4. **Determine the undeveloped runoff coefficient, $C_u$, using the runoff coefficient curve corresponding to the predominant soil type** in Appendix C of the County of Los Angeles Department of Public Works Hydrology Manual.

$C_u$ = _________

5. **Determine the developed runoff coefficient, $C_d$**

$C_d = (0.9 \times IMP) + [(1.0 - IMP)\ C_u]$

where, $C_d$ = Developed area runoff coefficient
IMP = Percent impervious
$C_u$ = Undeveloped area runoff coefficient

$C_d$ = _________

6. **Calculate the time of concentration, $T_c$**

$$T_c = \frac{0.31L^{0.483}}{(C_d * I_t)^{0.519} * S^{0.135}}$$ , $T_c$ = ________ minutes

7. **Compare the initial $T_c$ assumption with the calculated $T_c$. If the difference is not within 0.5 minutes, use the new $T_c$ value and begin at Step 3 to complete another iteration. If the difference is within 0.5 minutes, round the $T_c$ value to the nearest minute.**

The acceptable $T_c$ range is from 5 to 30 minutes. If a Tc of less than 5 minutes is calculated, use 5 minutes. If a $T_c$ greater than 30 minutes is calculated, the subarea must be divided into two or more subareas.

Acceptable $T_c$ value = _________ minutes

**TABLE FOR ITERATIONS:**

| Iteration No. | Initial $T_c$ (min) | $I_t$ (in/hr) | $C_u$ | $C_d$ | Calculated $T_c$ (min) | Difference (min) |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |

8. **Calculate the peak mitigated flow rate, $Q_{PM}$**

$Q_{PM} = C_d * I_t * A$,  $Q_{PM}$ = _________ cfs

## TABLE 1

## INTENSITY – DURATION DATA FOR 0.75-INCH OF RAINFALL

| Duration, $T_c$ (min) | Rainfall Intensity, $I_t$ (in/hr) |
|---|---|
| 5 | 0.447 |
| 6 | 0.411 |
| 7 | 0.382 |
| 8 | 0.359 |
| 9 | 0.339 |
| 10 | 0.323 |
| 11 | 0.309 |
| 12 | 0.297 |
| 13 | 0.286 |
| 14 | 0.276 |
| 15 | 0.267 |
| 16 | 0.259 |
| 17 | 0.252 |
| 18 | 0.245 |
| 19 | 0.239 |
| 20 | 0.233 |
| 21 | 0.228 |
| 22 | 0.223 |
| 23 | 0.218 |
| 24 | 0.214 |
| 25 | 0.210 |
| 26 | 0.206 |
| 27 | 0.203 |
| 28 | 0.199 |
| 29 | 0.196 |
| 30 | 0.193 |

### PEAK MITIGATED FLOW RATE, $Q_{PM}$, EXAMPLE

Proposed Project Characteristics:

| | |
|---|---|
| Drainage area | ___1.2____ acres |
| Type of development | Commercial_ |
| Predominant soil type # | ___006____ |
| % of project impervious | ___90%___ |

**By trial and error, determine the time of concentration ($T_c$), as shown below:**

**1. Determine subarea boundaries and then calculate flow path length, flow path slope, and area**

L = ___320___ feet
S = __0.035__ feet / feet
A = ___1.2___ acres

2. **Assume an initial value for $T_c$**

   $T_c$ = ___10___ minutes

3. **Using Table 1 on page IV, look up the assumed $T_c$ value and select the corresponding intensity, $I_t$**

   $I_t$ = ___0.323____ in/hr

4. **Using the runoff coefficient curves in Appendix C of the County of Los Angeles Department of Public Works Hydrology Manual, determine the undeveloped runoff coefficient, $C_u$, corresponding to the predominant soil type**

   $C_u$ = ___0.10___

5. **Determine the developed runoff coefficient, $C_d$**

   $C_d = (0.9*IMP) + [(1.0 - IMP)*C_u]$

   where, $C_d$ = Developed area runoff coefficient
   IMP = Percent impervious
   $C_u$ = Undeveloped area runoff coefficient

   $C_d = (0.9*0.9) + [(1.0 - 0.9)*0.1]$ = ___0.82____

6. **Calculate the time of concentration, $T_c$**

   $$T_c = \frac{0.31 * L^{0.483}}{(C_d * I_t)^{0.519} * S^{0.135}} \quad , \quad T_c = \frac{0.31 * (320)^{0.483}}{(0.82 * 0.323)^{0.519} * (0.035)^{0.135}} =$$ ___15.75___ minutes

7. **Compare the initial $T_c$ assumption with the calculated $T_c$. If the difference is not within 0.5 minutes, use the new $T_c$ value and begin at Step 3 to complete another iteration. If the difference is within 0.5 minutes, round the $T_c$ value to the nearest minute.**

   Initial $T_c$ = 10 minutes, Calculated $T_c$ = 15.75 minutes, Difference = 5.75 minutes

   Since the difference is greater than 0.5 minutes, 15.75 minutes is rounded to 16 minutes and used as the new $T_c$ value. Beginning at Step 3, additional iterations are performed until the initial and calculated $T_c$ values are within 0.5 minutes. See results below.

