allowable soil infiltration rate is 0.5 inches

per hour and the maximum allowable infiltration rate 3.0 inches per hour. The maximum allowable infiltration rate to be assumed for design without post-construction infiltration testing is 2.0 inches per hour. If a soil infiltration rate greater than 2.0 inches per hour is used for design, then post-construction infiltration testing shall be conducted to verify the infiltration rate assumed is met. The post-construction infiltration test to be completed is the ring infiltrometer test (ASTM D5126).

The flush mount swale design storm (precipitation rate) for the Rathdrum Prairie Aquifer (90% of stormwater treated) is 0.1 inches per hour intensity. The area of the swale is determined by matching the infiltrative capacity with the rate of flow into the swale. This calculation can be done incrementally with the Manning's flow equation. An acceptable method for calculating inflow into the swale from the impervious area is the Rational Method (Soil Conservation Service). None of the first half inch of storm runoff should reach the drywell prior to infiltration for the design to be acceptable. Refer to the Infiltrative Treatment Swale Design Tables for the required infiltrative swale area given the impervious area and the soil infiltration rate.

The stormwater facilities shall be designed to treat and store or dispose of the 25-yr, 2-hr storm event. The Bowstring Method shall be utilized to determine the storage volume required to store or dispose the runoff generated by a 25-year, 2-hour storm event. The Bowstring Method takes into account the outflow capacity of the drywell. The capacities of a single depth drywell and a double depth drywell are 0.3 cubic feet per second and 1.0 cubic feet per second, respectively. Refer to the Bowstring Method design worksheet for detailed explanation of calculations. Another alternative for designing the stormwater facilities to dispose the 25-yr, 2-hr storm event is to utilize the Rational Method to determine the maximum runoff flow and provide sufficient drywell capacity to handle the maximum runoff. The maximum runoff is determined by assuming the time of concentration is 5 minutes, resulting in a rainfall intensity of 2.8 inches per hour. Refer to the Hydrology section of these policies for an explanation of the Rational Method.

The drywell rim shall be a minimum of 0.1 feet above the bottom of the swale and 0.2 feet below drainage curb cuts or any other inlet invert elevation.

Combination of BMP #38a and BMP #38b

A combination of the two design methods (BMP #38a & BMP #38b) may be used in special circumstances at the discretion of the City Engineer. The BMP #38b would be used to determine the treatment area and the drywell rim elevation would be set 0.5' above the swale bottom as in BMP #38a.

Hydrology

Rational Method

A 25-year design frequency shall be used for stormwater drainage calculations. The preferred method for determining the peak runoff flow for basins 10 acres or less is the Rational Method. The following is an explanation of the Rational Method.

The rational formula is as follows:
$Q = C * I * A$
Where Q = Runoff in cubic feet per second (cfs)
C = Runoff Coefficient
I = Rainfall intensity in inches per hour
A = Contributing area in Acres

Runoff Coefficeints (C)
The runoff coefficients (C) should be as follows:

Ground Cover	Flat	Rolling 2% - 10%	Hilly Over 10%
Pavement and Roofs	0.90	0.90	0.90
Earth Shoulders	0.50	0.50	0.50
Drives and Walks	0.75	0.80	0.85
Gravel Pavement	0.50	0.55	0.60
Lawns, Sandy Soil	0.10	0.15	0.20
Lawns, Heavy Soil	0.17	0.22	0.35

Rainfall Intensity (I)
The rainfall intensity (I) shall be based on the Idaho Transportation Department, Figure I-C, Zone C, Intensity – Duration – Frequency Curve.

Time of Concentration (T_c)
The time of concentration for rainfall should be computed for all overland flow, ditches, channels, gutters, culverts and pipe systems. When using the rational formula, the time of concentration for overland flow may be computed by the following formula:

$T_c = C_t * ((L * n) / s^{1/2})^{0.6}$
Where T_c is the time of concentration in minutes
L is the length of the principal channel in feet
n is the friction factor of the ground surface
s is the average slope of the principal channel in feet per foot
C_t = 0.40 for natural drainage basins and 0.15 for overland flow

The time of concentration should be calculated for each significantly different slope. Travel time for flow in pipes, ditches and gutters should be computed as a function of the velocity as defined by Mannings formula. A time of concentration nomograph may also be used to calculate the time of concentration.

Piped Stormwater Systems
Upon the request of the City, the capacity of curb opening inlets and catch basin inlets shall be calculated. When utilizing a storm pipe system to collect and discharge the stormwater in a community swale, the flow shall be calculated for each pipe segment. When stormwater travels along a gutter line for long distance prior to discharging into a curb inlet or catch basin, roadway flooding calculations shall be provided upon the request of the City.

Stormwater Requirements for Special Cases

Any land disturbing activity along the Spokane River, high erosion hazard areas, or in sloped areas that may have adverse impacts to downstream sites are required to prepare an erosion and sedimentation control plan in accordance with Title 18.24.060, Site Disturbance. The post-developed stormwater runoff leaving the site shall not be greater than the pre-developed stormwater runoff leaving the site. All roof runoff shall be piped directly to a drywell or rock sumps.

Stormwater Management Report Submittal

The following information should be included in the stormwater management report. The drainage report shall be stamped and signed by the design professional licensed in the State of Idaho and two sets submitted to the City of Post Falls for review and approval.

Project Overview

The project overview shall include a brief description of the project, a description of the soils, a description of the analysis method used for the determination of the stormwater facilities size requirements, and any assumptions made for the design of the stormwater facilities. The project overview should also include a summary of the stormwater facilities.

Drainage Plan

The drainage plan shall include the existing ground contours and finish ground spot elevations or finish ground contours. The plan shall clearly define the proposed development, flow patterns, drainage basin limits, drainage sub-basins, environmentally sensitive areas, footprints of proposed drainage features, north arrow, and scale bar.

Calculations

All calculations for determining the required swale size shall be included in the drainage report. The calculations shall be based on the required criteria as stated in these guidelines. Calculations that shall be submitted shall include but not limited to:

1. Hydrology computations (Rational Method, Manning's, etc.)
    a. Pre-developed conditions
    b. Post-developed conditions
2. Required swale area for treatment
3. Bowstring routing spreadsheet
4. Pipe system capacities
5. Inlet capacities

Construction Plans

Stormwater management construction plans shall be prepared for all open and closed stormwater collection systems. The plans shall consist of the following but not limited to:

1. Swale footprints including the bottom elevation and slope

2. Location, size, and elevations of all existing and proposed storm drainage structures (drywells, catch basins, etc.)
3. Invert elevations, length, and type of pipe for all storm sewer pipe
4. Location and elevation of all low points
5. Flow patterns
6. Property lines and easements

Construction Methodology

Temporary erosion control and water pollution measures shall be required and installed, in accordance with the plans or accepted best management practices. At no time, will silts and/or debris be allowed to drain into an existing or newly installed facility.

Swales within areas of mass grading shall be scarified a minimum of 24 inches prior to shaping, and after installation of curb and gutter.

All disturbed areas shall receive a minimum inch dressing of top soil and be hydro seeded or sodded, as indicated on the plans. Seeded areas will not be accepted until the seed has germinated, and the grass is thoroughly established. Sodded areas will not be accepted until the roots have taken hold, and the grass has received two cuttings.

Care shall be taken to prevent compaction of the sub-grade in the grass infiltration areas of swales. In the event the sub-grade should be compacted or insufficient percolation is observed, testing of the sub-grade may be required at the discretion of the City Engineer. If a sufficient percolation is not observed, the sub-grade must be removed and replaced, or scarified to a depth of 24" and retested.

Topsoil placed within the swales shall be free draining, and placed at a depth greater than 1-inch and less than 3 inches. To prevent compaction of the sub-grade and topsoil, wheeled equipment should not be used within the swale area. The minimum percolation rate through a constructed swale shall meet design requirements. Testing of percolation rates through a constructed swale may be required at the discretion of the City Engineer.

Drywells shall be installed to the elevations indicated on the plans. The minimum depth of the swale below the rim of the drywell shall be 1-inch.

Grass infiltration areas shall be hydro seeded with 50 lb. / 1,000 square feet, consisting of a mixture with equal portions of Canada Bluegrass, Crested Wheatgrass, Hard Fescue and Sheep Fescue. Seeded areas shall be fertilized with a commercial fertilizer per the manufacturer's specifications and mulched with "Silva Fiber Plus", or an approved equal wood fiber cellulose at a rate of 1 ton per acre, or alternately with a clean weed free straw 2-3 inches deep (2 tons per acre) and anchored in place.

