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Stormwater Best Management Practices

Introduction

Incorporating stormwater pollution prevention best management practices during design, build, and operation of facilities can reduce stormwater runoff amounts, reduce pollution levels in stormwater, and prevent harmful effects of stormwater to receiving water bodies.



Kroon Hall Stormwater Collection

Please note that these listed practices are to be used as informational and educational resources only. This is not a formal stormwater management plan for the University and may not accurately represent all of the practices currently being used on campus. Environmental Health and Safety along with the Office of Facilities and other partners will be formalizing a plan under the Universities Strategic Sustainability Plan (http://sustainability.yale.edu/sites/default/files/FINAL_to_Print.pdf). For more information concerning stormwater management please visit the EPA site at http://cfpub.epa.gov/npdes/home.cfm?program_id=6 and CTDEP's Stormwater Quality Manual at <http://ct.gov/dep/cwp/view.asp?a=2721&q=325704>.

PROJECT DESIGN (STRUCTURAL BEST MANAGEMENT PRACTICES)

Incorporating sustainable stormwater best management practices as part of project design will have positive effects on stormwater management and pollution prevention for the life of the site, structure, or building as well as lessen Yale's impact on the environment. These practices can be applied to building and roof design including gutter and drainage systems, paved areas, catch basins for stormwater, infiltration, recharge, and capture and reuse methods, providing covered or indoor equipment/vehicle wash areas for building occupant use, and designing material, waste, and trash areas, such as underground/aboveground tank systems.

Roof and drainage system design

- Large impervious roofs generate significant stormwater run-off. Building footprint should be minimized to the extent practical to reduce roof size.



Large Impervious Area roof

- Roofing, flashing, rain gutter and exhaust stack material should be chosen to minimize potential for heavy metals or other pollutants.
- Vegetated roofs can reduce or even, for moderate precipitation events, eliminate run-off. Often called green roofs or roof gardens, these commonly have a waterproof synthetic membrane layer, a geo-textile layer to resist root infiltration, a soil layer, with a thickness dependant on the types of planting, and planting such as hardy native grasses, shrubbery, or even trees. The vegetation and soil retain the water, and it is returned to the atmosphere through evaporation.

Yale Sculpture Building
Green Roof



Modular green roof systems have been recently developed, for new installations or retrofit to existing buildings. Interlocking trays, already containing plants, can be delivered to the site for installation.

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- Benefits of Green roofs include
 - Natural filtration and temperature moderation of water that does run-off.
 - Increased building insulation reducing energy costs and sound infiltration
 - Reducing need for site stormwater controls
 - Reducing carbon dioxide and possible help against global warming
 - Reducing ambient urban air temperature
 - Provide habitat for birds and other creatures; increasing biodiversity

- Design Constraints of Green roofs include:
 - Structural reinforcements may be required
 - Roof slope angles may be limited due to erosion concerns
 - Initial and maintenance cost may be greater

Paved Areas (Parking lots and garages, sidewalks, courtyards)

- Paved areas can be one of the largest contributors to stormwater run-off, and parking areas can be a significant source of stormwater pollution.
- Parking lot size should be reduced to the extent possible, through use of enhanced internal geometry incorporating the natural contours of the land, and aisle and stall layouts, such as incorporating one-way aisles and angled stalls.
- Use of pervious (porous) asphalt or concrete allows water to infiltrate through, usually into infiltration/storage beds underneath the pavement, and then into soil to recharge the groundwater table. This naturally removes pollution, and reduces stormwater run-off. Use of porous pavement can be somewhat limited due to climate requiring sand application, which can clog pores, and may be most applicable in lighter traffic areas.



Pervious Pavement

- Bricks, paving stones, modular concrete paving blocks, and cast-in-place grids can allow increased water infiltration through joints. Stone or gravel can be used in low traffic applications.



Paving Stone Driveway

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Infiltration and Reuse

- Alternatives to connection to the storm sewer system include allowing stormwater to infiltrate into the ground directly, installing dry wells or holding chamber to recharge groundwater over time, or to capture the storm water and use for irrigation or other purposes, reducing use of potable water.
- Infiltration methods include use of infiltration beds, bio-retention areas (rain gardens), vegetated buffers, or vegetative swales.
- Infiltration beds can be gravel and/or porous piping that receive stormwater and allow it to infiltrate into the ground. They can be installed under fields (natural or artificial turf) or parking lots.



Infiltration Bed under field

- Bio-retention areas, including rain gardens, use plantings and soil in a shallow area to receive stormwater, normally from a nearby sheet-flow run-off. A grass filter strip is recommended for erosion control, and provisions for overflow should be designed.