| Iteration No. | Initial $T_c$ (min) | $I_t$ (in/hr) | $C_u$ | $C_d$ | Calculated $T_c$ (min) | Difference (min) |
|---|---|---|---|---|---|---|
| 1 | 10 | 0.323 | 0.10 | 0.82 | 15.75 | 5.75 |
| 2 | 16 | 0.259 | 0.10 | 0.82 | 17.67 | 1.67 |
| 3 | 18 | 0.245 | 0.10 | 0.82 | 18.18 | 0.18 |

   Acceptable $T_c$ value = ___18____ minutes

8. **Calculate the peak mitigated flow rate, $Q_{PM}$**

   $Q_{PM} = C_d * I_t * A$, , $Q_{PM} = 0.82 * 0.245 * 1.2$ = ___0.24___ cfs

# APPENDIX 2

## EXAMPLE BEST MANAGEMENT PRACTICES (BMPs)

The following are examples of BMPs that can be used for minimizing the introduction of pollutants of concern that may result in significant impacts, generated from site runoff to the storm water conveyance system. (See Reference 1: Suggested resources for additional sources of information):

- Provide reduced width sidewalks and incorporate landscaped buffer areas between sidewalks and streets. However, sidewalk widths must still comply with regulations for the Americans with Disabilities Act and other life safety requirements.
- Design residential streets for the minimum required pavement widths needed to comply with all zoning and applicable ordinances to support travel lanes; on-street parking; emergency, maintenance, and service vehicle access; sidewalks; and vegetated open channels.
- Comply with all zoning and applicable ordinances to minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.
- Use permeable materials for private sidewalks, driveways, parking lots, or interior roadway surfaces (examples: hybrid lots, parking groves, permeable overflow parking, etc.).
- Use open space development that incorporates smaller lot sizes.
- Reduce building density.
- Comply with all zoning and applicable ordinances to reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.
- Comply with all zoning and applicable ordinances to reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas.
- Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas, and avoid routing rooftop runoff to the roadway or the stormwater conveyance system.
- Vegetated swales and strips
- Extended/dry detention basins
- Infiltration basin
- Infiltration trenches
- Wet ponds
- Constructed wetlands
- Oil/Water separators
- Catch basin inserts
- Continuous flow deflection/separation systems
- Storm drain inserts
- Media filtration
- Bioretention facility
- Dry-wells
- Cisterns
- Foundation planting
- Catch basin screens
- Normal flow storage/separation systems
- Clarifiers
- Filtration systems
- Primary waste water treatment systems

# APPENDIX 3

RECORDING REQUESTED BY AND MAIL TO:

COUNTY OF LOS ANGELES
DEPARTMENT OF PUBLIC WORKS
BUILDING AND SAFETY DIVISION
900 S. FREMONT AVENUE, 3RD FLOOR
ALHAMBRA, CA 91803-1331

Space above this line is for Recorder's use

# MAINTENANCE COVENANT FOR STANDARD URBAN STORMWATER MITIGATION PLAN (SUSMP) REQUIREMENTS

Pursuant to Section 106.4.3 of the County of Los Angeles Building Code and Title 12, Chapter 12.80 of the Los Angeles County Code relating to the control of pollutants carried by stormwater runoff, structural and/or treatment control Best Management Practices (BMPs) have been installed on the following property:

LEGAL DESCRIPTION

ASSESSOR'S ID #____________________TRACT NO.____________________LOT NO.__________________________

ADDRESS: ____________________________________________________________

____________________________________________________________

REFERENCE

PLAN CHECK NO.: _________________________________ DISTRICT OFFICE NO.: ____________________________

I (we)________________________________________________, hereby certify that I (we) am (are) the legal owner(s) of
(Legal Name of Property Owners)
property indicated above, and as such owners for the mutual benefit of future purchasers, their heirs, successors, and assigns, do hereby fix the following protective conditions to which their property, or portions thereof, shall be held, sold and/or conveyed.

That owner(s) shall maintain the drainage devices such as paved swales, bench drains, inlets, catch basins, downdrains, pipes, and water quality devices on the property indicated above and as shown on plans permitted by the Los Angeles County Department of Public Works and as outlined in the attached "OPERATION AND MAINTENANCE GUIDELINES", in a good and functional condition to safeguard the property owners and adjoining properties from damage and pollution.

That owner(s) shall conduct maintenance inspection of all Structural or Treatment Control BMPs on the property at least once a year and retain proof of the inspection. Said maintenance inspection shall verify the legibility of all required stencils and signs and shall repaint and label as necessary.

That owner(s) shall provide printed educational materials with any sale of the property that provide information on what stormwater management facilities are present, the type(s) and location(s) of maintenance signs that are required, and how the necessary maintenance can be performed.