Erosion and Sediment Control

Erosion control and protection from sedimentation are critical to performance of stormwater drainage facilities. Therefore, during construction, all necessary measures

shall be taken to prevent sediments from entering the swales and stormwater drainage structures. All necessary measures shall be taken to prevent the swales from eroding prior to the establishment of the grass. All erosion and sediment control measures shall conform to the IDEQ Catalog of Stormwater BMP's.

Washout sites for concrete trucks and other equipment shall be designated. The slurry pits shall not be located within an existing or proposed swale, drainage area, nor any other stormwater facility.

Maintenance of Stormwater Drainage Facilities

For stormwater drainage facilities located outside of the public road rights-of-way as well as within the public rights-of-way, the adjacent land owner or the property owners association shall provide for perpetual maintenance of the drainage facilities. Perpetual maintenance includes mowing, irrigating, and keeping the swale free of weeds and debris.

When the swale has reached the end of its useful life, it shall be renovated. The useful life will be considered to have ended when water remains standing in the swale for more than 72 hours following the end of a runoff event or when the swale cover material dies, whether due to toxic materials in the soil or any other cause.

In the situation where infiltration fails, renovation may be accomplished by any needed action from standard soil aeration to removal of the sod layer, scarifying the underlying soil and sod replacement. The City of Post Falls will be responsible for renovating swales within the public rights-of-ways when the infiltration fails.

When the cover material dies, the sod and at least 6 inches of soil shall be removed from the affected area and disposed of in an acceptable site. The soil shall be replaced, graded and new cover material installed.

EXAMPLE SPREADSHETS

Stormwater Management Calculations
City of Post Falls
Bowstring Method - 208 DESIGN

Project Name	
Date	
Prepared By	
Basin	
Time Increment (min)	5
Time of Concentration, t_c (min	#DIV/0!
Outflow (cfs)	
Design Year (year)	25
Impervious Area, A_{Imp} (ft^2)	
Area (ft^2)	
Area (acres)	0.00
Developed "C" Factor	#DIV/0!
Area x "C"	#DIV/0!

#1 Time Inc. (min)	#2 Time Inc. (sec) (#1 * 60)	#3 Intensity (in / hr) (see below)	#4 Q_{dev} (cfs) (A * C * #3)	#5 V_{in} (ft^3) (see below)	#6 V_{out} (ft^3) (Outflow * #2)	#7 Storage (ft^3) (#5 - #6)
5	300	2.80	#DIV/0!	#DIV/0!	0	#DIV/0!
10	600	2.10	#DIV/0!	#DIV/0!	0	#DIV/0!
15	900	1.70	#DIV/0!	#DIV/0!	0	#DIV/0!
20	1200	1.60	#DIV/0!	#DIV/0!	0	#DIV/0!
25	1500	1.40	#DIV/0!	#DIV/0!	0	#DIV/0!
30	1800	1.20	#DIV/0!	#DIV/0!	0	#DIV/0!
35	2100	1.10	#DIV/0!	#DIV/0!	0	#DIV/0!
40	2400	0.95	#DIV/0!	#DIV/0!	0	#DIV/0!
45	2700	0.90	#DIV/0!	#DIV/0!	0	#DIV/0!
50	3000	0.87	#DIV/0!	#DIV/0!	0	#DIV/0!
55	3300	0.85	#DIV/0!	#DIV/0!	0	#DIV/0!
60	3600	0.78	#DIV/0!	#DIV/0!	0	#DIV/0!
65	3900	0.75	#DIV/0!	#DIV/0!	0	#DIV/0!
70	4200	0.70	#DIV/0!	#DIV/0!	0	#DIV/0!
75	4500	0.69	#DIV/0!	#DIV/0!	0	#DIV/0!
80	4800	0.67	#DIV/0!	#DIV/0!	0	#DIV/0!
85	5100	0.65	#DIV/0!	#DIV/0!	0	#DIV/0!
90	5400	0.63	#DIV/0!	#DIV/0!	0	#DIV/0!
95	5700	0.60	#DIV/0!	#DIV/0!	0	#DIV/0!
100	6000	0.59	#DIV/0!	#DIV/0!	0	#DIV/0!
105	6300	0.58	#DIV/0!	#DIV/0!	0	#DIV/0!
110	6600	0.55	#DIV/0!	#DIV/0!	0	#DIV/0!
115	6900	0.52	#DIV/0!	#DIV/0!	0	#DIV/0!
120	7200	0.5	#DIV/0!	#DIV/0!	0	#DIV/0!

#3 Intensities from Zone - C Intensity - Duration - Frequency Curve

#5 $V_{in} = 1.34 * Q_{dev} * t$ for $t \leq t_c$ **OR** $V_{in} = (Q_{dev} * t) + (.34 * Q_{dev} * t_c)$ for $t > t_c$

Stormwater Management Calculations
City of Post Falls

Project Name	0
Date	1/0/1900
Prepared By	0
Basin	0

Pre-Developed Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Grass		0.00	50	0.15
Gravel		0.00	76	0.55
Pavement		0.00	98	0.90
Trees/Brush		0.00	55	0.50
Totals	0	0.00	#DIV/0!	#DIV/0!

Post-Development Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Pavement/Concrete		0.00	98	0.90
House		0.00	98	0.90
Grass/Lawn		0.00	60	0.60
Trees/Brush		0.00	55	0.50
Totals	0	0.00	#DIV/0!	#DIV/0!

Pre-Developed Flow (cfs)	#DIV/0!
Post-Developed Flow (cfs)	#DIV/0!

'208' Design

Storage Volume (ft^3)	
Required (A_{imp} * .5 / 12)	Provided
0	

Treatment Area (ft^2)	
Required (A_{imp} / 12)	Provided
0	

25 year design (Bowstring)

Max Storage Required (ft^3)	#DIV/0!	
Max Storage Provided (ft^3)		
Number of Drywells Required		Double Depth Drywell
		Single Depth Drywell

Time of Concentration

$tc = C_t (Ln / S^{1/2})^{0.6}$

C_t is 0.4 for Natural Drainage Basins or 0.15 For Overland Flow — Ct = _____

L is Length — L = _____

n is the friction factor of the ground surface — n = _____

S is the slope — S = _____

Time of Concentration, tc = #DIV/0!

Bowstring Method
Procedure

The Bowstring Method for detention basin design is a procedure in which the modified rational method is used to design the detention basin without performing Routing. An allowable release rate and volume are calculated for the undeveloped condition using the modified rational method.. Similarly the developed rates and volumes are calculated for various time periods and the storage requirement of the basin is calculated as the maximum difference between the volumes for the developed and undeveloped conditions. This method should be limited to basin areas less than 10 acres in size. The procedure is:

1. Compute the peak discharges for a 25 - year storm for the developed and undeveloped conditions for various time periods (t):

$Q_{dt} = C_d I_t A$ t = at time t

d = developed

where the subscript d refers to the developed condition, Q is the peak discharge (*cfs), C is the runoff coefficient, I is the intensity of rainfall (in/hr) and A is the drainage area (acres).

2. For different t, calculate volumes:

Inflow Volume = $V_{in} = 1.34 * Q_{dev} * t$ for $t \leq t_c$ **OR** $V_{in} = (Q_{dev} * t) + (.34 * Q_{dev} * t_c)$ for $t > t_c$

Outflow Volume = $Q_{dev} * t$

3. The required storage is obtained as the maximum difference between inflow and outflow volumes by either graphical or tabular method.

Example

A Site within the City of Post Falls is to be developed. The site consists of the following:

Area = 317,117 square feet
Proposed Impervious Area = 246,114 square feet
Proposed Grass/Lawn Area = 71,003 square feet
Length of Channel, L = 700 feet
Friction Factor of Ground, n = 0.016
Slope of the Ground, S = .007

Step 1

Using the given information first compute the peak discharge

$tc = C_t (Ln / S^{1/2})^{0.6}$

$tc = .15 (700*.016 / .007^{1/2})0.6$

tc = 2.83 minutes Use 5 minutes

From the Idaho Transportation Department Figure I-C, Zone C, Intensity - Duration - Frequency Curve; I for 5 minutes = 2.8 inches /hour

Weighted "C" factor = (0.9*5.65 + .15*1.63) / (5.65 + 1.63)
Weighted "C" factor = 0.72

Bowstring Method
Procedure

Q developed = C * I * A
Q developed = .83 * 2.8 * 7.28
Q developed = 17.0 cfs 17 double depth drywells required

Select a desired outflow, such as 2 cfs
Q undeveloped = 2 cfs

Step 2

Select a time increment less than the time of concentration for calculating, or 5 minutes (tc is never less than 5 minutes). The solution is shown on the following page. Column is the time increment selected. Column #2 is Column #1 in seconds. Column #3 is the 25 year intensity from the Idaho Transportation Department Figure I-C, Zone C, Intensity - Duration - Frequency Curve at each time increment. Column #4 is the area times the weighted "C" factor times Column #3. Column #5 is the volume in using the equations for volume used in the Modified Rational Method Hydrographs. Column #6 is the desired outflow times Column #2. Column #7 is Column #5 minus Column #6.