Schematic of bio-retention area



- Vegetated buffers can be located along uncurbed parking areas to interrupt stormwater sheet flow, allow some infiltration, and for pollutant removal.
- Vegetated swales are shallow ditches with plantings that receive stormwater flow, allowing for some infiltration and pollutant removal. These swales can replace storm sewer piping at some locations.



Vegetated Swale

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- Dry wells are suitable for small drainage areas with soil of sufficient permeability. They typically are pits or trenches filled with clean washed stone, that receive stormwater and allow it to infiltrate into the soil.
- Rainwater is a resource that can be harvested for irrigation and other use, such as for grey water flushing. Collection can be by rain barrels or cisterns.
 - Rain barrels typically are used in small applications, receiving water from roof leaders for reuse in gardens and lawn irrigation. A hose fitting can be connected directly to the bottom of the barrel. Overflow outlets should be directed away from building foundations. Multiple rain barrels can be used for one roofing system to increase capacity.

Rain barrel with hose fitting



- Cisterns typically are of larger volume and can be above or underground, and can be cast in place for larger applications. Underground installations are preferably in urbanized areas where space is at a premium. Sizing requirements should be determined by run-off areas and typical precipitation volumes.



Installation of underground cistern

- It is possible to treat for potable use, however technologies such as reverse osmosis, ultraviolet light, ozone or chlorine, and carbon is required.

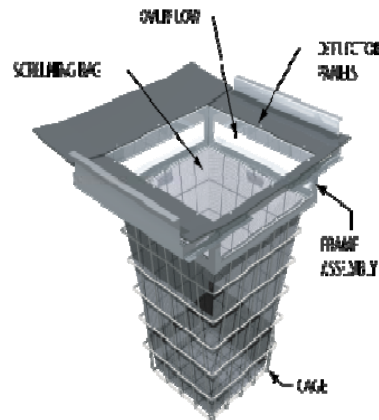
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Conventional Stormwater Treatment

- For stormwater that is directed into catch basins to the storm sewer systems, there are a number of devices and treatment systems that can be used for pollutant removal.
- **Catch Basin Inserts:** The first line of defense for stormwater is the catch basin. Catch basin inserts can be used to capture trash and sediment. Inserts typically consist of filter media, wire mesh, or fabric bag-type. Frequent inspection and maintenance may be required to avoid clogging. Additionally, to discourage dumping, catch basins can be marked “No Dumping, Drains to River (or Sound).”

Catch basin insert



- **Oil/Grit Separators:** For parking lots and garage uncovered top floors, fueling areas, vehicle maintenance facilities, and other areas with potential for leaks and spills, installation of oil and grit separators should be considered on storm sewer lines. Sizing and design should be based upon site characteristics and peak run-off velocities. More advanced designs use swirl and vortex technologies for grit and oil capture.



Installation of oil/grit separator

- **Media Filters:** Filter cartridges with various types of filter media (fabric, activated charcoal, sand, as well as other specialized media) can be installed in concrete vaults for filtering stormwater. Typically these would be installed after an oil/grit separator to reduce pollutant loading and extend filter life.

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Design of Material/Waste Storage Areas

- For areas which will be used for storage of materials such as chemicals, cleaners, lubricants, waste oils, fuels, and bulk landscaping materials indoors storage should be designed, which provide secondary containment (minimum containment volume of largest container, or 10% of total volume of containers, whichever is greater) for spills or releases. Materials such as fertilizers, pesticides, line paint, and fuels must be stored indoors or in designated watertight sheds or trailers, which provide secondary containment or in double-walled tanks with leak detection and high-level alarms.
- If outdoor storage is necessary, underground or above-ground double-walled tanks with leak detection and high-level alarms are required. Petroleum material storage tanks require approval of Professional Engineer. Contact EHS for specific requirements.

Double-wall above-ground storage tank



- If building occupancy will require washing of equipment or vehicles, design wash pads that discharge to oil/grit separators to sanitary sewer (permit required, contact EHS) or clean and recycle the wash water. Wash pads should have roofs to prevent stormwater from washing pollutants off pad.