Owner(s):

By:___________________________________ Date:___________________________________

By:___________________________________ Date:___________________________________

(PLEASE ATTACH NOTARY)

# APPENDIX 2

# TREATMENT CONTROL BMP DETAILS

# Extended Detention Basin



## Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

## Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

## California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

## Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency

## Targeted Constituents

| | Constituent | Effectiveness |
|---|---|---|
| ☑ | Sediment | ▲ |
| ☑ | Nutrients | ● |
| ☑ | Trash | ■ |
| ☑ | Metals | ▲ |
| ☑ | Bacteria | ▲ |
| ☑ | Oil and Grease | ▲ |
| ☑ | Organics | ▲ |

**Legend** *(Removal Effectiveness)*

● Low ■ High

▲ Medium

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relationships resulting from the increase of impervious cover in a watershed.

## Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).
- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.
- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

## Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.
- Outlet designed to discharge the capture volume over a period of hours.
- Length to width ratio of at least 1.5:1 where feasible.
- Basin depths optimally range from 2 to 5 feet.
- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.
- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.
- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

## Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.
- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

## Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

## Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

## Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices

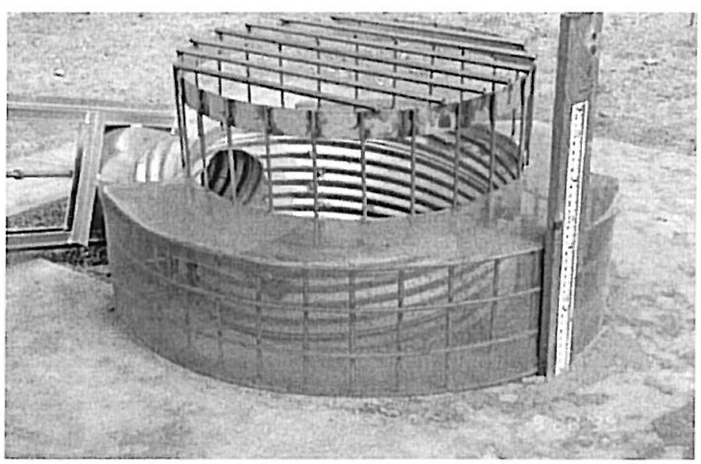

**Figure 1**
**Example of Extended Detention Outlet Structure**

sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

### *Summary of Design Recommendations*

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

(2) Pond Side Slopes - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(3) Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility.

(4) Basin Inlet – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.

(5) Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2g(H-H_o))^{0.5}$$

where: Q = discharge ($ft^3/s$)
C = orifice coefficient
A = area of the orifice ($ft^2$)
g = gravitational constant (32.2)
H = water surface elevation (ft)
$H_o$= orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to $H_o$. When using multiple orifices the discharge from each is summed.

(6) Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.

(8) Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

## Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and re-grade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

## Cost

### *Construction Cost*

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: C = Construction, design, and permitting cost, and
V = Volume ($ft^3$).

Using this equation, typical construction costs are:

$ 41,600 for a 1 acre-foot pond

$ 239,000 for a 10 acre-foot pond

$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about $160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

### *Maintenance Cost*

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

**Table 1 Estimated Average Annual Maintenance Effort**

| Activity | Labor Hours | Equipment & Material ($) | Cost |
|---|---|---|---|
| Inspections | 4 | 7 | 183 |
| Maintenance | 49 | 126 | 2282 |
| Vector Control | 0 | 0 | 0 |
| Administration | 3 | 0 | 132 |
| Materials | - | 535 | 535 |
| **Total** | **56** | **$668** | **$3,132** |

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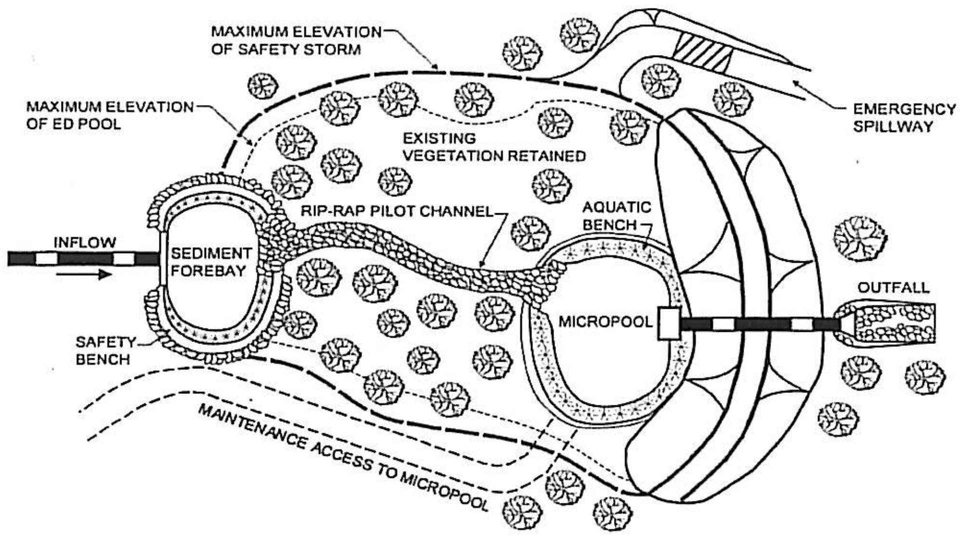
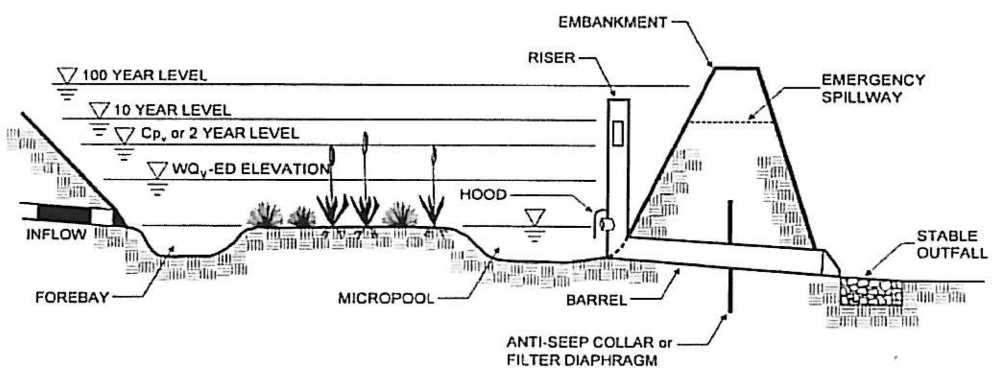



