Residential Developments:
How to Handle Runoff to Protect Water Quality

Water Quality Factsheet for Applicants

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This factsheet is a summary of information compiled by Water Quality Program staff. It is provided to familiarize the public with water quality issues encountered in residential developments. It is not a requirement by the Coastal Commission, and it may be superseded by site-specific information.

Water Quality Issue

Many residential developments, ranging from the construction of a single-family residence (SFR) on an individual lot, to those providing multiple-unit, high-density housing for a large number of people, raise similar challenges for protecting water quality. Water quality impacts from development of residential housing may be divided into temporary impacts that may occur during construction, and long-term, post-development impacts. This factsheet deals with post-development water quality issues. Additional information on water quality topics can be found on the Coastal Commission's Water Quality webpage, at http://www.coastal.ca.gov/water-quality/permits/.

There are two overarching, post-development water quality concerns for all housing projects. First is the potential decrease in infiltration of rainfall resulting from new impermeable surfaces, and second is that pollutants from automobiles, construction materials, landscaping, and household products may be transported by runoff into coastal waters. On undeveloped sites, soils and vegetation do a fair job of detaining or retaining stormwater runoff on-site, and can assimilate most pollutants that may be present in runoff. However, after development, runoff typically increases and carries more pollutants, and the increased volume of runoff can trigger erosion.

The contemporary approach to stormwater management is to design and manage residential development with a focus on limiting the pollutants introduced at a site, preserving the natural hydrology of the site, and where needed, adding features and Best Management Practices (BMPs) that will enhance water retention and filtration. For smaller residential developments, Source Control strategies (i.e., activities and structures to keep pollutants out of runoff) and good Site Design planning (i.e., designs to reduce the generation of runoff) are usually adequate to protect water quality.

As the size and density of residential developments increases, and as more site constraints such as small lot size or poor soil infiltration capacity are encountered, a greater level of site design and engineering is required. Larger sites and constrained sites often need to have Treatment Control Best Management Practices (TBMPs) to remove pollutants from runoff, or may need multiple BMPs to address pollution sources. For example, a busy parking lot may require both permeable pavement and a biofiltration system to treat runoff.

Long-term, post-development water quality protection should be considered early in the development's planning process, and should be central to project design. At a minimum, the project's conceptual approach to water quality protection (i.e., preliminary water quality plan) should be part of the Coastal Development Permit (CDP) proposal, and this can be expanded upon as the application materials are completed. Applicants can expect to submit a final water quality plan, if not already included with the project application, to fulfill a Special Condition required in the CDP. As stipulated in the Coastal Act itself, water quality provisions for the development should fully protect and, where feasible, should restore water quality.

Best Management Practices for Residential Developments

The Coastal Act requires the protection and enhancement of marine and coastal water resources, including water quality. Many residential projects can be fairly benign, and for those developments water quality impacts can be mitigated using basic protection principles. If the project is large, densely developed, in close contact with sensitive resources, or has site constraints, protection of coastal water quality becomes more challenging.

Source Control BMPs

Source Control BMPs are structural features or operational actions that are used to prevent pollutants from entering runoff. Source Control BMPs are of primary importance, and can be effective in protecting water quality in all residential developments.

The main post-development sources of pollutants at residential developments are automobiles, landscaping, materials used in building the development, and household products used by the residents. Source Control BMPs may mitigate some or all of these potential sources of pollution. Examples include using Integrated Pest Management principles (see UC Statewide Integrated Pest Management Program, http://www.ipm.ucdavis.edu/), landscaping with drought-tolerant plants, avoiding fertilizers and pesticides, and using efficient irrigation practices that minimize dry-weather runoff.

Source Control BMPs for parking lots in residential subdivisions typically stipulate that regular maintenance is conducted, such as trash removal and vacuum-sweeping, to remove sediment and other pollutants. Other Source Control BMPs may prohibit the use of copper roof gutters (which are a source of toxic metals in runoff), or may require that trash receptacles be designed to withstand rain and wind.