GENERAL OPERATIONAL BEST MANAGEMENT PRACTICES

- Do not dump wastewater, paints, chemicals, oils or any other material onto the ground, into streams or ponds, or into storm sewer catch basins. Only approved wastewater can be discharged into sanitary drains.
- Do not prepare or mix paints, varnishes, cleaners, or chemicals near catch basins. If spilled or inadvertently applied to paved surfaces, clean prior to irrigation cycles or precipitation.
- Clean paint brushes, mops, and applicators in sink connected to sanitary sewer, unless hazardous materials are being used. If hazardous materials are being used, clean over container and contact EHS for proper disposal.
- Regularly inspect material storage areas for proper storage, releases, drips, and container and secondary containment condition. Primary containers shall be kept closed (i.e. waste grease storage drums) as shall secondary containment sheds.
- Keep an up-to-date inventory of material and keep material labeled with name and expiration date. Store chemicals away from high-traffic areas to avoid accidents and damage.



Material Storage Cabinet



Inventory Sheet

- If possible, reuse or recycle waste chemicals. For proper disposal of waste chemicals contact EHS waste pick-up line at 2-6545.
- Use dry means such as sweeping or vacuuming for cleaning sidewalks and paved surfaces. Collect and dispose in regular trash.



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Vehicle and Equipment Washing

- Do not wash vehicles, equipment, dumpsters, carts onto pavement, ground surface, storm sewers, or into ponds or streams. Use designated wash pads.



- Even biodegradable detergents can harm fish and aquatic life. Exteriors of vehicles and equipment (which often have open engine compartments) can contain residual fuels and oils that can harm the environment.
- If possible, use wiping, sweeping or compressed air (30 psi max) to pre-clean, and reduce the amount of material that is discharged.
- If your work area does not have a vehicle wash pad, use off-site commercial car wash to clean vehicles, or contract with fleet vehicle cleaning services that use portable wash-pads and water recovery.
- Vehicle maintenance areas and oil/grit separators need to be inspected frequently. EHS is required to perform a semi-annual inspection of all vehicle wash oil/grit separators. Oil/grit separators must be pumped out when solids and oil reach a certain level.

Powerwashing



- Contact EHS prior to any powerwashing activity.
- Powerwashing includes cleaning, with or without detergents or chemicals, of building exteriors, pavement, sidewalks, garages, entry ways, and other outdoor surfaces by using pressurized or un-pressurized water.

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- Cleaners used and surface to be cleaned require approval of EHS, prohibited substances include lead painted surfaces, chlorinated compounds, certain solvents, and heavy metals. Discharge pH must be between 5.0 – 10.0.
- Discharge from paint stripping, other than graffiti removal, is prohibited.
- Discharge to storm sewers, streams, and ponds is prohibited. Block all storm sewers in vicinity. Discharge to sanitary sewer requires approval of local sewage treatment plant.

Covering storm sewer catch basin



- Discharge allowed to ground surface if sufficient absorption capacity exists and discharge does not affect any drinking water wells.
- Consider using contractor with water capture and recycling capability.
- Remove loose trash, debris and sand should first be removed by dry means such as sweeping, scrapping, shoveling or vacuuming.
- It is required to keep a log (EHS to provide form) of all powerwashing activity, and send copy of log to EHS.
- See EHS Powerwashing Guidance at:

<http://www.yale.edu/ehs/Documents/environ/powerwashingpolicy.pdf>

Spills and Spill Clean-up

- Clean-up small, non-hazardous spills immediately and properly dispose of spill clean-up residue. Contact EHS for larger and hazardous material spills.
- Keep spill clean-up material in your inventory and inform others where it is located.
- Report evidence of improper dumping, such as catch basins with paint residue, washwater on pavement or in storm drains, such as near loading docks from improper trash cart washing, and stained or distressed grass or vegetation.

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Guidance for Grounds Maintenance/Landscaping

- Follow all state, local, and federal requirements on the use of fertilizers and pesticides. Follow manufacturer's and label direction using minimum amounts necessary, and do not apply within 20 feet of catch basins or streams and ponds.
- Do not prepare or mix pesticide, fertilizers, and line paint near catch basins.
- Coordinate pesticide and fertilizer application with irrigation schedule and precipitation forecasts. Use an Integrated Pest Management Plan.
- If pesticides, fertilizers or line paints are spilled or inadvertently applied to paved surfaces, clean prior to irrigation cycles or precipitation.
- After grass cutting, mulch application, or leaf blowing, use dry means for cleaning sidewalks and paved surfaces of clippings, mulch and leaves. Reapply clippings to lawn or remove for composting. Remove animal waste from paved surfaces.
- Prevent grass clipping, leaves, sticks, chipper material, sand, and salt from discharging to storm sewer catch basins.
- Use mulch or other means to control erosion on exposed soils. Use silt fences and storm drain covers, filter fabric, or haybales around catch basins to minimize sediment discharge.