PLAN VIEW




PROFILE

**Schematic of an Extended Detention Basin (MDE, 2000)**

# APPENDIX 3

# VOLUME AND FLOW RATE CALCULATIONS

# LOS ANGELES COUNTY - SAN DIMAS DEVELOPMENT

8/25/2009

## Mitigation Volume Calculation

**$V_M$ = ( 2,722.5 $ft^3$ / acre ) * [ ( $A_I$ )( 0.9 ) + ( $A_P$ + $A_U$ )( $C_U$ ) ]**

| # | Drainage Area | Total Area | % Impervious | $A_I$ (acres) | $C_D$ | $A_P$ (acres) | $A_U$ (acres) | $C_U$ | Conversion Factor | $V_M$ (cubic feet) | $V_M$ (acre-feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | WQ Basin #1 | 54.7 | 30% | 16.41 | 0.900 | 38.29 | 0.00 | 0.1000 | 2722.50 | **50,633** | **1.16** |
| 2 | WQ Basin #2 | 22.86 | 30% | 6.86 | 0.900 | 16.00 | 0.00 | 0.1000 | 2722.50 | **21,160** | **0.49** |
| 3 | WQ Basin #3 | 2.95 | 30% | 0.89 | 0.900 | 2.07 | 0.00 | 0.1000 | 2722.50 | **2,731** | **0.06** |
| 4 | | | 30% | 0.00 | 0.900 | 0.00 | 0.00 | 0.1000 | 2722.50 | **0** | **0.00** |
| 5 | | | 30% | 0.00 | 0.900 | 0.00 | 0.00 | 0.1000 | 2722.50 | **0** | **0.00** |

## Conceptual Water Quality Basin Sizing

| # | Name | Treatment Required ($ft^3$) | Treatment Volume Required (acre-ft) | Sizing Depth (ft) | Original Basin Footprint (SF) | Volume @ 20% Contingency (acre-ft) | Footprint @ 20% Contingency (acres) | Footprint @ 20% Contingency (SF) |
|---|---|---|---|---|---|---|---|---|
| 1 | WQ Basin #1 | 50,633 | 1.16 | 5.0 | **10,127** | 1.4 | 0.3 | **12,152** |
| 2 | WQ Basin #2 | 21,160 | 0.49 | 5.0 | **4,232** | 0.6 | 0.1 | **5,078** |
| 3 | WQ Basin #3 | 2,731 | 0.06 | 2.0 | **1,365** | 0.1 | 0.0 | **1,638** |
| 4 | 0 | 0 | 0.00 | 5.0 | **0** | 0.0 | 0.0 | **0** |
| 5 | 0 | 0 | 0.00 | 5.0 | **0** | 0.0 | 0.0 | **0** |