Step 3

The required storage is the maximum difference between the inflow and outflow volumes, or 8953 cubic feet. This is less than the 10255 cubic feet required for the 208 ponding volume and the 2 cfs can be disposed of in 2 double depth drywells, rather than the 17 drywells required under step 1.

Stormwater Management Calculations
City of Post Falls
Bowstring Method - 208 DESIGN

Project Name	***EXAMPLE #1***
Date	***May 13, 2005***
Prepared By	***CITY OF POST FALLS***
Basin	***1***
Time Increment (min)	5
Time of Conectration, t_c (min)	5.00
Outflow (cfs)	***2***
Design Year (year)	25
Impervious Area, A_{imp} (ft^2)	***246114***
Area (ft^2)	***317117***
Area (acres)	7.28
Developed "C" Factor	0.73
Area x "C"	5.33

#1 Time Inc. (min)	#2 Time Inc. (sec) (#1 * 60)	#3 Intensity (in / hr) (see below)	#4 Q_{dev} (cfs) (A * C * #3)	#5 V_{in} (ft^3) (see below)	#6 V_{out} (ft^3) (Outflow * #2)	#7 Storage (ft^3) (#5 - #6)
5	300	2.80	14.92	5999	600	5399
10	600	2.10	11.19	7857	1200	6657
15	900	1.70	9.06	9078	1800	7278
20	1200	1.60	8.53	11102	2400	8702
25	1500	1.40	7.46	11953	3000	8953
30	1800	1.20	6.40	12164	3600	8564
35	2100	1.10	5.86	12909	4200	8709
40	2400	0.95	5.06	12668	4800	7868
45	2700	0.90	4.80	13440	5400	8040
50	3000	0.87	4.64	14383	6000	8383
55	3300	0.85	4.53	15411	6600	8811
60	3600	0.78	4.16	15389	7200	8189
65	3900	0.75	4.00	15996	7800	8196
70	4200	0.70	3.73	16049	8400	7649
75	4500	0.69	3.68	16923	9000	7923
80	4800	0.67	3.57	17504	9600	7904
85	5100	0.65	3.46	18021	10200	7821
90	5400	0.63	3.36	18473	10800	7673
95	5700	0.60	3.20	18553	11400	7153
100	6000	0.59	3.14	19187	12000	7187
105	6300	0.58	3.09	19789	12600	7189
110	6600	0.55	2.93	19645	13200	6445
115	6900	0.52	2.77	19405	13800	5605
120	7200	0.5	2.66	19458	14400	5058

#3 Intensities from Zone - C Intensity - Duration - Frequency Curve

#5 $V_{in} = 1.34 * Q_{dev} * t$ for $t \leq t_c$ **OR** $V_{in} = (Q_{dev} * t) + (.34 * Q_{dev} * t_c)$ for $t > t_c$

Stormwater Management Calculations

Project Name	EXAMPLE #1
Date	May 13, 2005
Prepared By	CITY OF POST FALLS
Basin	1

Pre-Developed Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Grass	***317117***	7.28	50	0.15
Gravel		0.00	76	0.55
Pavement		0.00	98	0.90
Trees/Brush		0.00	55	0.50
Totals	317117	7.28	50	0.15

Post-Development Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Pavement/Concrete	***246114***	5.65	98	0.90
House		0.00	98	0.90
Grass/Lawn	***71003***	1.63	60	0.15
Trees/Brush		0.00	55	0.50
Totals	317117	7.28	89	0.73

Pre-Developed Flow (cfs)	3.06
Post-Developed Flow (cfs)	14.92

'208' Design

Storage Volume (ft^3)	
Required (A_{imp} * .5 / 12)	Provided
10255	**10500**

Treatment Area (ft^2)	
Required (A_{imp} / 12)	Provided
20510	**21000**

25 year design (Bowstring)

Max Storage Required (ft^3)	8953	
Max Storage Provided (ft^3)		
Number of Drywells Required	***2***	Double Depth Drywell
	0	Single Depth Drywell

Time of Concentration

$tc = C_t (Ln / S^{1/2})^{0.6}$

C_t is 0.4 for Natural Drainage Basins or 0.15 For Overland Flow	Ct =	***0.15***
L is Length	L =	***700***
n is the friction factor of the ground surface	n =	***0.016***
S is the slope	S =	***0.007***
	Time of Concentration, tc =	2.83

INFILTRATIVE TREATMENT SWALE DESIGN TABLES

Rational Method: Q_{runoff} = CIA, cfs

Mass Flux for System:

Given:

Steady state conditions with "perfect" water distribution in swale

I= percipitation rate =	0.1	inches/hour per Stormwater TAC, IDWAR, & IDEQ (Jan. 2001)
C = Runoff coefficient =	0.9	for pavement
I = Soil Infiltration Rate =	0.5 - 3.0	Inches/hour per Stormwater TAC, IDWAR, & IDEQ

A_{swale} = REQUIRED INFILTRATIVE SWALE AREA GIVEN I AND A_{imp}, ft^2

Impervious Area A_{Imp} ft^2	Impervious Area Acres	Flow cfs	Soil Infiltration Rate = I, inches/hour					
			0.5	1.0	1.5	2.0	2.5	3.0
20	0.0005	0.0000	4.5	2.0	1.3	0.9	0.7	0.6
40	0.0009	0.0001	8.9	4.0	2.6	1.9	1.5	1.2
60	0.0014	0.0001	13.4	6.0	3.8	2.8	2.2	1.8
80	0.0018	0.0002	17.9	7.9	5.1	3.8	3.0	2.5
100	0.0023	0.0002	22.3	9.9	6.4	4.7	3.7	3.1
200	0.0046	0.0004	44.6	19.8	12.8	9.4	7.4	6.2
400	0.0092	0.0008	89.3	39.7	25.5	18.8	14.9	12.3
600	0.0138	0.0012	133.9	59.5	38.3	28.2	22.3	18.5
800	0.0184	0.0017	178.5	79.3	51.0	37.6	29.8	24.6
1000	0.0230	0.0021	223.1	99.2	63.8	47.0	37.2	30.8
1200	0.0275	0.0025	267.8	119.0	76.5	56.4	44.6	36.9
1400	0.0321	0.0029	312.4	138.8	89.3	65.8	52.1	43.1
1600	0.0367	0.0033	357.0	158.7	102.0	75.2	59.5	49.2
1800	0.0413	0.0037	401.7	178.5	114.8	84.6	66.9	55.4
2000	0.0459	0.0041	446.3	198.3	127.5	94.0	74.4	61.6
2200	0.0505	0.0045	490.9	218.2	140.3	103.4	81.8	67.7
2400	0.0551	0.0050	535.5	238.0	153.0	112.7	89.3	73.9
2600	0.0597	0.0054	580.2	257.9	165.8	122.1	96.7	80.0
2800	0.0643	0.0058	624.8	277.7	178.5	131.5	104.1	86.2
3000	0.0689	0.0062	669.4	297.5	191.3	140.9	111.6	92.3
3200	0.0735	0.0066	714.0	317.4	204.0	150.3	119.0	98.5
3400	0.0781	0.0070	758.7	337.2	216.8	159.7	126.4	104.6
3600	0.0826	0.0074	803.3	357.0	229.5	169.1	133.9	110.8
3800	0.0872	0.0079	847.9	376.9	242.3	178.5	141.3	117.0
4000	0.0918	0.0083	892.6	396.7	255.0	187.9	148.8	123.1
4200	0.0964	0.0087	937.2	416.5	267.8	197.3	156.2	129.3
4400	0.1010	0.0091	981.8	436.4	280.5	206.7	163.6	135.4
4600	0.1056	0.0095	1,026.4	456.2	293.3	216.1	171.1	141.6
4800	0.1102	0.0099	1,071.1	476.0	306.0	225.5	178.5	147.7
5000	0.1148	0.0103	1,115.7	495.9	318.8	234.9	186.0	153.9
6000	0.1377	0.0124	1,338.8	595.0	382.5	281.9	223.1	184.7
7000	0.1607	0.0145	1,562.0	694.2	446.3	328.8	260.3	215.4
8000	0.1837	0.0165	1,785.1	793.4	510.0	375.8	297.5	246.2
9000	0.2066	0.0186	2,008.3	892.6	573.8	422.8	334.7	277.0
10000	0.2296	0.0207	2,231.4	991.7	637.5	469.8	371.9	307.8
11000	0.2525	0.0227	2,454.5	1,090.9	701.3	516.7	409.1	338.6
12000	0.2755	0.0248	2,677.7	1,190.1	765.1	563.7	446.3	369.3
13000	0.2984	0.0269	2,900.8	1,289.3	828.8	610.7	483.5	400.1
14000	0.3214	0.0289	3,124.0	1,388.4	892.6	657.7	520.7	430.9
15000	0.3444	0.0310	3,347.1	1,487.6	956.3	704.7	557.9	461.7
16000	0.3673	0.0331	3,570.2	1,586.8	1,020.1	751.6	595.0	492.4
17000	0.3903	0.0351	3,793.4	1,686.0	1,083.8	798.6	632.2	523.2
18000	0.4132	0.0372	4,016.5	1,785.1	1,147.6	845.6	669.4	554.0
19000	0.4362	0.0393	4,239.7	1,884.3	1,211.3	892.6	706.6	584.8
20000	0.4591	0.0413	4,462.8	1,983.5	1,275.1	939.5	743.8	615.6