Many potential residential pollutant sources can be controlled using education and guidance, with a sprinkling of community rules and signage. Requiring "No dumping, flows to the ocean" signs on storm drain inlets is another example of Source Control BMPs. These signs are reminders that we, with our actions, are the ultimate source control that can keep pollutants out of runoff. Just by being aware of potential pollutants, and the pathways by which pollutants may end up in runoff, residents may effectively avoid potential water quality problems in everyday behavior. Examples include not washing your car in the driveway, and picking up after your pets.

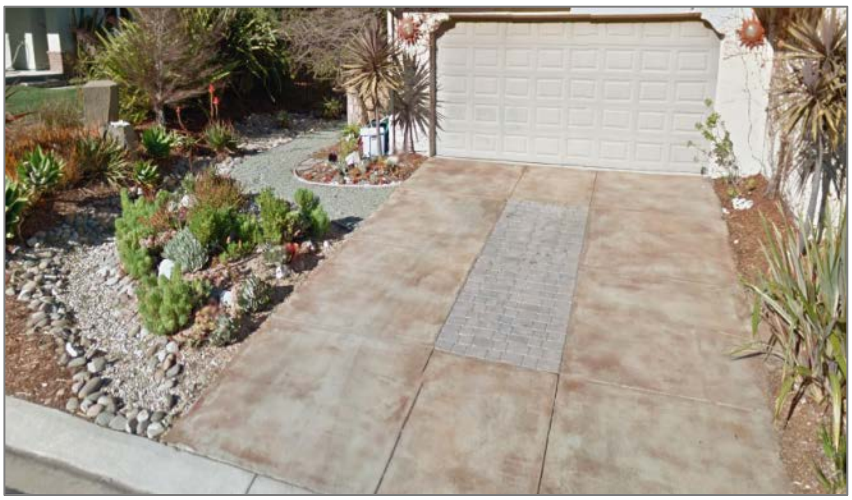
Infiltration

Infiltration is nature's way of dealing with both runoff volumes and pollutants. Over most landscapes, infiltrating the runoff from the most frequently occurring, smaller storm events (e.g., up to the 85th or 95th percentile storm events) and dry-weather runoff (e.g., excess irrigation water and other site-generated runoff that picks up pollutants) has the greatest benefit to water quality. The reason infiltration is effective is twofold. First, soils and vegetation act as natural filters to remove pollutants. And second, soaking rainfall into the ground regulates the volume and velocity of runoff from the site.

Almost all sites have physical properties that will allow some level of infiltration to occur, and methods can be used to improve the infiltration capacity of a site with inherently poor infiltration. For example, soil mulches can be imported to the site and mixed with the native soils to enhance infiltration and provide retention of runoff. Even where space is restricted, deep trenches, or subsurface vaults or reservoirs, can be used to help infiltrate runoff. Prioritizing site design options that minimize additions of impervious surface and provide for maximum infiltration makes good water quality sense.

Treatment Control BMPs

When infiltration is not adequate to treat runoff, a more aggressive solution must be considered. Treatment Control BMPs are structural features designed to remove pollutants from runoff. Typically, Treatment Control BMPs are sized to a numerical standard. The standard used most frequently in designing Treatment Control BMPs is known as the 85th percentile storm event, which means that, based on long-term historical records, 85% of storms are this size or smaller.



Decomposed granite, permeable pavements, and dry swales compliment the drought-resistant landscaping (with minimal chemical maintenance required) at this SFR.

These more frequent, smaller rainfall events tend to mobilize the most pollutants, so treating the runoff from these smaller storms effectively protects water quality.

This numerical standard is sometimes called the water quality volume or water quality flow, depending on whether the BMP infiltrates runoff, or passes runoff through and then discharges it, respectively.

Hydromodification

Runoff increases with the addition of impermeable surfaces (e.g., buildings, driveways, patios, or other hard surfaces), altering a site's pre-development runoff flow regime (i.e., runoff volume, flow rate, timing, and duration), which is known as hydromodification. It is estimated that runoff from as little as three to five percent added impervious area can imbalance the equilibrium of stream channels in a watershed. Minimizing the addition of impervious surface and maximizing on-site infiltration in the site design will contribute both to removing pollutants and minimizing increases in runoff.