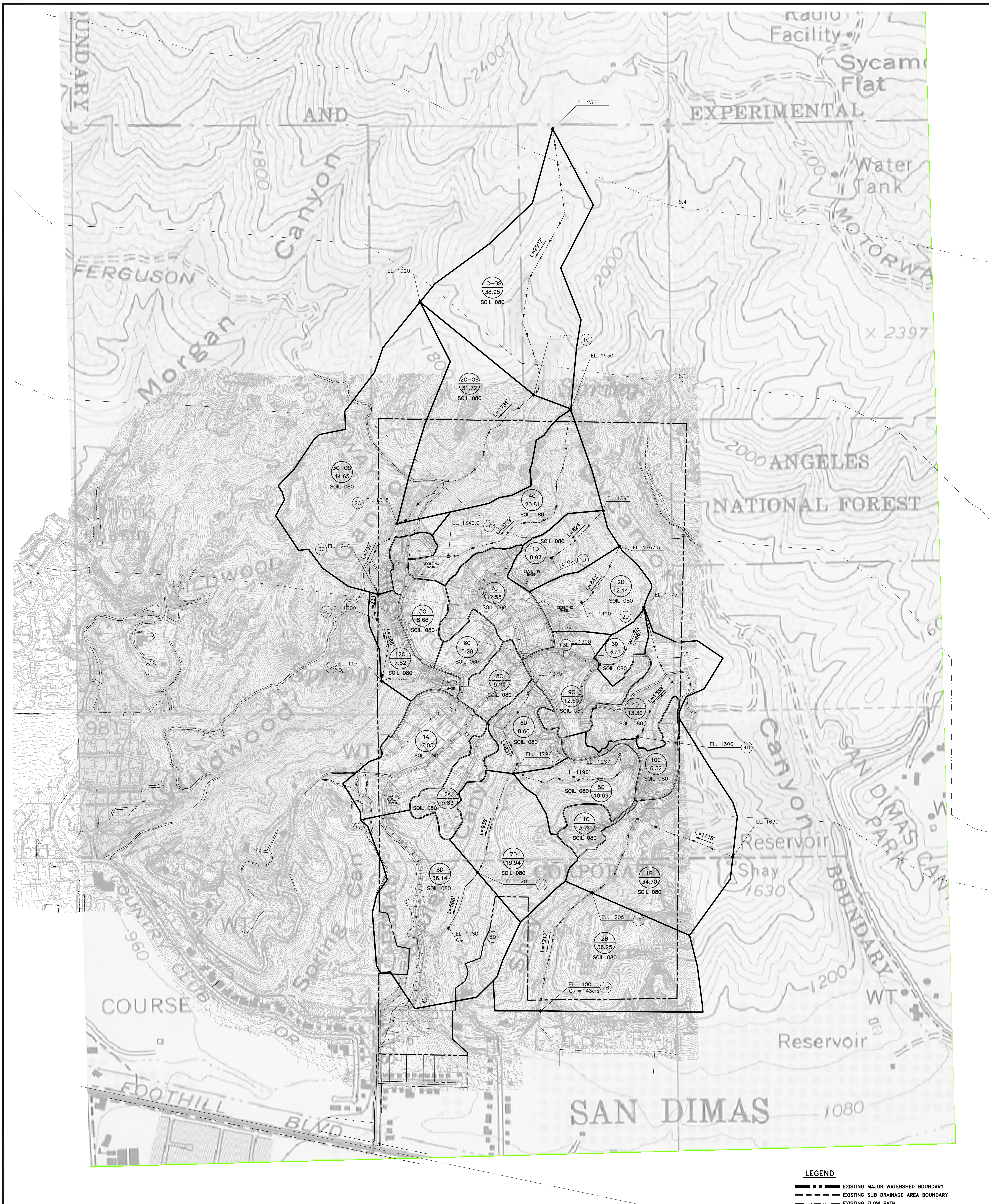
## Mitigation Flow Rate Calculation

**$Q_{PM}$ = $C_D$ * $I_X$ * $A_{Total}$ * (1.008333 $ft^3$-hour / acre-inches-seconds)**

| # | Name | % Impervious | $C_D$ | $I_X$ (in/hr) | $A_{total}$ (acres) | Conversion Factor | $Q_{PM}$ (cfs) |
|---|---|---|---|---|---|---|---|
| 1 | WQ Basin #1 | 30% | 0.340 | 0.20 | 54.70 | 1.008 | **3.75** |
| 2 | WQ Basin #2 | 30% | 0.340 | 0.20 | 22.86 | 1.008 | **1.57** |
| 3 | WQ Basin #3 | 30% | 0.340 | 0.20 | 2.95 | 1.008 | **0.20** |
| 4 | 0 | #DIV/0! | #DIV/0! | 0.20 | 0.00 | 1.008 | **#DIV/0!** |
| 5 | 0 | #DIV/0! | #DIV/0! | 0.20 | 0.00 | 1.008 | **#DIV/0!** |

