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ASSESSMENT OF NONPOINT SOURCE (NPS) POLLUTION POTENTIAL AT MILITARY BASES

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ASSESSMENT OF NONPOINT SOURCE (NPS) POLLUTION POTENTIAL AT MILITARY BASES

1. Purpose. The purpose of this Public Works Technical Note (PWTB) is to provide guidance on how to assess nonpoint source (NPS) pollution at Army installations.

2. Applicability. This PWTB applies to all Army Public Works activities.

3. References.

a. AR 420-46, Water Supply and Wastewater, 1 May 1992.

b. Public Law 100-4, Clean Water Act (CWA) of 1987. (Previously known as the Federal Water Pollution Control Act).

c. See Appendix B for a list of additional references applicable to Nonpoint Source (NPS) Pollution Assessment.

4. Glossary. Abbreviations and special terms used in this PWTB are explained in the Glossary (Appendix C).

5. Discussion.

a. The Clean Water Act requires US Army installation facility engineers to monitor surface water quality to locate and eliminate onsite sources of water pollution. To comply with this legislation, installations should begin programs to sample and analyze surface water to identify possible local sources of contamination.

b. Surface water quality is affected by point source and nonpoint source pollution. Point sources of water pollution are easier to identify than nonpoint sources because nonpoint sources are often spread over a relatively large area. Nonpoint source pollution is most commonly caused by rain or snow, and its effects appear downstream from the source. Pollutant loadings are closely related to rain volume and intensity, infiltration, and other hydrologic parameters. To assess actual or potential nonpoint source pollution, it is important to identify the hydrologic aspects of the drainage area, measure runoff volume, sample runoff water and sediment, and analyze water quality.

c. Appendix A provides guidance on how to assess nonpoint source pollution at Army installations by:

(1) Defining terms and giving background information.

(2) Specifying how to:

(a) Determine the volume of runoff.
(b) Sample water and analyze water quality.
(c) Evaluate data.
(d) Assess nonpoint source pollution impact.

(3) Providing a sample application of these procedures to a hypothetical Army installation.

6. Point of Contact. Questions and/or comments regarding this subject that cannot be resolved at installation or MACOM level should be directed to the US Army Center for Public Works, CECPW-ES, 7701 Telegraph Road, Alexandria, VA 22315-3862, at DSN 656-5194, commercial (703) 806-5194; or to the US Army Construction Engineering Research Laboratories, Environmental Engineering Division, CECER-EPO, Champaign, IL 61826-9005, at (toll-free) 1-800-USACERL, ext 3488 or COMM (217) 373-3488.

FOR THE DIRECTOR:

FRANK J. SCHMID, P.E.
Director of Engineering

APPENDIX A

Assessment of Nonpoint Source (NPS) Pollution Potential at Military Bases

A-1. Introduction. The purpose of this PWTB is to provide guidance on how to assess nonpoint source pollution at Army installations to help installations meet the requirements of the Federal Water Pollution Control Act. This PWTB defines terms and gives background information, and then spells out how to:

- Determine the volume of runoff
- Sample water and analyze water quality
- Evaluate data
- Assess nonpoint source pollution impact.

a. Background. Surface water quality is affected by two types of pollution: point source and nonpoint source. Point sources of water pollution are easy to identify (for example, pipes discharging from a factory). Sources of nonpoint source pollution are spread over a relatively large area and are harder to identify (for example, pollutants entering creeks, streams, and lakes from surface runoff, rain or snow, and improper sewer connections). Nonpoint sources of pollution are common, relatively unpredictable sources of water pollution. Nonpoint sources may be any water pollution source besides currently regulated point discharges. Some examples are: urban runoff; groundwater infiltration; septic tank discharges; and runoff from construction sites, fertilized fields, heavily trafficked roads, and hazardous waste disposal sites.

(1) NPS results. Nonpoint source pollution can cause water quantity problems (too much, too little, or availability not meeting demand) and quality problems (bad odor or appearance, fish kills, impaired use, high chemical levels, high levels of sediment).