Silt fence protecting exposed soil run-off

- Bulk landscaping materials such as sand and salt should be stored indoors if possible. If this type of storage is not available, cover materials with tarps and keep materials away from storm sewer catch basins. Material shall be stored on impervious liner as well, not located in areas prone to flooding, or in areas in proximity to streams or ponds, or near drinking water wells.
- Stockpiles of work materials such as mulch and soil should be kept away from catch basins. Soil should be covered during periods of rain.
- Abandoned underground storage tanks ("USTs") can leak or overflow. Look for evidence of abandoned USTs, such as old fill and vent lines, or areas of distressed vegetation.



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Guidance for Custodial and Facilities Staff

- Empty and rinse mop buckets to custodial slop sink or other sanitary sewer connection. Do not empty or rinse mop buckets outdoors either on ground or paved surface or to storm sewers.



- Rinse trash carts and trash cans indoors to sanitary sewer only. Do not rinse trash carts or trash cans outdoors such as on loading docks.



- Perform grinding, cutting, threading and blasting operations indoors in properly ventilated areas. Use drop cloth to capture cuttings and if lubricating oil is used, use absorbents or other means to capture



- If scrapping, sanding, or sand blasting outdoors, use drop cloth to capture material for proper disposal. Only specially-trained personnel can work on lead-based paint or other hazardous material surfaces.
- Regularly inspect exhaust vents and stacks for stains, drippage or particulate matter. If known to be non-hazardous, clean by dry methods. If suspected hazardous material, contact EHS.

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Trash, Regulated Waste, or Recycling Dumpsters, Compactors and Roll-Offs

- When building design allows, dumpsters should be stored under roofed areas. Covers shall be kept closed, and drain plugs left securely in place.
- Inspect dumpster and compactor areas and hydraulic lines for closed covers, dumpster plugs in place, and for spill or leaks. Clean-up spills and leaks promptly, or call EHS for assistance with larger hazardous material spills or leaks.



Hydraulic Leak from dumpster

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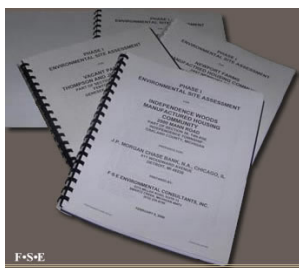
Construction Site Guidance



Stormwater generated during the construction process, especially from excavated and disturbed soil areas, can carry significant pollution, particularly sediment. Exposed soils are susceptible to erosion from precipitation and run-off, and vehicles can track dirt, sand, and sediment into roadways, where they are washed into the storm sewer system. Existing polluted soils can release contaminants, and construction and renovation activities can contribute further to stormwater pollution. Portable fueling tanks, vehicles and equipment, and construction material storage are another source of pollution, as can be undiscovered underground tanks.

Environmental Surveys

- Prior to excavation or site activities, it is recommended that an environmental site assessment (ESA) be conducted. EHS maintains a list of environmental consultants pre-qualified to perform these assessments. The type of assessment conducted depends on the complexity and history of the site.
- Phase I surveys use a site visit and site history and surrounding area records check. Site visits will look for evidence of past releases such as distressed vegetation, areas of concern (AOC), such as chemical, fuel, or waste storage or transfer areas, and other site conditions. Records check usually include DEP spill report database, tank registrations for site and neighboring site, Sanborn Fire Insurance Maps, and property use records. Ground Penetrating Radar can also be used to identify presence of underground tanks and other Utilities.



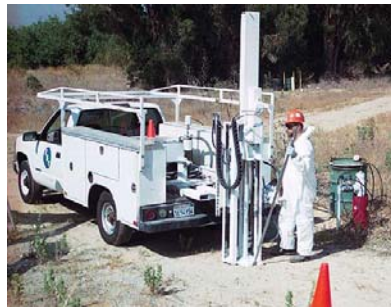
Environmental Site Assessment Reports

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- Phase II testing involves soil and groundwater sampling to determine pollutant levels. Pollutants in soil can be picked up by stormwater and run-off into surface waters. Polluted groundwater may require treatment before dewatering activities, which may be discharged to storm sewers.