| Project | Subarea | Area (acres) | %imp | Frequency | Soil Type | Length (ft) | Slope (ft/ft) | Isohyet (in.) | Tc-calculated (min.) | Intensity (in./hr) | Cu | Cd | Flowrate (cfs) | Tc Equation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SD1 | 1A | 28.73 | 0.21 | 50 | 80 | 3176 | 0.1483 | 7.7 | 14 | 2.83 | 0.65 | 0.7 | 57 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 2A | 35.64 | 0.09 | 50 | 80 | 2766 | 0.17028 | 7.7 | 12 | 3.04 | 0.67 | 0.69 | 75 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 3A | 32.38 | 0.01 | 50 | 80 | 1721 | 0.06915 | 7.7 | 11 | 3.17 | 0.68 | 0.68 | 70 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 4A | 34.58 | 0.21 | 50 | 80 | 3602 | 0.07912 | 7.6 | 17 | 2.55 | 0.63 | 0.69 | 61 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 5A | 8.8 | 0.09 | 50 | 80 | 314 | 0.00163 | 7.6 | 7 | 3.87 | 0.72 | 0.74 | 25 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 1B | 34.7 | 0.09 | 50 | 80 | 1718 | 0.24738 | 7.7 | 8 | 3.68 | 0.71 | 0.73 | 93 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 2B | 32.24 | 0.01 | 50 | 80 | 1212 | 0.08663 | 7.55 | 8 | 3.61 | 0.71 | 0.71 | 83 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 1C | 38.95 | 0.01 | 50 | 80 | 2502 | 0.25979 | 8.3 | 10 | 3.58 | 0.71 | 0.71 | 99 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 2C | 31.72 | 0.01 | 50 | 80 | 1778 | 0.22216 | 8.1 | 8 | 3.87 | 0.72 | 0.72 | 88 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 3C | 43.51 | 0.01 | 50 | 80 | 778 | 0.0964 | 8 | 6 | 4.38 | 0.75 | 0.75 | 143 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 4C | 34.72 | 0.21 | 50 | 80 | 3557 | 0.21929 | 8 | 13 | 3.05 | 0.67 | 0.72 | 76 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |
| SD1 | 5C | 41.05 | 0.21 | 50 | 80 | 3526 | 0.17158 | 7.85 | 14 | 2.89 | 0.66 | 0.71 | 84 | Tc=(10)^-0.507*(Cd*I)^-0.519*(L)^0.483*(S)^-0.135 |

| Area (acres) | Intensity (in./hr) | Cd | Q |
|---|---|---|---|
| 28.73 | 2.83 | 0.7 | 57.4 |
| 35.64 | 3.04 | 0.69 | 75.4 |
| 32.38 | 3.17 | 0.68 | 70.4 |
| 34.58 | 2.55 | 0.69 | 61.3 |
| 8.8 | 3.87 | 0.74 | 25.4 |
| 34.7 | 3.68 | 0.73 | 94.0 |
| 32.24 | 3.61 | 0.71 | 83.3 |
| 38.95 | 3.58 | 0.71 | 99.8 |
| 31.72 | 3.87 | 0.72 | 89.1 |
| 43.51 | 4.38 | 0.75 | 144.1 |
| 34.72 | 3.05 | 0.72 | 76.9 |
| 41.05 | 2.89 | 0.71 | 84.9 |




## LEGEND

- EXISTING MAJOR WATERSHED BOUNDARY
- EXISTING SUB DRAINAGE AREA BOUNDARY
- EXISTING FLOW PATH
- DIRECTION OF FLOW
- C17 — DRAINAGE AREA DESIGNATION
- 70.21 — ACRES
- 340 — NODE DESIGNATION
- L=300' — LENGTH OF EXISTING FLOW PATH
- $Q_{50}$ — CALCULATED 50-YEAR STORM RUNOFF

NORTH
SCALE: 1"=300'

FUSCOE ENGINEERING
16795 Von Karman, Suite 100
Irvine, California 92606
tel 949.474.1960 ∘ fax 949.474.5315
www.fuscoe.com

CANYON OAKS
TENTATIVE TRACT
**PROPOSED DRAINAGE HYDROLOGY MAP**

SHEET 1 of 1

P:\PROJECTS\349\04\ENG_FILE CABINET\REPORTS\HYDROLOGY\34904-XH-PROPHYD-61-LOTS.DWG (08-26-09 1:37:58PM) Plotted by: April McMillian

# APPENDIX 4

# STORM WATER OBSERVATION REPORT FORM

# STORMWATER OBSERVATION REPORT FORM

## - STANDARD URBAN STORMWATER MITIGATION PLAN (SUSMP) -
## - SITE SPECIFIC MITIGATION PLAN -

***STORMWATER OBSERVATION means the visual observation of the stormwater related Best Management Practices (BMPs) for conformance with the approved SUSMP/Site Specific Mitigation Plan at significant construction stages and at completion of the project. Stormwater observation does not include or waive the responsibility for the inspections required by Section 108 or other sections of the City of Los Angeles Building Code***.

***STORMWATER OBSERVATION must be performed by the engineer or architect responsible for the approved SUSMP/Site Specific Mitigation Plan or designated staff in their employment.***

***STORMWATER OBSERVATION REPORT must be signed and stamped (see below) by the engineer or architect responsible for the approved SUSMP and submitted to the city <u>prior</u> to the issuance to the certificate of occupancy.***

| | |
|---|---|
| Project Address: | Building Permit No.: |
| Name of Engineer or Architect responsible for the approved SUSMP/Site Specific Mitigation Plan: | Phone Number: |
| Name of SUSMP/Site Specific Mitigation Plan Observer: | Phone Number: |

**I DECLARE THAT THE FOLLOWING STATEMENTS ARE TRUE TO THE BEST OF MY KNOWLEDGE:**

1. I AM THE ENGINEER OR ARCHITECT RESPONSIBLE FOR THE APPROVED SUSMP/SITE SPECIFIC MITIGATION PLAN, AND

2. I, OR DESIGNATEDSTAFF UNDER MY RESPONSIBLECHARGE, HAS PERFORMED THE REQUIRED SITE VISITS AT EACH SIGNIFICANT CONSTRUCTIONSTAGE AND AT COMPLETION TO VERIFY THAT THE BEST MANAGEMENT PRACTICES AS SHOWN ON THE APPROVED PLAN HAVE BEEN CONSTRUCTEDAND INSTALLEDIN ACCORDANCEWITH THE APPROVED SUSMP/SITE SPECIFIC MITIGATION PLAN.

