Pavement Rehabilitation

Water Quality Factsheet for Permit Applicants

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This factsheet is a summary of information compiled by Water Quality Program staff. It is not a requirement by the Coastal Commission, and it may be superseded by site-specific information.

Introduction

This factsheet focuses on the water quality impacts of pavement rehabilitation. Water quality issues for pavement rehabilitation projects may be of concern both during the grinding process used to remove the old pavement, as well as during the construction of new pavement or application of sealants.

Pavement Materials

The two most common types of pavement can be distinguished by their color.

Portland Cement Concrete – commonly called *concrete* – is a light-colored pavement (labeled **PCC** on plans and project specification documents) that uses ***Portland cement*** as a binder to harden, waterproof, and texture the pavement. Portland cement is made from calcium carbonate (i.e., limestone) derived from marine fossils.

Asphalt Concrete – commonly called *blacktop* or *asphalt* – is a dark-colored pavement (labeled **AC** on plans and project specification documents) that uses ***asphaltic cement*** as a binder. Asphaltic cement (also called *bitumen*) is produced from a complex blend of hydrocarbons and organic compounds that is derived from petroleum byproducts.

PCC and AC pavements consist of multiple layers, including a compacted foundation, a base material layer, and a driving surface. A surface sealant may also be applied to protect the pavement. The bulk of both PCC and AC pavements is comprised of ***mineral aggregate***. Mineral aggregate is a blend of rock of various sizes and shapes, derived either from sand and gravel mined from alluvial deposits, or from crushed stone quarried from bedrock sources.

Common applications of these pavements include PCC by itself, AC overlaid PCC (e.g., a highway initially constructed with PCC may be resurfaced with AC), full-depth AC, and AC overlaid AC. The most durable and rigid of these pavement types is PCC, but it is also the most costly.

Coal tar-based pavements – similar in appearance to but not to be confused with asphalt – were used to pave roads as early as the 8th century in Baghdad. In the early days of automobiles, roads were commonly surfaced with coal tar, which was used as a binder to produce a *tarmacadam*, or "*tarmac*." Coal tar, like asphalt, is derived from hydrocarbons, and it is still used in the United States in pavement sealants (commonly called *sealcoats*), particularly where it is regionally available as a byproduct from steel manufacturing, or in the gasification of coal in producing fuel oil. As coal is not produced in California, other petroleum-based products are used for pavement sealants in the state, based on the products' availability and the proximity to oil and gas producers. This is an important distinction, as most researchers agree that coal tar-based sealant is a major source of polycyclic aromatic hydrocarbon (PAH) pollution of waterways.[1]

Pavement Surface Sealants

A variety of surface sealants may be applied to extend the life of the pavement, including:

Chip seal (also called a sand seal, depending on the coarseness of the aggregate used) is an asphaltic surface treatment in which a layer of asphalt and fine-grained aggregate are distributed onto an existing pavement as a sealant. Chip seal is frequently used on residential streets and parking lots. Laying down a chip seal is usually a two-step process. The technique involves spraying the worn pavement surface with a hot, liquid asphalt emulsion, followed by spreading fine-grained aggregate and embedding the aggregate into the emulsion using rollers. When the chip seal dries and hardens, the sandy residue is swept up and disposed.

Slurry seal (also called microsurfacing) is a technique in which fine-grained aggregate is blended directly into the asphalt emulsion.

Sealcoat is an application of hot, liquid emulsion over the pavement; in California, the sealcoat used is a petroleum- or asphalt-based product.

Chemical and Physical Contaminants in Pavements

There are two classes of contaminants encountered with pavements: ***chemical*** contaminants and ***physical*** contaminants. The main chemical contaminants are hydrocarbons found in asphaltic cement, and alkaline substances derived from Portland cement and some mineral aggregates. Physical contaminants are solid particles that are released from the pavement through weathering and erosion, or during construction activities. As the pavement ages, the binder slowly deteriorates and can release both physical and chemical contaminants during the unraveling process. For the most part, these inherent chemical and physical contaminants are bound in the pavement after it is installed, but they may pose water quality concerns during pavement installation, rehabilitation, or removal.

Additional chemical contaminants are introduced to pavement surfaces after construction, and are present in pavement grindings. These pollutants may include trace metals from leaked motor oil, lead from traffic paint and leaded fuel, and hydrocarbons from vehicle exhaust. These pollutants are most prevalent in pavements in high traffic areas (such as highways and parking lots), and may contaminate stormwater and dry weather runoff from these pavements, potentially impacting coastal water resources.