(2) NPS causes. Nonpoint source pollution is usually caused by rain or snow acting on materials or contaminants on the ground or other surface, creating a contaminated runoff. Effects can appear downstream from the source as stormwater volume and peak flows increase. Pollutant loadings are closely related to rain volume and intensity, infiltration, and storage characteristics of the drainage basin, and other hydrologic parameters. Therefore, to assess actual or potential nonpoint source pollution problems originating from Army installations, it

is important to identify and quantify the hydrologic aspects of the drainage area.

(3) Regulatory agency involvement. Nonpoint source pollution problems, including stormwater runoff, are among the latest nationwide concerns. However, regulatory agencies and environmental groups are just now undertaking the issues involved in measuring the extent of the problem and how to address the problem. Presently, all Army installations have National Pollutant Discharge Elimination System (NPDES) permit applications in place for stormwater runoff from industrial sources. The associated permits will require each installation to develop a Stormwater Pollution Prevention Plan (SWP_3) for its stormwater runoff from industrial sources. The EPA has issued guidance for SWP_3 preparation, and installations have prepared them. Model stormwater SWP_3s have also been developed. This PWTB provides a broader approach to examining nonpoint source pollution problems that may arise or exist at an installation, which, in addition to the industrial runoff, may include substantial sediment runoff.

b. Hydrologic aspects and stormwater runoff quantity. Stormwater runoff created by precipitation has three parts, each of which can carry significant amounts of nonpoint source pollutants:

(1) Surface runoff. This volume of water is observed in drainage after all other losses have been saturated. As defined here, losses include interception by surface vegetation, depression storage and ponding, infiltration, and evaporation from the surface.

(2) Interflow. This water infiltrates into the vadose zone, which moves horizontally, directly beneath the surface water in a drainage.

(3) Groundwater flow. Almost all groundwater originates from infiltrated precipitation after subtraction of surface losses, surface runoff, evapotranspiration, and interflow. Nonpoint source pollution from surface water sources can also contaminate groundwater flows.

(a) The quantity of surface runoff is a primary consideration in managing nonpoint source pollution. Peak flows can cause downstream flooding if stormwater drainage is not controlled. Some areas of the country have stormwater management ordinances to protect areas from flooding. Army installations may consider similar measures.

(b) The volume and timing of runoff also affects nonpoint source water quality. The highest concentrations of pollutants and pollutant loadings from nonpoint sources usually occur during high flow and flood conditions. Erosion and sediment concentrations in the surface water drainage are the most visible effects of large volume and peak flows from rain and snowmelt. This may especially affect Army installations, which have activities that may change the natural soil conditions, making soil erosion easier. For example, artillery ranges and tank maneuvering areas may be subject to erosion during storms.

(c) A nonpoint source assessment must be based on an understanding of the quantity of runoff from each of the drainage basins located on an Army installation. Methods for determining volume of runoff are given in para. 2.a.(5).

c. Nonpoint source water quality. Many types of pollutants from nonpoint sources appear in stormwater runoff. A basic knowledge of the type of pollutants found in stormwater runoff is needed to find the specific water quality parameters that should be analyzed for nonpoint source assessment procedures. The specific water quality caused by nonpoint source pollution depends on the type of activity in the drainage area. This and the next sections describe typical water quality parameters monitored in nonpoint sources, and explain how these parameters can be related to the land activity within the drainage area.

(1) Water quality characteristics. Dissolved oxygen concentration is one of the most important water quality characteristics of surface water. Nonpoint source pollution can cause eutrophication; that is, it can provide organic material, which, as it is decomposed by microorganisms, can severely depress or deplete dissolved oxygen concentration due to the demands of organic and reduced inorganic compounds. Industrial and cantonment areas may contain oils, toxic materials, and other chemicals that have an oxygen demand. Recommended indicator parameters are: total oxygen demand (TOD), 5-day biochemical oxygen demand (BOD_5), and chemical oxygen demand (COD).