Swales sized based upon I= 0.1 inches/hour and a max I = 2.0 inches/hour without testing.

Drywells sized using the ITD Zone C curve and Rational Method.

Stormwater Management Calculations
City of Post Falls
Bowstring Method - FLUSH MOUNT

Project Name	
Date	
Prepared By	
Basin	
Time Increment (min)	5
Time of Concentration, t_c (min)	#DIV/0!
Outflow (cfs)	
Design Year (year)	25
Impervious Area, A_{imp} (ft^2)	
Area (ft^2)	
Area (acres)	0.00
Developed "C" Factor	#DIV/0!
Area x "C"	#DIV/0!

#1 Time Inc. (min)	#2 Time Inc. (sec) (#1 * 60)	#3 Intensity (in / hr) (see below)	#4 Q_{dev} (cfs) (A * C * #3)	#5 V_{in} (ft^3) (see below)	#6 V_{out} (ft^3) (Outflow * #2)	#7 Storage (ft^3) (#5 - #6)
5	300	2.80	#DIV/0!	#DIV/0!	0	#DIV/0!
10	600	2.10	#DIV/0!	#DIV/0!	0	#DIV/0!
15	900	1.70	#DIV/0!	#DIV/0!	0	#DIV/0!
20	1200	1.60	#DIV/0!	#DIV/0!	0	#DIV/0!
25	1500	1.40	#DIV/0!	#DIV/0!	0	#DIV/0!
30	1800	1.20	#DIV/0!	#DIV/0!	0	#DIV/0!
35	2100	1.10	#DIV/0!	#DIV/0!	0	#DIV/0!
40	2400	0.95	#DIV/0!	#DIV/0!	0	#DIV/0!
45	2700	0.90	#DIV/0!	#DIV/0!	0	#DIV/0!
50	3000	0.87	#DIV/0!	#DIV/0!	0	#DIV/0!
55	3300	0.85	#DIV/0!	#DIV/0!	0	#DIV/0!
60	3600	0.78	#DIV/0!	#DIV/0!	0	#DIV/0!
65	3900	0.75	#DIV/0!	#DIV/0!	0	#DIV/0!
70	4200	0.70	#DIV/0!	#DIV/0!	0	#DIV/0!
75	4500	0.69	#DIV/0!	#DIV/0!	0	#DIV/0!
80	4800	0.67	#DIV/0!	#DIV/0!	0	#DIV/0!
85	5100	0.65	#DIV/0!	#DIV/0!	0	#DIV/0!
90	5400	0.63	#DIV/0!	#DIV/0!	0	#DIV/0!
95	5700	0.60	#DIV/0!	#DIV/0!	0	#DIV/0!
100	6000	0.59	#DIV/0!	#DIV/0!	0	#DIV/0!
105	6300	0.58	#DIV/0!	#DIV/0!	0	#DIV/0!
110	6600	0.55	#DIV/0!	#DIV/0!	0	#DIV/0!
115	6900	0.52	#DIV/0!	#DIV/0!	0	#DIV/0!
120	7200	0.5	#DIV/0!	#DIV/0!	0	#DIV/0!

#3 Intensities from Zone - C Intensity - Duration - Frequency Curve

#5 $V_{in} = 1.34 * Q_{dev} * t$ for $t \leq t_c$ **OR** $V_{in} = (Q_{dev} * t) + (.34 * Q_{dev} * t_c)$ for $t > t_c$

Stormwater Management Calculations
City of Post Falls

Project Name	0
Date	1/0/1900
Prepared By	0
Basin	0

Pre-Developed Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Grass		0.00	50	0.15
Gravel		0.00	76	0.55
Pavement		0.00	98	0.90
Trees/Brush		0.00	55	0.50
Totals	0	0.00	#DIV/0!	#DIV/0!

Post-Development Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Pavement/Concrete		0.00	98	0.90
House		0.00	98	0.90
Grass/Lawn		0.00	60	0.60
Trees/Brush		0.00	55	0.50
Totals	0	0.00	#DIV/0!	#DIV/0!

Pre-Developed Flow (cfs)	#DIV/0!
Post-Developed Flow (cfs)	#DIV/0!

Flush Mount Design

Treatment	
Required Treatment Area From Flush Mount Table	Provided Treatment Area

25 year design (Bowstring)

Max Storage Required (ft^3)	#DIV/0!	
Max Storage Provided (ft^3)		
Number of Drywells Required		Double Depth
		Single Depth

