Drainage Guidelines for Residential Developments
Stormwater Detention
City of Redwood City
Engineering Division

General Requirements
A. A Grading and Drainage Plan must be submitted with Building Permit applications for all new single family residences and additions associated with single family residences. This plan shall be a separate sheet included with the Building Permit submittal and must be prepared by a qualified licensed engineer (or architect when allowed by City Engineer) and be signed by the same.

B. New single family residences are required to implement permanent stormwater quality control measures per the GI Development Guidelines. All projects shall provide site design measures where practical. Acceptable site design measures include measures a-f on Attachment R2.

C. The goal of the drainage design is to maintain post-development storm water runoff to pre-development runoff conditions, especially when existing drainage flows onto neighboring properties. (Roof Drains to pervious areas, vegetative filters, grassed swales and infiltrative landscaping)

D. Use Post-Construction, Best Management Practices (BMP’s) with the best technology available as appropriate to control runoff. (See “Blueprint for a Clean Bay”)

E. Designers are encouraged to use porous paving systems for driveways, walkways, and patios to reduce the effect of contaminant runoff.

F. The use of dry wells is not allowed in the City of Redwood City.

G. The use of curb drains is not allowed in the design of plot and finished grading plan.

Design Criteria
A. Refer to Part II of the Engineering Standards Design Criteria for requirements of a plot and finished grading plan.

B. If fill is to be added adjacent to the property lines, grades on neighboring properties will need to be obtained to document any potential impacts to these properties. Site grading shall not impede existing drainage from adjacent properties.

C. Design the drainage for sheet flow to lawn or pervious landscaped areas of the site, in lieu of area drains and pipe collection systems, wherever possible without creating unintended ponding and erosion.

D. Show where the roof downspouts are located. These downspouts should direct to approved splash blocks (minimum 2 feet long) that deflect the water away from the building. Show (with arrows) how the water is proposed to move away from the splash blocks.

E. If a basement is proposed for the project, a drainage plan for a separate subgrade drainage system must be included in this plan. This should also include the method of outlet, and is not to connect sub drain to surface storm drain piping.

F. Sites which slope away from the street require special design considerations. It is recommended that the designer schedule a pre-design meeting with the City’s engineering staff prior to submitting the plans for review.

G. For sites that require a separate grading permit, an erosion control plan is required.

H. See Sample Calculation on Sheet 2 and 3, and Attached Design Concepts 1-4.
SAMPLE LOT DRAINAGE CALCULATION FOR STORMWATER RUN-OFF CONTROL

Notes:

1. Runoff Control - To the extent practicable, maintain post-development peak runoff rate and average volume of runoff at levels that are similar to pre-development levels. The developer must design the proposed project accordingly.

2. Design for 10-year storm event: for most residential lots less than 10,000 square feet, use \( i = 1.75 \text{in/hr} \) for a rain duration of about 10 minutes, which corresponds to a time of concentration \( (t_c) \) of about 10 minutes.

3. Detention volume is designed based on a modified hydrograph with a rain duration of \( 3 \times t_c \), which equals to about 30 minutes.

4. Pump may be used as required with discharge at pre-development rate

5. Use a value of \( K = 0.6 \) for orifice diameters from 1.5" to 4" and with a storage pipe diameter of 10" to 24". Use \( K = 0.7 \) if storage diameter < 10".

6. Use runoff coefficients as follows: Use \( C = 0.30 \) for dirt and lawn. Use \( C = 0.95 \) for roof

7. When calculating discharge through a grassed swale/lawn area prior to entering an inlet/filter basin, if lawn area is \( \geq 2 \times \) roof run-off area, \( "C" \) of 0.75 can be used instead of 0.95 for step 2 regarding roof run-off.

8. Run-off toward the front of the house can use depressed lawn area for filtration/detention in-lieu-of gravel beds.

9. Storage pipe material shall be PVC, DR rating of 26; and pipe shall have 0.5’ minimum cover. Minimum pipe size is 4” with a minimum slope of 0.005.