Runoff Controls

Runoff Controls, which address post-development increases in runoff peaks, may be needed for developments that add a significant area of impervious surface (i.e., a net total of more than 22,500 square feet impervious surfaces). Runoff Controls detain or retain additional runoff resulting from development that has not been fully mitigated by infiltration or Treatment Control BMPs. The numerical design standard for a Runoff Control is based on the 2-year to 10-year recurrence storm events (which are larger than the 85th percentile design standard storms). Storms that exceed the Runoff Control design requirement tend to overwhelm the site's capacity to infiltrate runoff, so that any impervious area added does not change the post-development runoff peaks for storm events that exceed the 10-year recurrence interval.

Low Impact Development

Low Impact Development (LID) is a water quality protection approach that uses Source Control BMPs, infiltration, Treatment Control BMPs, and other principles to manage runoff close to its source, focusing on small-scale integrated site design and management practices. LID is well-suited to residential development, since it focuses on preserving or replicating a site's natural hydrologic balance to protect water quality, using infiltration, evapotranspiration, filtration, detention, and retention of runoff.

Infiltration, evapotranspiration, filtration, detention, and retention of runoff are key LID concepts.

Practices for Small or Moderately-Sized Single-Family Residences

Water quality protection for a small or moderately-sized SFR (i.e., with a footprint of 15,000 square feet or less) can normally be addressed with early Site Design planning using LID practices, including:

- Minimizing disturbance of coastal waters and natural drainage patterns.
- Minimizing impervious surfaces by concentrating development on portions of the site to avoid disturbance of coastal waters and highly permeable soils, while leaving the remaining land in a natural, undisturbed state.
- Limiting clearing and grading of native vegetation to the minimum area needed to build the project, allow access, and provide fire protection.
- Minimizing compaction of highly permeable soil.
- Minimizing site runoff.

Using strips of permeable pavers to intercept runoff from large expanses of impervious surfaces disconnects these surfaces from the storm drain system.

Using permeable concrete for gutters, sharing driveways, and minimizing street dimensions all decrease the impervious surface area in housing developments.

Infiltration-based LID practices can be effective for water quality protection of a single-family residence, and ideally should be required where feasible. These practices include:

Install rain gardens and dry swales, and augment soils, to enhance infiltration, disperse flows, and detain runoff at low-permeability sites.

- Directing roof runoff onto vegetated areas safely away from building foundations and footings, consistent with the California building code.
- Directing runoff from sidewalks, walkways, and/or patios onto vegetated areas safely away from building foundations and footings, consistent with the California building code.
- Directing runoff from driveways and/or uncovered parking lots onto vegetated areas safely away from building foundations and footings, consistent with the California building code.
- Constructing driveways, low-traffic areas, uncovered parking lots, walkways, and patios with permeable surfaces.
- Disconnecting impervious surface areas from the storm drain system, by interposing distributed pervious surface areas.
- Using drought-tolerant vegetation, integrated pest management, and efficient irrigation, to reduce the generation of runoff and pollutants.

Where infiltration is not appropriate or feasible, including areas where the infiltration rate is moderate or moderately low, the following alternative LID practices can be considered:

- Maximizing infiltration to the extent possible for the specific property.
- Directing roof runoff into rain barrels or cisterns for later use.
- Evaporating roof runoff.
- Installing a rain garden "green roof."
- Constructing a rain garden.
- Planting trees.

Post-Development Runoff Plan for Single-Family Residences

A Post-Development Runoff Plan (PDRP) must be submitted to document the water quality planning for SFRs. The PDRP must record all of the site planning and decisions, and must include a site map showing drainage and water quality features, such as impervious surfaces, areas used to infiltrate runoff, and BMPs. If Treatment Control BMPs are needed, a numerical standard must be used in their design, and the criteria used to size these BMPs must be documented.