Time of Concentration

$tc = C_t (Ln / S^{1/2})^{0.6}$

Natural Drainage

L is Length

n is the friction factor of the ground surface

S is the slope

Ct = _____

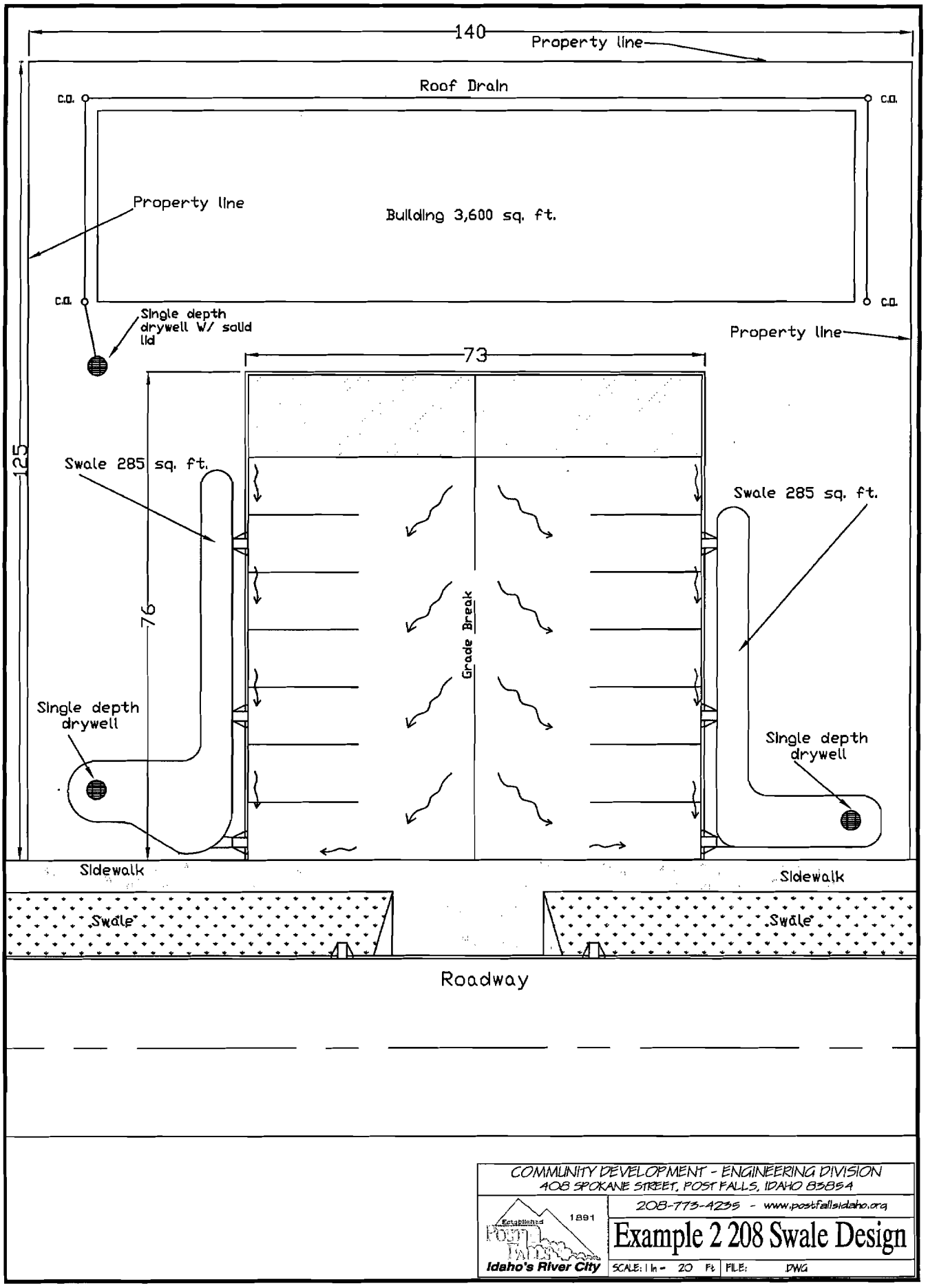
L = _____

n = _____

S = _____

Time of Concentration, tc = **#DIV/0!**

EXAMPLE #2
208 DESIGN



COMMUNITY DEVELOPMENT - ENGINEERING DIVISION
408 SPOKANE STREET, POST FALLS, IDAHO 83854

208-773-4235 - www.postfallsidaho.org

Established 1891 POST FALLS Idaho's River City

Example 2 208 Swale Design

SCALE: 1 In = 20 Ft | FILE: DWG

Stormwater Management Calculations
City of Post Falls
Bowstring Method - 208 DESIGN

Project Name	***EXAMPLE #2***
Date	***December 9, 2005***
Prepared By	***CITY OF POST FALLS***
Basin	**Roof**
Time Increment (min)	5
Time of Concentration, t_c (min	5.00
Outflow (cfs)	0.3
Design Year (year)	25
Impervious Area, A_{imp} (ft^2)	3600
Area (ft^2)	3600
Area (acres)	0.08
Developed "C" Factor	0.90
Area x "C"	0.07

#1 Time Inc. (min)	#2 Time Inc. (sec) (#1 * 60)	#3 Intensity (in / hr) (see below)	#4 Q_{dev} (cfs) (A * C * #3)	#5 V_{in} (ft^3) (see below)	#6 V_{out} (ft^3) (Outflow * #2)	#7 Storage (ft^3) (#5 - #6)
5	300	2.80	0.21	84	90	0
10	600	2.10	0.16	110	180	0
15	900	1.70	0.13	127	270	0
20	1200	1.60	0.12	155	360	0
25	1500	1.40	0.10	167	450	0
30	1800	1.20	0.09	170	540	0
35	2100	1.10	0.08	180	630	0
40	2400	0.95	0.07	177	720	0
45	2700	0.90	0.07	188	810	0
50	3000	0.87	0.06	201	900	0
55	3300	0.85	0.06	215	990	0
60	3600	0.78	0.06	215	1080	0
65	3900	0.75	0.06	223	1170	0
70	4200	0.70	0.05	224	1260	0
75	4500	0.69	0.05	236	1350	0
80	4800	0.67	0.05	244	1440	0
85	5100	0.65	0.05	252	1530	0
90	5400	0.63	0.05	258	1620	0
95	5700	0.60	0.04	259	1710	0
100	6000	0.59	0.04	268	1800	0
105	6300	0.58	0.04	276	1890	0
110	6600	0.55	0.04	274	1980	0
115	6900	0.52	0.04	271	2070	0
120	7200	0.5	0.04	272	2160	0

#3 Intensities from Zone - C Intensity - Duration - Frequency Curve

#5 $V_{in} = 1.34 * Q_{dev} * t$ for $t \leq t_c$ **OR** $V_{in} = (Q_{dev} * t) + (.34 * Q_{dev} * t_c)$ for $t > t_c$

Stormwater Management Calculations
City of Post Falls

Project Name	EXAMPLE #2
Date	12/9/2005
Prepared By	CITY OF POST FALLS
Basin	**Roof**

Pre-Developed Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Grass	3600	0.08	50	0.15
Gravel	0	0.00	76	0.55
Pavement	0	0.00	98	0.90
Trees/Brush	0	0.00	55	0.50
Totals	3600	0.08	50	0.15

Post-Development Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Pavement/Concrete		0.00	98	0.90
House	3600	0.08	98	0.90
Grass/Lawn		0.00	60	0.60
Trees/Brush	0	0.00	55	0.50
Totals	3600	0.08	98	0.90

Pre-Developed Flow (cfs)	0.03
Post-Developed Flow (cfs)	0.21

'208' Design

Storage Volume (ft^3)	
Required (A_{imp} * .5 / 12)	Provided
150	0

Treatment Area (ft^2)	
Required (A_{imp} / 12)	Provided
300	0

25 year design (Bowstring)

Max Storage Required (ft^3)	0	
Max Storage Provided (ft^3)	0	
Number of Drywells Required	0	Double Depth Drywell
	1	Single Depth Drywell

Time of Concentration

$tc = C_t (Ln / S^{1/2})^{0.6}$

C_t is 0.4 for Natural Drainage Basins or 0.15 For Overland Flow	Ct =	0
L is Length	L =	0
n is the friction factor of the ground surface	n =	0
S is the slope	S =	0.005
	Time of Concentration, tc =	**0.00**

Stormwater Management Calculations
City of Post Falls
Bowstring Method - 208 DESIGN

Project Name	***EXAMPLE #2***
Date	***December 9, 2005***
Prepared By	***CITY OF POST FALLS***
Basin	**Parking 1**
Time Increment (min)	5
Time of Concentration, t_c (min	5.43
Outflow (cfs)	0.3
Design Year (year)	25
Impervious Area, A_{imp} (ft^2)	2774
Area (ft^2)	6950
Area (acres)	0.16
Developed "C" Factor	0.72
Area x "C"	0.11

#1 Time Inc. (min)	#2 Time Inc. (sec) (#1 * 60)	#3 Intensity (in / hr) (see below)	#4 Q_{dev} (cfs) (A * C * #3)	#5 V_{in} (ft^3) (see below)	#6 V_{out} (ft^3) (Outflow * #2)	#7 Storage (ft^3) (#5 - #6)
5	300	2.80	0.32	129	90	39
10	600	2.10	0.24	171	180	0
15	900	1.70	0.20	197	270	0
20	1200	1.60	0.18	241	360	0
25	1500	1.40	0.16	259	450	0
30	1800	1.20	0.14	263	540	0
35	2100	1.10	0.13	279	630	0
40	2400	0.95	0.11	274	720	0
45	2700	0.90	0.10	290	810	0
50	3000	0.87	0.10	311	900	0
55	3300	0.85	0.10	333	990	0
60	3600	0.78	0.09	332	1080	0
65	3900	0.75	0.09	345	1170	0
70	4200	0.70	0.08	347	1260	0
75	4500	0.69	0.08	365	1350	0
80	4800	0.67	0.08	378	1440	0
85	5100	0.65	0.07	389	1530	0
90	5400	0.63	0.07	399	1620	0
95	5700	0.60	0.07	400	1710	0
100	6000	0.59	0.07	414	1800	0
105	6300	0.58	0.07	427	1890	0
110	6600	0.55	0.06	424	1980	0
115	6900	0.52	0.06	419	2070	0
120	7200	0.5	0.06	420	2160	0

#3 Intensities from Zone - C Intensity - Duration - Frequency Curve

#5 $V_{in} = 1.34 * Q_{dev} * t$ for $t \leq t_c$ **OR** $V_{in} = (Q_{dev} * t) + (.34 * Q_{dev} * t_c)$ for $t > t_c$

Stormwater Management Calculations
City of Post Falls

Project Name	EXAMPLE #2
Date	12/9/2005
Prepared By	CITY OF POST FALLS
Basin	**Parking 1**

Pre-Developed Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Grass	6950	0.16	50	0.15
Gravel	0	0.00	76	0.55
Pavement	0	0.00	98	0.90
Trees/Brush	0	0.00	55	0.50
Totals	6950	0.16	50	0.15

Post-Development Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Pavement/Concrete	2774	0.06	98	0.90
House	0	0.00	98	0.90
Grass/Lawn	4176	0.10	60	0.60
Trees/Brush	0	0.00	55	0.50
Totals	6950	0.16	75	0.72