**Stamp of Engineer or Architect responsible for the approved SUSMP**

# APPENDIX 5

# MASTER COVENANT AND AGREEMENT

**RECORDING REQUESTED BY:**
***City of San Dimas***

**WHEN RECORDED MAIL TO:**

***City Clerk***
***City of San Dimas***
***245 East Bonita Avenue***
***San Dimas, CA 91773***

SPACE ABOVE THIS LINE FOR RECORDER'S USE

# MAINTENANCE COVENANT FOR STANDARD URBAN STORMWATER MITIGATION (SUSMP) REQUIREMENTS

Pursuant to Chapter 14.11 of the Municipal Code of **San Dimas** relating to the control of pollutants carried by stormwater runoff, structural and/or treatment control Best Management Practices (BMP's) have been installed on the following property:

LEGAL DESCRIPTION

ASSESSOR'S ID # ____________________TRACT NO.____________________LOT NO. _____________________
ADDRESS: _________________________________________________________________________________
_________________________________________________________________________________

I (we)____________________________________________, hereby certify that I (we) am (are) the legal owner (s) of
(Legal Name of Property Owners)
property indicated above, and as such owners for the mutual benefit of future purchasers, their heirs, successors, and assigns, do hereby fix the following protective conditions to which their property, or portions thereof, shall be held, sold and/or conveyed.

That owner(s) shall maintain the drainage devices such as paved swales, bench drains, inlets, catch basins, downdrains, pipes and water quality devices on the property indicated above and as shown on plans permitted by the City of San Dimas, in a good functional condition to safeguard the property owners and adjoining properties from damage and pollution.

That owner(s) shall conduct maintenance inspection of all Structural or Treatment Control BMP's on the property at least once a year and retain proof of the inspection. Said maintenance inspection shall verify the legibility of all required stencils and signs and shall repaint and label as necessary.

That owner(s) shall provide printed educational materials with any sale of the property which provide information on what stormwater management facilities are present, the type(s) and location(s) of maintenance signs that are required, and how the necessary maintenance can be performed.

Owner(s):

By: _____________________________________ Date:___________________________

By: _____________________________________ Date: ___________________________

(PLEASE ATTACH NOTARY)

# APPENDIX 6

# SAMPLE
# MASTER TERMINATION OF COVENANT AND AGREEMENT

Recording requested by and mail to:

Name: ____________________________________

Address: ____________________________________

____________________________________

____________________________________

************************************************* Space Above This Line For Recorder's Use ******************************************************

**MASTER TERMINATION OF COVENANT AND AGREEMENT**
REGARDING ON-SITE BMP MAINTENANCE

The undersigned hereby certifies I am (we are) the owner(s) of the hereinafter legally described real property located in the City of Los Angeles, County of Los Angeles, State of California (please give the legal description):

______________________________________________________________________________

Site Address ____________________________________________________________________

We do hereby, with approval of the City of Los Angeles, Bureau of Sanitation, terminate the covenant and agreement entered into with the City of Los Angeles as recorded on the ________ day of ________________________ 20 _____, as Document No. ________________________________.

This covenant and agreement is terminated for the reason that:

______________________________________________________________________________

______________________________________________________________________________

__________________________________________ (Print Name of Property Owner)

__________________________________________ (Signature of Property Owner)

__________________________________________ (Print Name of Property Owner)

__________________________________________ (Signature of Property Owner)

Dated this _________ day of ____________ 20____.

Termination approved by: ____________________________________________ (Watershed Protection Division)

Date: _____________________________

****************************************** Space Below This Line For City of Los Angeles Notary's Use ***************************************

ALL-PURPOSE ACKNOWLEDGMENT

STATE OF CALIFORNIA, COUNTY OF LOS ANGELES

On ___________________________ before me, ______________________________________ (name and title of officer), personally appeared ____________________________, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

WITNESS my hand and official seal.

_____________________________________ (SEAL)
Notary Public Signature

# INSTRUCTIONS FOR FILING TERMINATION OF COVENANT AND AGREEMENT FORMS

***Note:*** **This Termination of Covenant & Agreement Form is to be used to terminate existing Covenant & Agreement Forms for *Ministerial and Discretionary Projects*.**

1. Fill out, in BLACK INK ONLY, one copy of the Termination of Covenant and Agreement Form.

2. Property owner(s) must print and sign their name(s).

3. Submit the completed Termination of Covenant & Agreement (C&A) Form to the Watershed Protection Division Bureau of Sanitation for termination approval and signature **– City staff signature must be notarized**.