Hydrocarbons and trace metals from pavement surfaces, especially when mobilized by grinding, can have a range of adverse impacts on water quality, from discoloration and odors to acute toxicity, depending on their type, concentration, and duration of exposure. Erosion and transport of pavement grindings to surface waters can have catastrophic impacts on aquatic systems. Ongoing contamination of stormwater runoff by these same chemicals can also have chronic or acute toxic effects on aquatic organisms.

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[1]Studies in Austin, Texas indicated that particles in runoff from parking lots with a coal-tar sealcoat had levels of PAH about 65 times higher than that of parking lots without a sealcoat. For more information, see *Parking Lot Sealcoat: A Major Source of Polycyclic Aromatic Hydrocarbons (PAHs) in Urban and Suburban Environments.* 2006. U.S. Geological Survey and the City of Austin. http://pubs.usgs.gov/fs/2005/3147/

Polycyclic aromatic hydrocarbons (PAHs) are a group of organic contaminants linked to incomplete combustion of hydrocarbons, such as coal and gasoline. Coal tar is a byproduct of the coking of coal, and can contain 50 percent or more PAH by weight. While it is fortunate that coal tar is not used as a pavement sealant in California, elevated PAH levels have been detected in California and are linked to numerous other sources. PAH pollution is an issue because of its toxicity to aquatic life, and because several PAHs are suspected human carcinogens.

Limestone used to create Portland cement is an alkaline substance that can significantly raise the pH of surface waters. Once cement has cured, it has little effect on pH, but cement can be toxic to plants or animals in the pre-mixed powdered form or during the curing process. High pH water is caustic or toxic to aquatic organisms, and powdered cement can create soil conditions that adversely impact plants.

Particulates released from pavements, either due to grinding or to breakdown of the pavement binding materials (i.e., raveling), can have adverse physical impacts on surface waters and aquatic organisms. Particulates carried to surface waters can lead to excessive sedimentation, burying natural sediments. Fine-grained particles can increase turbidity in surface waters, impairing ecological processes, for example, by inhibiting reproduction, delaying emergence, inciting sediment avoidance behavior, and increasing rates of mortality in aquatic invertebrates.

Mineral aggregates may contain harmful constituents, based on their lithology (i.e., rock type). For example, Northern California greenstone in quarries is sometimes associated with serpentine, a rock type that may contain asbestos and high levels of trace metals. Most rock sources in coastal areas of California, however, are without recognized concentrations of harmful constituents.

Pavement Rehabilitation Process

Rehabilitation of the pavement focuses on reworking the surface layer. However, repairs to isolated problems in the foundation, such as unevenness from substrate consolidation, may be conveniently repaired coincident with rehabilitation of the surface.

Rehabilitation of high-use pavements that include a ‘sacrificial’ wearing surface (which is expected to wear out after a predicted period of time), such as highways and freeways, requires removal of the worn surface layer by grinding. The grinding process loosens a range of sediment particle sizes, from dust to broken chunks of pavement. Containing, collecting, and removing the tons of sediment that is generated by the grinding of pavements is a major effort in pavement rehabilitation. Fine sediment may enter runoff and compromise water quality; very fine sediment may become airborne.

PCC pavement rehabilitation may employ a process known as *diamond grinding* to expose a fresh surface without the addition of a new pavement layer. This approach can be used until the thickness is reduced to a minimum design threshold established by the pavement engineer. The grinding process evens out the travelled way, and sometimes is used to groove the pavement to improve drainage, help traction, and/or increase the noise-buffering qualities of the pavement.

In grinding, leveling, and re-texturing PCC pavements, pavement waste can be removed and collected in one step, and hauled to a concrete batching plant capable of receiving and recycling used material. PCC grinding generates volumes of very fine particles that are controlled by using a wet-vacuum system. Typically, this process generates a highly alkaline cement slurry; in California, the slurry must be removed from the site.

Usually a local concrete manufacturer will have the capability to reprocess the slurry material. When recycled, the hydrocarbon and other chemical contaminants in the both AC and PCC grindings are volatilized due to the high processing temperatures. The containment of the slurry at the plant should be guaranteed by redundant Best Management Practices (BMPs) imposed by the recycling facility's permit to operate.

AC pavement rehabilitation generally involves grinding the worn, uneven surface layer of asphalt and adding a fresh "lift" (i.e., layer) of asphalt. However, residential streets and parking lots are often overlain, or recoated and sealed, without grinding.