Practices for Large Single-Family Residences, Multiple-Dwelling Units, or Residential Subdivisions

A greater level of design and engineering work can improve water quality conditions significantly, and the larger scale of the project warrants professional guidance. This design work is required to be documented by a licensed professional.

Also, the increasing density of the development and the additional impervious surfaces call for more precise water quality planning. At this level of development, infiltration and Treatment Control BMPs must be more closely matched to rainfall to get the best result. For Multiple Dwelling Units (MDUs) and small residential subdivisions, numerical sizing standards and treatment objectives should be set for structural Treatment Control BMPs and for retaining increased post-development runoff. Numerical sizing standards and treatment objectives are generally not needed for SFRs unless they are site-constrained (e.g., geologically unstable or space-limited), or are very large.

As the number and density of houses increases, the measures to protect water quality must keep pace. Rigorous Site Design planning can allow for more inclusive use of the land. Homes may be clustered, sensitive land areas with wetlands and highly permeable soils set aside, grading and soil compaction minimized, and open infiltration spaces and Treatment Control BMPs may be shared by the community.

Shared Treatment Control BMPs can be used in planned open space areas in multiple-dwelling unit developments and residential subdivisions.

Addressing stormwater management in the design of streets, sidewalks, and landscaped areas also opens the door to communal water quality treatment. Neighborhood-shared infiltration areas, permeable pavements in sidewalk and street design, and shared Treatment Control BMPs make sense for a residential subdivision or MDU. For example, a space-constrained site may share the cost of a Centrifugal Deflection Separator (CDS) unit among the community and make this option affordable.

The use of overlapping BMP designs is a good option for a large residential development. One possibility is using LID at each house or MDU, then layering on [Green Streets](http://www.lowimpactdevelopment.org/greenstreets/) practices (see LID Center, http://www.lowimpactdevelopment.org/greenstreets/) for community roads and sidewalks, and adding a pre-treatment wetland that doubles as a runoff control.

Residential subdivisions and MDUs differ from SFRs in that water quality responsibilities for the property are shared by several unrelated individuals. Generally there are community rules that are documented and must be followed. Source Control BMPs for street sweeping and trash pickup in communal areas such as visitor parking, for landscaping requirements, and for restrictions on the types of building materials that could introduce pollutants, should be covered in the governing guidelines for community planning and maintenance (e.g., Homeowner's Association requirements).

Site Constraints in Residential Developments

There are a number of constraining factors that complicate the perfect water quality protection scenario. Most common are poor soil infiltration characteristics, space constraints, and slope stability issues. It is not unusual that more than one constraint could be present on a single site.

Poor Infiltration

Perhaps the foremost site constraint is where site soils have *poor infiltration* and are not able to infiltrate the design storm runoff. However, most sites have physical properties that will allow some level of infiltration to occur, and there are ways to improve infiltration on a site with poor infiltration. For example, soil mulches can be imported and mixed with the on-site soils to enhance infiltration and provide greater retention of runoff.

An SFR can also use an earthen-based structural feature such a graded swale to augment the ability of the site's vegetated areas and open space to capture and infiltrate runoff. For an SFR, these measures typically are not designed to a numerical standard, but will function in the same way as a Treatment Control BMP to detain or retain runoff, and enhance infiltration.

The preferred technique for poor infiltration sites is to use Low Impact Development techniques to the extent feasible. LID alternatives to infiltration include retaining site runoff using evapotranspiration, or capturing stormwater for later use. For example, planting trees can enhance transpiration, as can preserving the site's vegetation, or a rain garden can be used to improve a site's evapotranspiration rate. Rain barrels or a cistern can be used to store roof runoff for irrigation in dry periods.

If infiltration can't be used to address polluted runoff, Treatment Control BMPs must be designed as flow-based BMPs. A flow-based BMP uses a numerical standard (inches per hour plus a factor of safety) to size the BMP, so that adequate residence time is provided for assimilating pollutants in the BMP prior to exiting. The preferred flow-through Treatment Control BMPs are earthen-based, such as a bioswale, and are usually designed using engineered soils and a sub-drain.