Pre-Developed Flow (cfs)	0.07
Post-Developed Flow (cfs)	0.32

'208' Design

Storage Volume (ft^3)	
Required (A_{imp} * .5 / 12)	Provided
116	142.5

Treatment Area (ft^2)	
Required (A_{imp} / 12)	Provided
231	285

25 year design (Bowstring)

Max Storage Required (ft^3)	39	
Max Storage Provided (ft^3)	285	
Number of Drywells Required	0	Double Depth Drywell
	1	Single Depth Drywell

Time of Concentration

$tc = C_t (Ln / S^{1/2})^{0.6}$

C_t is 0.4 for Natural Drainage Basins or 0.15 For Overland Flow	Ct =	0.15
L is Length	L =	70
n is the friction factor of the ground surface	n =	0.4
S is the slope	S =	0.005
	Time of Concentration, tc =	**5.43**

Stormwater Management Calculations
City of Post Falls
Bowstring Method - 208 DESIGN

Project Name	***EXAMPLE #2***
Date	***December 9, 2005***
Prepared By	***CITY OF POST FALLS***
Basin	**Parking 2**
Time Increment (min)	5
Time of Concentration, t_c (min	5.43
Outflow (cfs)	0.3
Design Year (year)	25
Impervious Area, A_{imp} (ft^2)	2774
Area (ft^2)	6950
Area (acres)	0.16
Developed "C" Factor	0.72
Area x "C"	0.11

#1 Time Inc. (min)	#2 Time Inc. (sec) (#1 * 60)	#3 Intensity (in / hr) (see below)	#4 Q_{dev} (cfs) (A * C * #3)	#5 V_{in} (ft^3) (see below)	#6 V_{out} (ft^3) (Outflow * #2)	#7 Storage (ft^3) (#5 - #6)
5	300	2.80	0.32	129	90	39
10	600	2.10	0.24	171	180	0
15	900	1.70	0.20	197	270	0
20	1200	1.60	0.18	241	360	0
25	1500	1.40	0.16	259	450	0
30	1800	1.20	0.14	263	540	0
35	2100	1.10	0.13	279	630	0
40	2400	0.95	0.11	274	720	0
45	2700	0.90	0.10	290	810	0
50	3000	0.87	0.10	311	900	0
55	3300	0.85	0.10	333	990	0
60	3600	0.78	0.09	332	1080	0
65	3900	0.75	0.09	345	1170	0
70	4200	0.70	0.08	347	1260	0
75	4500	0.69	0.08	365	1350	0
80	4800	0.67	0.08	378	1440	0
85	5100	0.65	0.07	389	1530	0
90	5400	0.63	0.07	399	1620	0
95	5700	0.60	0.07	400	1710	0
100	6000	0.59	0.07	414	1800	0
105	6300	0.58	0.07	427	1890	0
110	6600	0.55	0.06	424	1980	0
115	6900	0.52	0.06	419	2070	0
120	7200	0.5	0.06	420	2160	0

#3 Intensities from Zone - C Intensity - Duration - Frequency Curve

#5 $V_{in} = 1.34 * Q_{dev} * t$ for $t \leq t_c$ **OR** $V_{in} = (Q_{dev} * t) + (.34 * Q_{dev} * t_c)$ for $t > t_c$

Stormwater Management Calculations
City of Post Falls

Project Name	EXAMPLE #2
Date	12/9/2005
Prepared By	CITY OF POST FALLS
Basin	**Parking 2**

Pre-Developed Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Grass	6950	0.16	50	0.15
Gravel	0	0.00	76	0.55
Pavement	0	0.00	98	0.90
Trees/Brush	0	0.00	55	0.50
Totals	6950	0.16	50	0.15

Post-Development Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Pavement/Concrete	2774	0.06	98	0.90
House	0	0.00	98	0.90
Grass/Lawn	4176	0.10	60	0.60
Trees/Brush	0	0.00	55	0.50
Totals	6950	0.16	75	0.72

Pre-Developed Flow (cfs)	0.07
Post-Developed Flow (cfs)	0.32

'208' Design

Storage Volume (ft^3)	
Required (A_{Imp} * .5 / 12)	Provided
116	142.5

Treatment Area (ft^2)	
Required (A_{Imp} / 12)	Provided
231	285

25 year design (Bowstring)

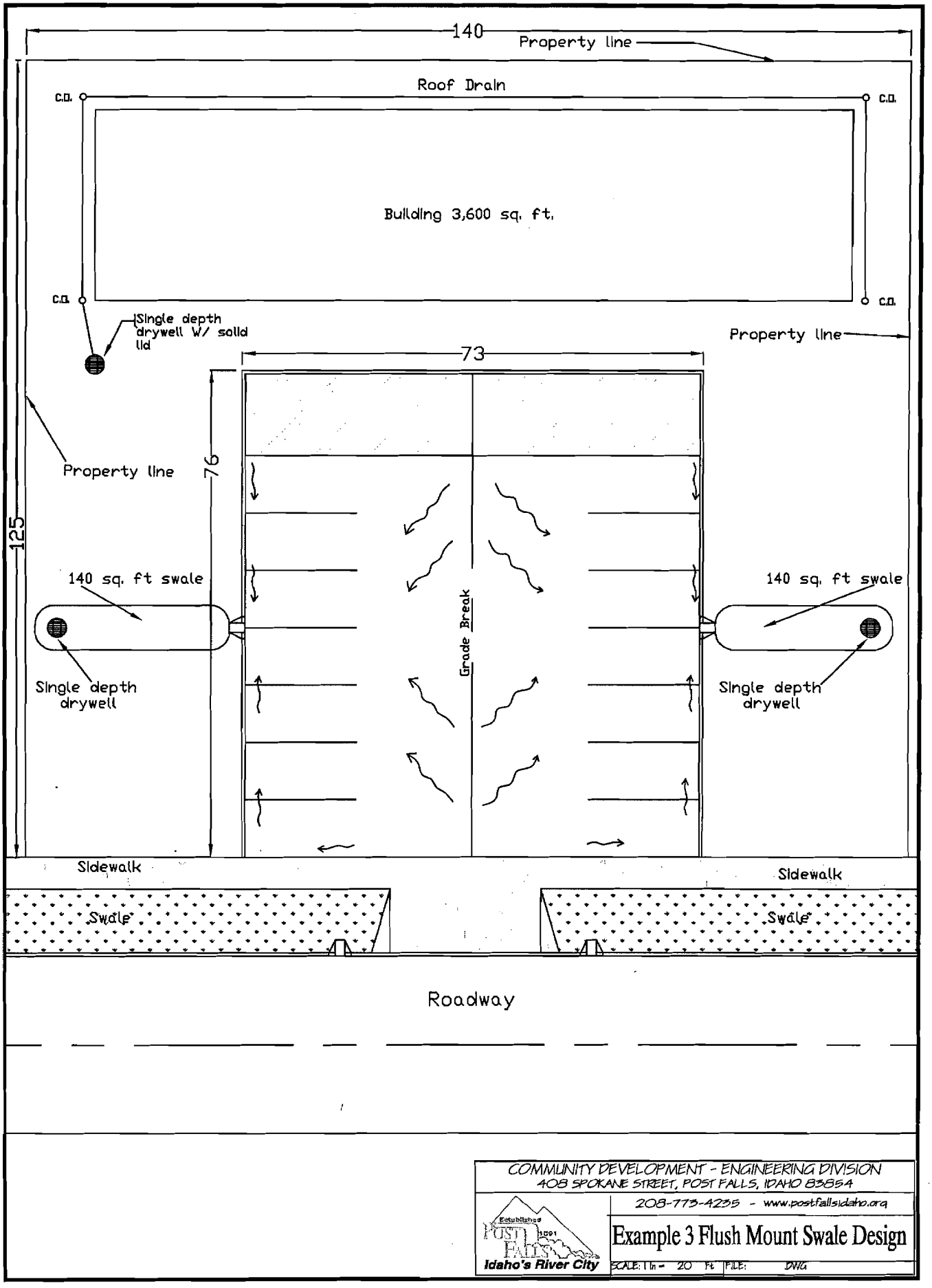
Max Storage Required (ft^3)	39	
Max Storage Provided (ft^3)	285	
Number of Drywells Required	0	Double Depth Drywell
	1	Single Depth Drywell

Time of Concentration

$tc = C_t (Ln / S^{1/2})^{0.6}$

C_t is 0.4 for Natural Drainage Basins or 0.15 For Overland Flow	Ct =	0.15
L is Length	L =	70
n is the friction factor of the ground surface	n =	0.4
S is the slope	S =	0.005
	Time of Concentration, tc =	**5.43**