Like PCC, AC demolition also requires grinding; the most common technique is *cold plane milling*. Cold plane milling uses a rotary milling machine that removes the material and transfers it into trucks via a conveyor system. AC grindings may be recycled on the spot by incorporating materials on the job as road base or foundation material in road shoulders or in structures. Generally AC grindings are used for less rigorous applications such as to pave contractor staging yards, or else the material is temporarily stockpiled to be used off-site. An estimated 80% of AC grindings are recycled in California.

Pavement Rehabilitation BMP Recommendations

Since this factsheet focuses on pavement rehabilitation, all of the Best Management Practices (BMPs) listed are considered to be *Construction-Phase BMPs*. Information on *Post-Construction BMPs* for pavements can be found on the internet. Another distinction between types of BMP for pollution control is between *Source Control* BMPs used to keep pollutants from being picked up by stormwater or dry weather runoff, and *Treatment Control* BMPs used to remove contaminants from already polluted runoff. For pavement rehabilitation projects, Treatment Control BMPs are used as a backup in case Source Control BMPs fail.

Source Control BMPs

In each phase of pavement rehabilitation – demolition, stockpiling or removal, and reapplication – Source Control BMPs are used to minimize or prevent contact between potential pollutants and runoff. Source Control BMPs can be either *non-structural* BMPs (such as educating employees on how to handle a spill from a broken hydraulic line, or limiting work during rain events), or *structural* BMPs (such as covering stockpiles, or blocking drain inlets during construction).

- **Heavy Equipment BMPs:** Pavement rehabilitation uses heavy equipment and other machinery to accomplish the work. Source Control BMPs for heavy equipment and machinery address fuels and lubricants, spills, and proper equipment storage and maintenance, including:
  - Always park paving machines over drip pans or absorbent materials, since they tend to drip continuously.
  - Conduct fueling and maintenance of construction equipment and vehicles off site if feasible. Any fueling and maintenance of mobile equipment conducted on site should take place at a designated area located at least 50 feet from coastal waters, drainage courses, and storm drain inlets, if feasible (unless these inlets are blocked to protect against fuel spills). The designated fueling and maintenance area should be protected from storm water run-on and runoff, and designed to fully contain any spills of fuel, oil, or other contaminants.

- Equipment (such as cranes) that cannot be feasibly relocated to a designated fueling and maintenance area may be fueled and maintained in other areas of the site, provided that procedures are implemented to fully contain any potential spills.
- Ensure that wash water used during cleaning of equipment and tools is prevented from being released to watercourses or road drains.
- Ensure that all equipment used on-site is well maintained and free of fluid leaks.
- Have a spill response plan in place, and spill kits on-site.

➢ **Stockpile Management BMPs:** BMPs for stockpiling construction materials for pavement rehabilitation should include:

- Use temporary covers to keep erodible construction materials dry if they are stored on-site near watercourses.
- Store hazardous materials (e.g., chemicals, sealants, and patching materials) in accordance with applicable regulations, and ensure that deleterious substances are not in contact with stormwater runoff.
- During the rainy season, stockpiles of PCC or AC rubble and aggregate should be covered or surrounded by a perimeter sediment barrier. During the non-rainy season, the stockpiles should be covered or protected with a perimeter sediment barrier prior to any precipitation.

➢ **Pavement Grinding BMPs:** Examples of BMPs associated with pavement grinding include vacuuming, sweeping, or washing surfaces into a collection system; covering storm drains; and operating during dry weather (or slightly damp conditions to keep down dust and particulates, if the weather will cooperate). Appropriate BMPs to keep grindings under control during demolition, and to collect the grindings efficiently, include the following:

- Prior to beginning pavement rehabilitation, identify any Environmentally Sensitive Habitat Areas (ESHA) and watercourses within the work area. Educate construction personnel about sensitive portions of the site, and demarcate ESHA, watercourses, and other sensitive areas with flagging or fencing.
- Arrange to do the job during periods of dry weather (i.e., late spring, summer, and early fall), as this allows easier control of deleterious materials and runoff. Typically, this is also a less sensitive period for fish and wildlife than during other seasons.
- If the work schedule requires working in the rain, install appropriate site isolation and sediment controls. Ensure that any disturbance is contained, and that the release of sediment-laden water or any other deleterious substances to watercourses is prevented.
- When work involves the disturbance of soils, or handling or storage of erodible materials (e.g., sand, aggregate, or topsoil), prevent the transport of sediment by installing appropriate erosion and sediment control BMPs and devices.
- Use sediment control BMPs, such as slope treatments (e.g., straw wattles or silt fencing), retention swales, and detention basins. Other sediment retention techniques include straw mulching or hydro-mulching of disturbed areas, and long-term revegetation.
- Ensure that slurries containing PCC or AC generated from saw cutting or grinding do not enter the storm drain system or coastal waters.