(2) Total suspended solids. High concentrations of suspended sediment in streams may cause such bad consequences as increased turbidity, reduced light penetration, clogging of gills and filters in aquatic life, smothering of benthic communities,

more rapid filling of impoundments, and several others. It is important to measure particulate solids in stormwater runoff to measure potential amounts of sedimentation that can occur in the stormwater flow. The recommended parameter for indicating particulate concentration is total suspended solids.

(3) Bacteria. Bacterial levels in runoff in developed areas usually exceed public health standards for water contact recreation. Recommended parameters are fecal coliform and fecal streptococcus.

(4) Nutrients. The main nutrients of concern in stormwater discharges are compounds of nitrogen and phosphorus, which can lead to undesirable algal blooms in downstream receiving waters. Nutrient export sources include land uses that receive unusually high fertilizer inputs, such as golf courses, cemeteries, and other intensively landscaped areas, along with agricultural lands and sewage treatment plants. Recommended analyses to determine eutrophication potential are oxidized nitrogen and Total Kjeldahl Nitrogen for nitrogen and total phosphorus.

(5) Toxic compounds. Many compounds of varying toxicity and concentration may be found in stormwater runoff, including heavy metals, pesticides, herbicides, and other organic substances. A flow composite should be analyzed for lead, zinc, copper, chromium, mercury, cadmium, arsenic, nickel, or tin, depending on the drainage area. Over half of the trace metal fraction is usually attached to sediment. Other characteristics may also reduce the effect of toxic trace metals present; however, some are toxic to stream life in certain situations.

(6) Organics. If the project budget allows, organic parameters may be measured, including tests for total organic carbon (TOC), and total organic halogen (TOX), priority pollutant and gas chromatography/mass spectrometry (GC/MS) scans, and analyses for local use of pesticides and herbicides.

(a) There may be some exotic species unique to the Army for which representative indicators should be sought, for example, missile propellants or ammunition storage areas.

(b) The requirement for sampling and analyses of specific compounds should be identified after the specific land uses are identified within a drainage area.

(7) Other. Chlorides or salts may be introduced after their use for ice and snow removal. Warming of stormwater, which occurs when stormwater runs off over relatively warm soil, may also create serious problems for stream biota.

d. Water quality and land use. The type of pollutant that may be present in stormwater runoff depends on the land use of the drainage area. Understanding land use helps determine which water quality parameters to measure at a specific installation. Types of pollutants detected from land use activities similar to those on Army installations are:

(1) Urban development (Cantonment). Nonpoint source runoff from developed areas can contain a wide range of pollutants. Typical installation activities occur in: staff housing (barracks, single-family, multi-family, Bachelor Officers' Quarters/Visiting Officers' Quarters [BOQs/VOQs]), street and lawn areas, schools, light commercial areas, and shopping areas. Typical pollutants originating from those activities are: fertilizers and herbicides (from lawn areas), trash waste from storage and handling, used automobile crankcase oil, road surface materials (from sanding and salting of roads in winter), and sanitary waste from pets and livestock. These pollutants have significant concentrations of nitrogen, phosphorous, biochemical oxygen demand (BOD), suspended solids, oil and grease, fecal coliforms, chlorides, as well as metals and organics on the EPA's Priority Pollutant List. Field (1985) has reported that all of the heavy metals on the Priority Pollutant List were found consistently in urban nonpoint source runoff. This has also been the case in many of the metropolitan areas that were sampled for the National Urban Runoff Program (NURP) conducted by the EPA from 1979 to 1983.

(a) Organic pollutants have also been detected in urban runoff. A number of common priority pollutants in nonpoint source runoff from urban development have been reported.

(b) Areas served by individual sewage disposal systems can show higher loadings of nutrients, BOD, and fecal coliform in the stormwater runoff than those with centralized systems. This is because some of the systems are old and may not be operating properly, or may have failed completely. Commercial areas exhibit higher loadings than residential areas because the surfaces of commercial areas are relatively impervious; water runs off.