EXAMPLE #3
FLUSH MOUNT DESIGN



COMMUNITY DEVELOPMENT - ENGINEERING DIVISION
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Idaho's River City

Example 3 Flush Mount Swale Design

SCALE: 1 in = 20 Ft FILE: DWG

INFILTRATIVE TREATMENT SWALE DESIGN TABLES

Rational Method: Q_{runoff} = CIA, cfs **EXAMPLE #3**

Mass Flux for System:

Given:

Steady state conditions with "perfect" water distribution in swale

I= perciplitation rate =	0.1	inches/hour per Stormwater TAC, IDWAR, & IDEQ (Jan. 2001)
C = Runoff coefficient =	0.9	for pavement
I = Soil Infiltration Rate =	0.5 - 3.0	inches/hour per Stormwater TAC, IDWAR, & IDEQ

A_{swale} = REQUIRED INFILTRATIVE SWALE AREA GIVEN I AND A_{imp}, ft^2

Impervious Area A_{imp} ft^2	Impervious Area Acres	Flow cfs	Soil Infiltration Rate = I, Inches/hour					
			0.5	1.0	1.5	2.0	2.5	3.0
20	0.0005	0.0000	4.5	2.0	1.3	1.0	0.7	0.6
40	0.0009	0.0001	8.9	4.0	2.6	1.9	1.5	1.2
60	0.0014	0.0001	13.4	6.0	3.8	2.8	2.2	1.8
80	0.0018	0.0002	17.9	7.9	5.1	3.8	3.0	2.5
100	0.0023	0.0002	22.3	9.9	6.4	4.7	3.7	3.1
200	0.0046	0.0004	44.6	19.8	12.8	9.4	7.4	6.2
400	0.0092	0.0008	89.3	39.7	25.5	18.8	14.9	12.3
600	0.0138	0.0012	133.9	59.5	38.3	28.2	22.3	18.5
800	0.0184	0.0017	178.5	79.3	51.0	37.6	29.8	24.6
1000	0.0230	0.0021	223.1	99.2	63.8	47.0	37.2	30.8
1200	0.0275	0.0025	267.8	119.0	76.5	56.4	44.6	36.9
1400	0.0321	0.0029	312.4	138.8	89.3	65.8	52.1	43.1
1600	0.0367	0.0033	357.0	158.7	102.0	75.2	59.5	49.2
1800	0.0413	0.0037	401.7	178.5	114.8	84.6	66.9	55.4
2000	0.0459	0.0041	446.3	198.3	127.5	94.0	74.4	61.6
2200	0.0505	0.0045	490.9	218.2	140.3	103.4	81.8	67.7
2400	0.0551	0.0050	535.5	238.0	153.0	112.7	89.3	73.9
2600	0.0597	0.0054	580.2	257.9	165.8	122.1	96.7	80.0
2774	**0.0637**	**0.0057**	**619.0**	**275.1**	**176.9**	**130.3**	**103.2**	**85.4**
2800	0.0643	0.0058	624.8	277.7	178.5	131.5	104.1	86.2
3000	0.0689	0.0062	669.4	297.5	191.3	140.9	111.6	92.3
3200	0.0735	0.0066	714.0	317.4	204.0	150.3	119.0	98.5
3400	0.0781	0.0070	758.7	337.2	216.8	159.7	126.4	104.6
3600	0.0826	0.0074	803.3	357.0	229.5	169.1	133.9	110.8
3800	0.0872	0.0079	847.9	376.9	242.3	178.5	141.3	117.0
4000	0.0918	0.0083	892.6	396.7	255.0	187.9	148.8	123.1
4200	0.0964	0.0087	937.2	416.5	267.8	197.3	156.2	129.3
4400	0.1010	0.0091	981.8	436.4	280.5	206.7	163.6	135.4
4600	0.1056	0.0095	1,026.4	456.2	293.3	216.1	171.1	141.6
4800	0.1102	0.0099	1,071.1	476.0	306.0	225.5	178.5	147.7
5000	0.1148	0.0103	1,115.7	495.9	318.8	234.9	186.0	153.9
6000	0.1377	0.0124	1,338.8	595.0	382.5	281.9	223.1	184.7
7000	0.1607	0.0145	1,562.0	694.2	446.3	328.8	260.3	215.4
8000	0.1837	0.0165	1,785.1	793.4	510.0	375.8	297.5	246.2
9000	0.2066	0.0186	2,008.3	892.6	573.8	422.8	334.7	277.0
10000	0.2296	0.0207	2,231.4	991.7	637.5	469.8	371.9	307.8
11000	0.2525	0.0227	2,454.5	1,090.9	701.3	516.7	409.1	338.6
12000	0.2755	0.0248	2,677.7	1,190.1	765.1	563.7	446.3	369.3
13000	0.2984	0.0269	2,900.8	1,289.3	828.8	610.7	483.5	400.1
14000	0.3214	0.0289	3,124.0	1,388.4	892.6	657.6	520.7	430.9
15000	0.3444	0.0310	3,347.1	1,487.6	956.3	704.6	557.9	461.7
16000	0.3673	0.0331	3,570.2	1,586.8	1,020.1	751.6	595.0	492.4
17000	0.3903	0.0351	3,793.4	1,686.0	1,083.8	798.6	632.2	523.2
18000	0.4132	0.0372	4,016.5	1,785.1	1,147.6	845.6	669.4	554.0
19000	0.4362	0.0393	4,239.7	1,884.3	1,211.3	892.6	706.6	584.8
20000	0.4591	0.0413	4,462.8	1,983.5	1,275.1	939.5	743.8	615.6

Swales sized based upon I= 0.1 inches/hour and a max I = 2.0 inches/hour without testing.

Drywells sized using the ITD Zone C curve and Rational Method.

Stormwater Management Calculations
City of Post Falls
Bowstring Method - FLUSH MOUNT

Project Name	***EXAMPLE #3***
Date	***December 9, 2005***
Prepared By	***CITY OF POST FALLS***
Basin	**Parking 1**
Time Increment (min)	5
Time of Concentration, t_c (min)	5.00
Outflow (cfs)	0.3
Design Year (year)	25
Impervious Area, A_{imp} (ft^2)	2774
Area (ft^2)	6950
Area (acres)	0.16
Developed "C" Factor	0.72
Area x "C"	0.11

#1 Time Inc. (min)	#2 Time Inc. (sec) (#1 * 60)	#3 Intensity (in / hr) (see below)	#4 Q_{dev} (cfs) (A * C * #3)	#5 V_{in} (ft^3) (see below)	#6 V_{out} (ft^3) (Outflow * #2)	#7 Storage (ft^3) (#5 - #6)
5	300	2.80	0.32	129	90	39
10	600	2.10	0.24	169	180	0
15	900	1.70	0.20	196	270	0
20	1200	1.60	0.18	239	360	0
25	1500	1.40	0.16	258	450	0
30	1800	1.20	0.14	262	540	0
35	2100	1.10	0.13	278	630	0
40	2400	0.95	0.11	273	720	0
45	2700	0.90	0.10	290	810	0
50	3000	0.87	0.10	310	900	0
55	3300	0.85	0.10	332	990	0
60	3600	0.78	0.09	332	1080	0
65	3900	0.75	0.09	345	1170	0
70	4200	0.70	0.08	346	1260	0
75	4500	0.69	0.08	365	1350	0
80	4800	0.67	0.08	377	1440	0
85	5100	0.65	0.07	388	1530	0
90	5400	0.63	0.07	398	1620	0
95	5700	0.60	0.07	400	1710	0
100	6000	0.59	0.07	413	1800	0
105	6300	0.58	0.07	426	1890	0
110	6600	0.55	0.06	423	1980	0
115	6900	0.52	0.06	418	2070	0
120	7200	0.5	0.06	419	2160	0

#3 Intensities from Zone - C Intensity - Duration - Frequency Curve

#5 $V_{in} = 1.34 * Q_{dev} * t$ for $t \leq t_c$ **OR** $V_{in} = (Q_{dev} * t) + (.34 * Q_{dev} * t_c)$ for $t > t_c$

Stormwater Management Calculations
City of Post Falls

Project Name	EXAMPLE #3
Date	12/9/2005
Prepared By	CITY OF POST FALLS
Basin	**Parking 1**

Pre-Developed Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Grass	6950	0.16	50	0.15
Gravel	0	0.00	76	0.55
Pavement	0	0.00	98	0.90
Trees/Brush	0	0.00	55	0.50
Totals	6950	0.16	50	0.15