- Residue from PCC grinding should be collected using a vacuum attachment to the grinding machine, and should not be left on the surface of the pavement or allowed to run off the pavement.
- Protect drainage inlets by placing straw bales, sandbags, or gravel dams around the catch basins, and remove accumulated sediment and the protective devices prior to project completion.
- Inspect drain blocks, sediment controls, and wash water runoff areas to ensure they are functioning properly, and repair as required.
- Keep aggregate from entering road drains, gutters, and watercourses by cleaning or sweeping material away from these areas, rather than using these structures as collection and disposal routes.
- Wash down exposed pavements only when the wash water can: (1) flow into a protected area; (2) drain onto a berm-protected surface from which it can be pumped out and disposed of properly; or (3) be vacuumed along a curb where sediment has accumulated, by blocking a storm drain inlet.
- Allow aggregate rinse water to settle, and pump the water to the sanitary sewer if allowed by your local wastewater authority.
- Apply concrete, asphalt, and sealcoat during dry weather to prevent contaminants from contacting stormwater runoff.
- Cover storm drain inlets and manholes when paving or applying a sealcoat or slurry seal.
- After the liquid drains or evaporates, shovel or vacuum slurry residue from the pavement or gutter, and remove from the site.
- If dust generated by cleaning activities is a concern, consider the use of a cleaning system such as a vacuum sweeper or sweeper with applied water.
- Recycle broken concrete and asphalt.

➢ **PCC Pavement Application BMPs:**

- Where concrete trucks and other concrete-coated equipment are washed on site, use a temporary concrete washout facility that is constructed and maintained according to industry standards, and is located at least 50 feet from coastal waters, drainage courses, and storm drain inlets.
- Prevent powdered cement from being picked up by wind or runoff and carried to soil or coastal waters.

➢ **AC Pavement Application BMPs:** AC pavements are generally applied as a “hot-mix,” so-called because they are heated to a temperature of 180 degrees (F) when applied. As it cools, the mixture dries and hardens, providing a water-tight, relatively inert media. While it is being applied, and prior to hardening, the material must not be allowed to enter water courses; drains must be protected, and residual material must be collected and disposed of properly.

- **Pavement Surface Sealant Application BMPs:** Additional BMPs may be needed for application of specific types of pavement surface sealants:

  Chip seal (or sand seal) involves spraying the pavement surface with a hot, liquid asphalt emulsion, then spreading fine-grained aggregate and embedding the aggregate into the emulsion using rollers. When the chip seal dries and hardens, the sandy residue is swept up and disposed. This process tends to produce fine-grained sediment for several weeks, so inlet protection should be left in place and removed only when sediment production has dwindled.

  Slurry seal (or microsurfacing) blends fine-grained aggregate directly into the asphalt emulsion. As there is no loose aggregate on the pavement's surface, this avoids the need for sweeping up sandy residue for an extended period.

  Sealcoat involves application of a hot, liquid petroleum- or asphalt-based emulsion over the pavement. The liquid sealcoat may flow off the pavement, and thus must be carefully applied and contained until it hardens.

Treatment Control BMPs

As a backup to Source Control BMPs, or where Source Control BMPs are not adequate to protect water quality, Treatment Control BMPs should be included in pavement rehabilitation projects. These are always *structural* BMPs, meaning that they are physical constructs to capture runoff in order to reduce overall flow volumes, moderate flow peaks, and/or remove pollutants from runoff.

Treatment Control BMPs can add to the cost of a project when required during construction, or needed as a permanent post-construction BMP. All Treatment Control BMPs should be sized to capture and treat runoff produced by storms up to and including the 85th percentile storm event.[2] This design standard allows the BMPs to treat both the smaller, more frequent storms that mobilize most pollutants, as well as dry weather flows. Examples of Treatment Control BMPs include:

- **Biofiltration Strips and Swales:** Biofiltration strips and swales are designated treatment zones that receive stormwater discharges from the highway or other impervious surfaces. Biofiltration swales are vegetated channels that convey stormwater. Biofiltration strips, also known as vegetated buffer strips, are vegetated sections of land over which stormwater flows as overland sheet flow. Pollutants are removed by filtration through the vegetation, sedimentation, adsorption to soil particles, and infiltration through the soil.
- **Wet, Dry, and Extended Detention Basins:** These devices store runoff and allow it to infiltrate into the ground. Infiltration effectively prevents the pollutants in the captured runoff from reaching surface waters. In areas of high sediment loads, pre-treatment to remove excess sediment may be required before runoff enters the basin.
- **Infiltration Basins and Trenches:** Infiltration basins and trenches are backfilled with rock, and require pre-treatment by a detention device and sand filter to reduce maintenance to an acceptable level. Infiltration basins may be rejected as a viable BMP if groundwater quality is a site condition concern, or where depth to groundwater does not allow adequate filtration of pollutants.

[2] Design BMPs to capture and treat, at a minimum, the runoff produced by the 85th percentile 24-hour storm event for volume-based BMPs, or two times the 85th percentile 1-hour storm event for flow-based BMPs.

- **Sand and Media Filters:** Sand filters are vaults or tanks with a layer of sand through which stormwater flows by gravity. These filters are preceded by detention devices that provide pre-treatment and protect the filters from clogging.
- **Vortex Separator:** These systems use deflective flows into the unit, and are effective to separate out trash and capture sediment.

Reuse of Pavement Materials

The waste collected from pavement demolition can be loaded directly into trucks and moved off-site, or stockpiled and reused (as fill or base) on the job. When this material is offloaded at a concrete recycling plant, it is handled with redundant containment systems and incorporated into new batches of AC or PCC.

The reuse of pavement materials on the job is restricted, in part, by the State Water Resources Control Board and the nine Regional Water Quality Control Boards (RWQCBs). The San Francisco Bay RWQCB has provided guidance on the reuse of AC and PCC grindings.[3]

In addition, the North Coast RWQCB in 2010 allowed Caltrans to employ pavement grindings as sub-base for noise wall foundations, shoulder backing, and/or embankments for the Ten Mile River bridge replacement project on Highway 1 in Mendocino County. These applications required that the material was placed five feet above the seasonal high groundwater elevation. Placement of the material in this fashion would prevent impacts to beneficial uses of water by meeting numerical limits or narrative limits for water quality; confirmation by leach testing and water quality sampling was required.

The limitations imposed by the North Coast RWQCB concerning reuse of pavement grindings for the Ten Mile River bridge project included the following:

- Material shall be properly characterized for potential on-site and/or off-site disposal; material that is determined to be non-hazardous solid waste or inert can be used onsite, and will be placed at an elevation at least five feet above seasonally high groundwater elevations and be underlain by the least permeable material available at the site. An impermeable membrane will be used if low permeable material is not available.
- Material will be placed under a cap (i.e., asphalt, concrete, or soil with vegetation) that will act as a low permeability surface.
- Material will not be placed in drainage ways or wetlands.
- Caltrans shall comply with local grading ordinances.
- Material is not transported or exposed during wet weather conditions.
- Materials shall be protected utilizing best management practices (BMPs).
- Caltrans shall document the location of the placed materials.

[3] Memo from the San Francisco Bay Regional Water Quality Control Board to Caltrans entitled "*California Department of Transportation asphalt-concrete and Portland Cement Concrete grindings reuse guidance*." Feb. 8, 2007. http://www.dot.ca.gov/hq/env/haz/pdfs/ac_grindings/h108.pdf

For More Information

- **California Stormwater Quality Association (CASQA) Construction BMP Handbook (2011).** Includes an introduction to the impacts of construction sites on water quality, a guide to developing a construction-phase Stormwater Pollution Prevention Plan (SWPPP), and factsheets on construction BMPs. Water Quality Program staff have an annual subscription to the current version of this handbook, including downloadable individual BMP factsheets. The 2011 Handbook is also available online on some municipalities' websites, such as: http://www.cityofbuellton.com/files/Storm%20Water%20Management%20Program/195D3-CASQA-BMP-ConstructionHandbookComplete.pdf

- **Caltrans' Construction Site Best Management Practices (BMPs) Manual (2003).** Provides instructions for the selection and implementation of construction site BMPs. Includes factsheets on construction BMPs that are very similar to CASQA's factsheets. http://www.dot.ca.gov/hq/construc/stormwater/CSBMPM_303_Final.pdf

  Caltrans' Construction BMP factsheets (2003; some revised in 2006) are also available for downloading individually at http://www.dot.ca.gov/hq/construc/stormwater/factsheets.htm