(2) Industrial areas. The type of pollutant in nonpoint source runoff from industrial areas depends on the type of industrial activity in the area. Since many industrial activities on Army installations use solvents, trace metals and toxic organics are routinely detected. Spills that could run off into surface water are a special danger in these industrial areas. Information on industrial areas within Army installations is usually available in the form of Environmental Impact Statements (EISs), installation spill plans, and/or hazardous materials audits. Such documents provide ready sources of lists of possible contaminants.

(3) Agricultural activities. Many installations contain farm land. These areas should be identified by location and by the farming methods used on them. The primary pollutants from croplands are sediments, nutrients, and pesticides. However, the amount of pollutant loading depends on the type of irrigation, fertilizer application, and erosion prevention practiced. Stock grazing can add large quantities of nutrients and fecal coliforms, and large amounts of sediment where there is overgrazing.

(4) Transportation. Much nonpoint source pollution traces back to structures and activities surrounding transportation.

(a) Highways, streets, and roads provide impervious surfaces for stormwater drainage. Airborne particles collect on these hard surfaces and wash into tributaries. Road traffic adds many of the pollutants found in nonpoint source water. Tire wear particles can contribute greatly to street dust and are reported to contain high concentrations of zinc and lead oxides (Galvin and Moore, 1982). Brake lining wear is a main source of copper, chromium, and nickel in street dust metal concentrations. Petroleum from cars is a source of both inorganic and organic toxicants. Asphalt particles and yellow lane-stripping paint can add polynuclear aromatic hydrocarbons (PAHs) and chromium. Due to their extreme solubility, almost all chlorides (salts) wash into surface or groundwaters after they are used to remove ice from roads and sidewalks (Pitt 1985). Army installations typically have motor pool activities that may generate many of these pollutants. These areas should be specifically identified and investigated as possible sources of nonpoint source pollution. Airfields should also be included as they are sources of deicing chemicals and fuel spills among other contaminants.

(b) Railroad corridors can also contribute pollutants to a watershed. Spills of rail-transported hazardous materials have significantly contributed to nonpoint source and groundwater pollution. Passenger train discharge of untreated sanitary wastes along the rights-of-way is a source of fecal contamination.

A-2. Nonpoint source assessment procedures. This section presents step-by-step procedures to assess the nonpoint source issues on a typical Army installation. In some cases, there may be adequate information on stormwater flows and only the water quality aspects would need to be investigated. Therefore, these procedures have been organized into two areas: ways to assess volumes of nonpoint source stormwater, and ways to assess quality of nonpoint source water. Specific steps are presented in the referenced flow charts.

a. Ways to assess volumes of nonpoint source stormwater. To evaluate the effect of nonpoint source pollution, it is important to assess the volume of stormwater runoff. Large stormwater flow can cause flooding and erosion, which add nutrients. Nutrient loadings can damage quality by causing algae growth, which in turn lowers water oxygen content. Nutrient loadings from stormwater runoff and their associated impact on surface water quality are evaluated by calculating a flow-weighted average concentration of pollutants, based on stormwater runoff volumes. Figure 1 shows the following steps:

Figure 1. Steps for Assessing Nonpoint Source Stormwater Volume.

(1) Define drainage areas and sub-basins. To begin assessing stormwater volumes, define the drainage areas and sub-basin in which the installation is located by using topographic maps and field reconnaissance. Find the drainage basin boundaries by using the topographic maps to estimate the water flow pattern. Locate the sub-basin areas by using a planimeter on the topographic map. This task will produce a detailed map of the installation's drainage pattern.

(2) Categorize land use. Categorize and plot land use on an installation map. These land use data and drainage patterns will help calculate stormwater runoff. Changes in land use can alter the volume and flow rate by changing the infiltration rate and surface storage volumes. A geographic information system (GIS) developed by USACERL called Geographic Resources Analysis Support System (GRASS) may help to do this analysis (Martin 1989).