SF = square feet = \( \text{ft}^2 \)

CF = cubic feet = \( \text{ft}^3 \)

CFS = cubic feet per second = \( \text{ft}^3/\text{s} \)

GPM = gallons per minute

Input values in SHADeD AREAS ONLY

Figure A: Lot With Existing Structure

Figure B: Lot with Existing Structure & New Addition

Step 1: New Additional Impervious Roof Area. \( A_{\text{imp}} = \text{Length} \times \text{Width} \)

Length of New Impervious Area (ft): a) 40

Width of New Impervious Area (ft): b) 50

\( A_{\text{imp}} = 40 \times 50 = 2000 \text{sf} \)

Step 2: The Change in the Run-off Coefficient From New Roof to Existing Lawn. \( \Delta C = |C_{\text{roof}} - C_{\text{dirt}}| \)

Run-off Coefficient for Roof: d) 0.95

Run-off Coefficient for Dirt: e) 0.30

\( \Delta C = 0.95 - 0.30 = 0.65 \)

Step 3: Discharge Rate of Additional Impervious Area. \( \Delta Q = A_{\text{imp}} \times i \times \Delta C \)

Note: \( i = 1.75 \) at \( t_c = 10 \text{ Minutes} \) for a 10 year storm event.

\( \Delta Q = 2000 \times 1 \text{ acre} \times 1.75 \times 0.65 = 0.052 \text{ CFS} \)

or in GPM \( g_1 = 23 \text{ gpm} \)

Step 4: Determine storage/detention volume. \( V = \Delta Q \times 1.5 \times t_c \)

Note: if in CFS must convert \( t_c \) to seconds. However if in GPM, then there is no need for a conversion.

\( V = 0.052 \times 1.5 \times 60 \text{ second} = 47 \text{ CF} \)
**Option 1**: Gravel Bed Method With Filtration as Detention Device. (See Design Guide Sheet 4.)

**Step 5**: Determine required size of gravel bed. \( V_{\text{gravel bed}} = \frac{V}{0.4} \)

- Proposed storage by shallow gravel bed method with 40% of the void accounted for water content, so the required size is:  
  
  \[ h) \frac{47}{[47\text{CF}]} \div 0.4 = j) \frac{118}{[118\text{CF}]} \]

**Step 6**: Estimate Dimensions of Shallow Gravel Bed By Finding Area of Bed. \( V_{\text{gravel bed}} \div 2ft = A_{\text{gravel bed}} \)

- Area of the Gravel Bed: \( j) \frac{118}{[118\text{CF}]} \div 2 = k) \frac{59}{[59\text{SF}]} \) 

Now Select any equivalent dimensions which satisfy the estimated area of 59SF. EXAMPLES: 6' width and 9.83' length. OR 4' width and 14.75' length. OR 3' width and 19.7' length.

**Option 2**: Storage Pipe Method as Filtration and Detention Devices. (See Design Guide Sheet 3.)

**Step 7**: Pipe Storage Length. (Choose size to fit field condition.) Input Trial Diameter in \( l) \)

- Storage Pipe Diameter (inches): \( l) 12 \)

**Step 8**: Calculate Cross Sectional Area of Pipe Using Trial Diameter. \( \text{Cross Section} = \pi \cdot d^2 + 4 + 144in^2/ft^2 \)

\[
3.14159 \times 12 \times 12 \div 4 \div 144 = 0.79 \text{[0.79SF]} 
\]

**Step 9**: Trial Pipe Length. (check size to fit field condition.)

\[ h) \frac{47}{[47\text{CF}]} + m) 0.79 = n) 60 \text{[60 ft]} \]

**Step 10**: A Variable Hydraulic Head = Height Difference From High to Low Point (Discharge Orifice) of Pipe. (Input values in \( o \) and \( p \))

- Highest Pipe Upstream Overflow Elevation: (feet) \( o) 100 \text{[100ft]} \)
- Lowest Pipe Invert Elevation: (feet) \( p) 98 \text{[98ft]} \)

\[ o) \frac{100}{[100\text{ft}]} - p) \frac{98}{[98\text{ft}]} = q) \frac{2}{[2\text{ft}]} \]