Post-Development Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Pavement/Concrete	2774	0.06	98	0.90
House	0	0.00	98	0.90
Grass/Lawn	4176	0.10	60	0.60
Trees/Brush	0	0.00	55	0.50
Totals	6950	0.16	75	0.72

Pre-Developed Flow (cfs)	0.07
Post-Developed Flow (cfs)	0.32

Flush Mount Design

Treatment Area (ft^2)	
Required Treatment Area From Flush Mount Table	Provided Treatment Area
130.3	140

25 year design (Bowstring)

Max Storage Required (ft^3)	39	
Max Storage Provided (ft^3)	70	
Number of Drywells Required	0	Double Depth
	1	Single Depth

Time of Concentration

$tc = C_t (Ln / S^{1/2})^{0.6}$

Natural Drainage

L is Length

n is the friction factor of the ground surface

S is the slope

Ct =	0.15
L =	25
n =	0.4
S =	0.005
Time of Concentration, tc =	**2.93**

Stormwater Management Calculations
City of Post Falls
Bowstring Method - FLUSH MOUNT

Project Name	***EXAMPLE #3***
Date	***December 9, 2005***
Prepared By	***CITY OF POST FALLS***
Basin	**Parking 2**
Time Increment (min)	5
Time of Concentration, t_c (min)	5.00
Outflow (cfs)	0.3
Design Year (year)	25
Impervious Area, A_{imp} (ft^2)	2774
Area (ft^2)	6950
Area (acres)	0.16
Developed "C" Factor	0.72
Area x "C"	0.11

#1 Time Inc. (min)	#2 Time Inc. (sec) (#1 * 60)	#3 Intensity (in / hr) (see below)	#4 Q_{dev} (cfs) (A * C * #3)	#5 V_{in} (ft^3) (see below)	#6 V_{out} (ft^3) (Outflow * #2)	#7 Storage (ft^3) (#5 - #6)
5	300	2.80	0.32	129	90	39
10	600	2.10	0.24	169	180	0
15	900	1.70	0.20	196	270	0
20	1200	1.60	0.18	239	360	0
25	1500	1.40	0.16	258	450	0
30	1800	1.20	0.14	262	540	0
35	2100	1.10	0.13	278	630	0
40	2400	0.95	0.11	273	720	0
45	2700	0.90	0.10	290	810	0
50	3000	0.87	0.10	310	900	0
55	3300	0.85	0.10	332	990	0
60	3600	0.78	0.09	332	1080	0
65	3900	0.75	0.09	345	1170	0
70	4200	0.70	0.08	346	1260	0
75	4500	0.69	0.08	365	1350	0
80	4800	0.67	0.08	377	1440	0
85	5100	0.65	0.07	388	1530	0
90	5400	0.63	0.07	398	1620	0
95	5700	0.60	0.07	400	1710	0
100	6000	0.59	0.07	413	1800	0
105	6300	0.58	0.07	426	1890	0
110	6600	0.55	0.06	423	1980	0
115	6900	0.52	0.06	418	2070	0
120	7200	0.5	0.06	419	2160	0

#3 Intensities from Zone - C Intensity - Duration - Frequency Curve

#5 $V_{in} = 1.34 * Q_{dev} * t$ for $t \leq t_c$ OR $V_{in} = (Q_{dev} * t) + (.34 * Q_{dev} * t_c)$ for $t > t_c$

Stormwater Management Calculations
City of Post Falls

Project Name	EXAMPLE #3
Date	12/9/2005
Prepared By	CITY OF POST FALLS
Basin	**Parking 2**

Pre-Developed Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Grass	6950	0.16	50	0.15
Gravel	0	0.00	76	0.55
Pavement	0	0.00	98	0.90
Trees/Brush	0	0.00	55	0.50
Totals	6950	0.16	50	0.15

Post-Development Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Pavement/Concrete	2774	0.06	98	0.90
House	0	0.00	98	0.90
Grass/Lawn	4176	0.10	60	0.60
Trees/Brush	0	0.00	55	0.50
Totals	6950	0.16	75	0.72

Pre-Developed Flow (cfs)	0.07
Post-Developed Flow (cfs)	0.32

Flush Mount Design

Treatment Area (ft^2)	
Required Treatment Area From Flush Mount Table	Provided Treatment Area
130.3	140

25 year design (Bowstring)

Max Storage Required (ft^3)	39	
Max Storage Provided (ft^3)	70	
Number of Drywells Required	0	Double Depth
	1	Single Depth

Time of Concentration

$tc = C_t (Ln / S^{1/2})^{0.8}$

Natural Drainage

L is Length

n is the friction factor of the ground surface

S is the slope

Ct =	0.15
L =	25
n =	0.4
S =	0.005
Time of Concentration, tc =	**2.93**

Stormwater Management Calculations
City of Post Falls
Bowstring Method - FLUSH MOUNT

Project Name	***EXAMPLE #3***
Date	***December 9, 2005***
Prepared By	***CITY OF POST FALLS***
Basin	**Roof**
Time Increment (min)	5
Time of Concentration, t_c (min)	5.00
Outflow (cfs)	0.3
Design Year (year)	25
Impervious Area, A_{imp} (ft^2)	3600
Area (ft^2)	3600
Area (acres)	0.08
Developed "C" Factor	0.90
Area x "C"	0.07

#1 Time Inc. (min)	#2 Time Inc. (sec) (#1 * 60)	#3 Intensity (in / hr) (see below)	#4 Q_{dev} (cfs) (A * C * #3)	#5 V_{in} (ft^3) (see below)	#6 V_{out} (ft^3) (Outflow * #2)	#7 Storage (ft^3) (#5 - #6)
5	300	2.80	0.21	84	90	0
10	600	2.10	0.16	110	180	0
15	900	1.70	0.13	127	270	0
20	1200	1.60	0.12	155	360	0
25	1500	1.40	0.10	167	450	0
30	1800	1.20	0.09	170	540	0
35	2100	1.10	0.08	180	630	0
40	2400	0.95	0.07	177	720	0
45	2700	0.90	0.07	188	810	0
50	3000	0.87	0.06	201	900	0
55	3300	0.85	0.06	215	990	0
60	3600	0.78	0.06	215	1080	0
65	3900	0.75	0.06	223	1170	0
70	4200	0.70	0.05	224	1260	0
75	4500	0.69	0.05	236	1350	0
80	4800	0.67	0.05	244	1440	0
85	5100	0.65	0.05	252	1530	0
90	5400	0.63	0.05	258	1620	0
95	5700	0.60	0.04	259	1710	0
100	6000	0.59	0.04	268	1800	0
105	6300	0.58	0.04	276	1890	0
110	6600	0.55	0.04	274	1980	0
115	6900	0.52	0.04	271	2070	0
120	7200	0.5	0.04	272	2160	0

#3 Intensities from Zone - C Intensity - Duration - Frequency Curve

#5 $V_{in} = 1.34 * Q_{dev} * t$ for $t \leq t_c$ **OR** $V_{in} = (Q_{dev} * t) + (.34 * Q_{dev} * t_c)$ for $t > t_c$

Stormwater Management Calculations
City of Post Falls

Project Name	EXAMPLE #3
Date	12/9/2005
Prepared By	CITY OF POST FALLS
Basin	**Roof**

Pre-Developed Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Grass	3600	0.08	50	0.15
Gravel	0	0.00	76	0.55
Pavement	0	0.00	98	0.90
Trees/Brush	0	0.00	55	0.50
Totals	3600	0.08	50	0.15

Post-Development Conditions

Description	Area (ft^2)	Area (acres)	CN	Runoff Coefficients
Pavement/Concrete	0	0.00	98	0.90
House	3600	0.08	98	0.90
Grass/Lawn	0	0.00	60	0.60
Trees/Brush	0	0.00	55	0.50
Totals	3600	0.08	98	0.90

Pre-Developed Flow (cfs)	0.03
Post-Developed Flow (cfs)	0.21

Flush Mount Design

Treatment Area (ft^2)	
Required Treatment Area From Flush Mount Table	Provided Treatment Area
0.0	0

25 year design (Bowstring)

Max Storage Required (ft^3)	0	
Max Storage Provided (ft^3)	0	
Number of Drywells Required	0	Double Depth
	1	Single Depth

Time of Concentration

$tc = C_t (Ln / S^{1/2})^{0.6}$

Natural Drainage	Ct =	0
	L =	0
L is Length	n =	0
n is the friction factor of the ground surface	S =	0.005
S is the slope	**Time of Concentration, tc =**	**0.00**