Even though there is a very high rate of percolation in sandy soils, runoff from sites with sandy soils may need to be pre-treated prior to infiltration, because sandy soils are less able to filter out pollutants. Pre-treatment prior to infiltration is typically also required where there are high-use parking areas associated with automobile-related pollutants, where the distance to groundwater in the sand substrate is minimal, or where the site is close to coastal waters.

Space-Constrained

In a *space-constrained SFR*, the building footprint typically is defined by setbacks required by the local building code, which may not leave much space for BMPs. The obvious solution is to plan for a smaller building footprint, but creative solutions often come into play in order to optimize the size of the residence. In space-constrained sites, deep trenches or vaults can help infiltrate runoff. Also, parking areas and patios can be constructed using a reservoir-substrate with a permeable pavement overlay, which double as a water quality BMP. A roof can become a rain garden "green roof."

In a *space-constrained residential subdivision or MDU*, housing units are tightly spaced, but there are usually common areas that are suitable for infiltration or Treatment Control BMPs. In a residential subdivision, there may be some flexibility to reduce the number of housing units and dedicate communal areas within the development for water quality purposes. Also limiting the number, width, and length of roadways and driveways to the minimum required for public safety is a good option.

Poor Infiltration and Also Space-Constrained

Where a *poor infiltration site is also space-constrained*, a manufactured proprietary device, such as a media filter system, can be used instead of an earthen-based Treatment Control BMP. This system is designed as a flow-based BMP. Although popular in densely populated areas, proprietary devices require aggressive maintenance to keep the system running properly, including periodic media replacement, typically twice per year.

Use proprietary pollution control devices where site constraints limit options, and where the cost is feasible.

Slope Stability-Constrained

Another constraining site factor is *slope stability*, which may be especially relevant when evaluating *bluff-top* sites. Adding weight to the slope by infiltrating runoff may further destabilize a slope assessed with a marginal factor of safety. Even though the site soils may be capable of infiltration, the stability issue may trump the water quality benefit of infiltration.

However, it should not be presumed that bluff-top sites can't infiltrate some portion of the site's runoff onto some part of the site. An example is that a driveway could be constructed on the landward side of the residence using permeable pavement. Infiltration of rainfall, as opposed to infiltration of concentrated runoff collected from an impervious surface, is also often acceptable, even at a slope stability-constrained site. Options for infiltration should be assessed on a site-by-site basis, and often require input from a geotechnical engineer.

Where it is determined that infiltration should not occur on a site, runoff from roof-tops, patios, driveways, and other hard surfaces may be directed to flow-through Treatment Control BMPs before being directed off-site, usually to a storm drain system. The preferred flow-through BMP is an earthen-based BMP, such as a bioswale that has engineered soils, an impermeable liner, and a sub-drain that will gravity-flow to the landward side of the project site and exit to a storm drain system or established drainage course.

Many *bluff-top* sites are also *space-constrained*. If so, the most common scenario is to route runoff from the site to a manufactured proprietary device, usually a media filter system, located in a vault in the lowest portion of the site. The treated runoff – as well as runoff in excess of the treated runoff – is then pumped landward to a storm drain system. The proprietary water quality Treatment Control BMPs require periodic media replacement, and a power source is often needed to run the pump. It is especially important to ensure that regular maintenance is done and that the pump system does not fail during storms, when it is needed most.

A slope stability and space-constrained site may require professional input to determine whether or not infiltration is an appropriate water quality protection practice. Irrigated landscaping might also be problematic in this type of setting.

New bluff outfalls should be avoided, and runoff should be routed inland to the storm drain network, or if no storm drain is present, to an existing drainage channel. If runoff flows to a natural stream channel or an unprotected drainage course, determine whether the added volume of runoff is large enough to trigger erosion. Where the new runoff volume would be large and erosion of the receiving channel is likely to occur, a Runoff Control must be used to detain a portion of the runoff volume to manage increases in peak flows.