**Step 11**: Velocity of Discharge Through the Orifice. 

\[ 2 \times 32.2 \times q) \frac{2}{[2\text{ft}]} = r) 128.8 \text{[128.8]} \]

**Step 12**: Discharge Rate of Pre-Developmental Area. 

\[ Q_{\text{pre}} = A_{\text{imper}} \cdot i \cdot C_{\text{pre}} \]

\[ c) \frac{2000}{[2000\text{SF}]} \times 1 \text{ acre} \times 1.75 \times t) \frac{0.30}{[0.30]} = u) \frac{0.024}{[0.024\text{CFS}]} \]

**Step 13**: Cross Section of Discharge Orifice. (orifice cross section = \( Q_{\text{pre}} + \text{Velocity} \)) (Use restrictor plate (prefer) or small pipe if it does not affect long term maintenance.)

\[ Q_{\text{pre}} + \text{Velocity} \]

**Step 14**: Diameter of Orifice. 

\[ Diameter = \sqrt{\frac{\text{Area}}{\pi}} = x) \frac{0.8}{[0.8\text{inch}]} \] so say approximately \( 1 \text{[1inch]} \)

**Step 15**: Input Trial Length \( L \) (ft) For Design of Weir Overflow Height

\[ y) \frac{2}{[2\text{ft}]} \]

**Step 16**: Weir Overflow Height. \( H = (Q_{\text{post}} + C + L)^{2/3} \) Where \( C = 3 \). Determine \( H \)

\[ g) \frac{0.052}{[0.052\text{CFS}]} + 3 \div y) \frac{2}{[2\text{ft}]} = z) \frac{0.0087}{[0.0087]} \]

**Step 17**: Conclude Calculations for Weir Overflow Height \( H \). \( H = 0.0087^{2/3} \)

\[ z) \frac{0.0087}{[0.0087^{2/3}]} = a_1) \frac{0.042}{[0.042\text{ft}]} \text{ or } \frac{0.508}{[0.508\text{ln}]} \]

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Lot Drainage - Design Concept No. 1

Site slope toward street

- New house or additions -

Q - Total post-development run-off rate from site shall not exceed pre-development rate.

Provide run-off control devices such as storage pipes, restrictor plates, and/or detention basins.

Grading and drainage plan required.

Legend:
- Sheet flow
- Splash block
- Grassed swale

Not to scale.
LOT DRAINAGE - DESIGN CONCEPT NO.2
SITE SLOPE AWAY FROM STREET
- NEW HOUSE OR ADDITIONS -
EXAMPLES OF TYPICAL STORMWATER DETENTION FOR REUSE OR INFILTRATION

SECTION A - A

SECTION B - B

NOTE:
1. PVC DRAINAGE/STORAGE PIPE AND RESTRICTOR PLATE WITH ORIFICE ARE IN ADDITION TO GRASSED SWALE TO CONTROL ADDITIONAL RUN-OFF (DETENTION AND SLOW RELEASE) SIZE SYSTEM FOR 10-YEAR STORM EVENT (SEE CITY DESIGN CRITERIA)
2. PROVIDE DESIGN CONSIDERATION FOR SAFE OVERFLOW DISCHARGE OF A 100-YEAR STORM EVENT.

CITY OF REDWOOD CITY
ENGINEERING AND CONSTRUCTION
EXAMPLES OF TYPICAL STORMWATER DETENTION FOR REUSE OR INFILTRATION

DATE: 11/08/19

DESIGN GUIDE
SHEET 3 OF 4
NOTE: ANY ONE OR A COMBINATION OF THESE METHODS CAN BE USED TO ACCOMMODATE A 10-YEAR STORM EVENT. PROVIDE DESIGN CONSIDERATION FOR SAFE OVERFLOW DISCHARGE OF A 100-YEAR STORM EVENT.