4. Record the C&A Form with the Los Angeles County Registrar-Recorder and obtain a certified copy. County Recorder located at:

   1) 12400 Imperial Highway
      Norwalk, CA 90650
      (Near the intersection of the 5 and 605 freeways)

   2) 14340 Sylvan Street
      Van Nuys, CA 91401
      (Near Van Nuys City Hall)

5. Return the certified copy of the recorded form to the Watershed Protection Division requiring the covenant (should be a purple stamp on the back of the last document recorded).

# APPENDIX 7

# TREATMENT CONTROL BMP OPERATION & MAINTENANCE PLAN SUPPLEMENT

# Inspection and Maintenance Checklist
# WATER QUALITY / DETENTION BASINS

Date: ____________________ Property: ________________________________

Type of Inspection: ☐ After Storm ☐ Weekly ☐ Monthly ☐ Annual

BMP Location (ID): ________________________________________________

| Part / Location | Conditions When Maintenance is Needed | Problem Observed? | | Comments |
|---|---|---|---|---|
| | | Y | N | |
| Basin floor & side slopes | Trash and debris present; Sediment accumulation is greater than 10%; erosion or damage is present on floor or side slopes; mosquitoes or other vector issues are present | | | |
| Vegetation | Vegetation is overgrown or showing signs of disease; weeds are present; replant as needed | | | |
| Inlet & Outlet Structures | Accumulated sediment, trash or debris; damage to structure is observed; water does not drain within 72 hours | | | |

IF "YES" IS CHECKED ON ANY OF THE ABOVE INSPECTION ITEMS, MAINTENANCE IS REQUIRED

| **Detail of Maintenance Scheduled/Performed:** |
|---|
| |

Inspection performed by:

Name: ________________________________________

Signature: ________________________________________

**Design Considerations**

- Tributary Area
- Area Required
- Hydraulic Head

**Targeted Constituents**

| | | |
|---|---|---|
| ☑ | Sediment | ▲ |
| ☑ | Nutrients | ● |
| ☑ | Trash | ■ |
| ☑ | Metals | ▲ |
| ☑ | Bacteria | ▲ |
| ☑ | Oil and Grease | ▲ |
| ☑ | Organics | ▲ |

**Legend** *(Removal Effectiveness)*

● Low ■ High

▲ Medium

## Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

## California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

## Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

relationships resulting from the increase of impervious cover in a watershed.

## Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).

- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.

- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

## Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.

- Outlet designed to discharge the capture volume over a period of hours.

- Length to width ratio of at least 1.5:1 where feasible.

- Basin depths optimally range from 2 to 5 feet.

- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.

- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.

- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

## Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.

- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

## Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

## Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

## Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices

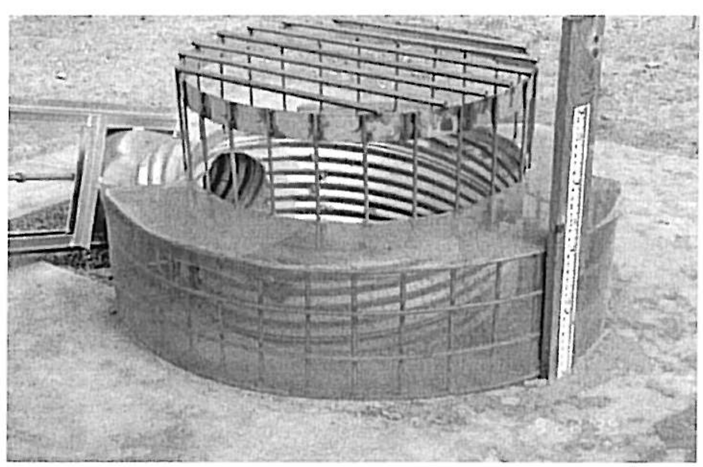


**Figure 1**
**Example of Extended Detention Outlet Structure**

sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

### *Summary of Design Recommendations*

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

(2) Pond Side Slopes - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(3) Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility.

(4) Basin Inlet – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.

(5) Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2g(H-H_o))^{0.5}$$

where:
$Q$ = discharge ($ft^3/s$)
$C$ = orifice coefficient
$A$ = area of the orifice ($ft^2$)
$g$ = gravitational constant (32.2)
$H$ = water surface elevation (ft)
$H_o$= orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to $H_o$. When using multiple orifices the discharge from each is summed.

(6) Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.

(8) Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

## Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and re-grade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

## Cost

### *Construction Cost*

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: $C$ = Construction, design, and permitting cost, and
$V$ = Volume ($ft^3$).

Using this equation, typical construction costs are:

$ 41,600 for a 1 acre-foot pond

$ 239,000 for a 10 acre-foot pond

$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about $160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

### *Maintenance Cost*

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

**Table 1 Estimated Average Annual Maintenance Effort**

| Activity | Labor Hours | Equipment & Material ($) | Cost |
|---|---|---|---|
| Inspections | 4 | 7 | 183 |
| Maintenance | 49 | 126 | 2282 |
| Vector Control | 0 | 0 | 0 |
| Administration | 3 | 0 | 132 |
| Materials | - | 535 | 535 |
| **Total** | **56** | **$668** | **$3,132** |

## References and Sources of Additional Information

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