Groundwater Sampling



Stormwater Permit Requirements

- Construction excavation activities that disturb one or more than one acre and discharge to a separate storm sewer require coverage under the Connecticut Department of Environmental Protection's *General Permit for the Discharge of Stormwater and Dewatering Wastewaters Associated with Construction Activities*. Permit can be found at: http://www.ct.gov/dep/lib/dep/Permits_and_Licenses/Water_Discharge_General_Permits/storm_const_gp_reissue08.pdf
- Construction excavation activities that disturb greater than five acres must file a *General Permit for the Discharge of Stormwater and Dewatering Wastewaters Associated with Construction Activities* registration. Additionally, a Stormwater Pollution Control Plan must be developed for the site. The Plan must follow the *Connecticut Guidelines for Soil Erosion and Sediment Control*, and include a description of the site, the construction sequencing, pollution controls and measures, erosion and sediment controls, stabilization and structural practices, dewatering practices, post-construction storm water management, site waste control measures, vehicle tracking controls, inspections, list contractors and subcontractors, and include a contractor certification statement.
- Construction sites of five acres or less do not require registration, however they must receive written approval from the town of the site's erosion and sediment control measures, and must follow the *Connecticut Guidelines for Soil Erosion and Sediment Control*, found at: http://www.ct.gov/dep/cwp/view.asp?a=2720&q=325660&depNav_GID=1654
- USEPA Construction and Development Stormwater Requirements (40 CFR Part 450) become effective February 2, 2010 for all sites that disturb one or more acres. These regulations contain requirements for erosion and sediment controls, soil stabilization, dewatering, pollution prevention measures, prohibit certain discharges including concrete washout, control of vehicle washing, and mandate the use of discharge outlets that discharge from the surface of basins and impoundments, to minimize sediment. The regulations and Fact Sheet can be found at: <http://www.epa.gov/waterscience/guide/construction>.

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- Construction may create the need for dewatering excavations. If possible, this groundwater should be redirected to the ground at a nearby location. If discharged to a storm sewer, the above permit requirements may apply. Discharge of groundwater to the sanitary sewer may require metering and the payment of sewer tax.



Dewatering of an excavation

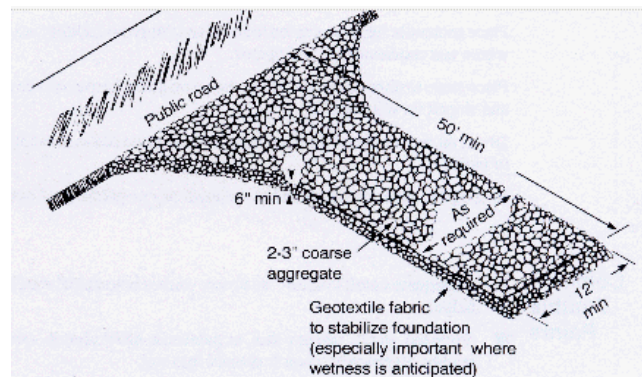
- EHS should be contacted during planning and design phase of projects to determine stormwater and dewatering requirements. EHS will review the project and determine permit requirements. All permit applications should be reviewed by and coordinated with EHS prior to submittal.

Sediment Control

- Sediment is the main pollutant from excavation activities. Gravel drive-offs should be established at all exits from the site. If necessary, dedicate personnel to periodically sweep dirt from the roadway back onto the site. Mulch, netting, and erosion control blankets can be used to cover disturbed surfaces, especially slopes. Silt fences and hay bales around storm sewers remove sediment from run-off, and catch basin insert grit separators can be used in storm drains on site to further reduce sediment load.



Silt fence



Design of construction drive-off

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Storm drain sediment protection



Installation of erosion control blankets

- Condition of erosion and sediment controls need to be inspected frequently. If the site has a Stormwater Pollution Prevention Plan, a minimum inspection frequency must be established and followed. Inspections should be documented and corrective action taken when deficiencies are noted.

Stormwater Testing Requirements

- USEPA Construction and Development Stormwater discharge effluent testing requirements (40 CFR Part 450) become effective August 2, 2011 for all sites that disturb twenty (20) or more acres, and February 2, 2014 for all sites that disturb ten (10) or more acres. Average daily turbidity (a measure of sediment in the water) cannot exceed 280 standard units.

Fuel and Chemical Storage and Use

- All fuel and chemical tanks, including integrated generator tanks, shall be covered and within double walls and/or secondary containment. Fueling operations should be over an impervious surface, if possible, with prompt clean-up of any drips, overflows, or spills.

Fuel Tanks must be double wall



- Construction equipment containing fuels, lubricants, or hydraulic fluid should be inspected frequently. Braided steel hydraulic hoses are recommended.
- Construction supplies shall be kept covered if they have a potential for contaminating runoff.

Vehicle and Equipment Washing

- Construction vehicles and equipment (including concrete delivery trucks) should not be washed on-site, if possible. If necessary, use portable wash pad system to collect water for off-site disposal.