(3) Review local drainage regulations. Many local governments have ordinances to control stormwater runoff. Local ordinances usually limit peak stormwater flows to pre-developed maximum stormwater flow rates.

(4) Obtain criteria. If local drainage regulations exist, the local government will have outlined stormwater discharge evaluation procedures. These procedures will be modified and calibrated to local conditions and generally will provide accurate estimates of stormwater runoff volumes. Available watershed drainage plans may already have estimated stormwater flows from Army sites.

(5) Calculate stormwater runoff. Calculating stormwater runoff involves estimating a number of variables relating to land use, including the imperviousness of the ground, soil slope and type, and rainfall intensity. Many local governments have developed simple procedures and regional models to estimate stormwater volumes to assess nonpoint source pollution based on local conditions.

(a) Sometimes stormwater runoff must be calculated to assess nonpoint source from an Army installation. There are various methods available to perform this exercise. Peak flows from a drainage basin can be estimated using a procedure called the Rational Formula. This simplified procedure incorporates a watershed area of less than 160 acres,[1] rainfall intensity, and a land use/soil type coefficient.

(b) To produce a hydrograph of the stormwater runoff, the Soil Conservation Service (SCS) method is universally accepted. A hydrograph plots stormwater flow against time at a particular location in the drainage during a given storm event. The area under the hydrograph shows the total volume of flow for the storm.

(c) The SCS method has been adapted to determine maximum runoff flow rates instantaneous flow rates, and runoff volume. Thus, the SCS method is accepted for use for both drainage and nonpoint source evaluation. There is much affordable software available that performs the SCS method. A qualified engineer should complete any hydrologic study.

(d) Another method for estimating total volume of runoff from a site is to use a runoff coefficient available in most hydrological textbooks. The runoff coefficient (which can be adjusted to season and other variables) is multiplied by the area of the runoff basin and the rainfall on the area. This product is the estimated volume of runoff from the site.

(6) <u>Determine if onsite calibration is required</u>. The mathematical models used to calculate stormwater runoff can accurately estimate actual runoffs. However, all mathematical models generally only express the essential features of a system or process. Onsite calibration is typically not required for nonpoint source assessment. Onsite calibration should be considered for complex basins for study sites where no accurate rainfall data has been collected.

(7) <u>Install rain gauge and flow measurement</u>. To measure onsite flow, install rain gauges and a flow measurement device. Rain gauges must be unsheltered and located where they will accurately record the watershed's rainfall. Properly establishing stream gauging sites is important. A flow measurement device should be installed where stormwater flows offsite, and at other points within the basin. There must be a good constant section. Stormwater may be measured in areas that contain potential sources of pollution. Two recommended references for the practitioner are *Water Quality Information*

[1] 1 acre = 0.405 hectare.

Paper No. 37 NPDES, Sampling Protocol for Stormwater Permit Applications from the Army Environmental Hygiene Agency (21 April 1992), and Douglas M. Grant, *ISCO Open Channel Flow Measurement Handbook*, 3d ed. (1991).

(8) Assess downstream impacts. Once stormwater runoff has been measured, determine the overall impact of the installation's stormwater runoff. The object is to find out how much stormwater flow originates in the installation and the extent that land use within the watershed affects the flow.

b. How to assess nonpoint source water quality. This step-by-step procedure can help the facility engineer identify the sources and extent of water pollution from Army installations and to decide whether water quality field sampling is needed. Note that this procedure is not intended for regulatory compliance or for scientific research. Figure 2 shows how the following steps can help identify potential water quality problems:

(1) Review state and local management plans. An important part of accessing nonpoint source pollution problems is to find out if any specific state or local programs are already developed for the area. These plans may identify sensitive environmental areas on or near Army installations. Obtain and review copies of the state nonpoint source Assessment Report and Management Plan. These documents should refer to any applicable local programs. Contact the state nonpoint source coordinator to find out how to obtain these nonpoint source plans. The USACERL point of contact (POC) can supply these names.

(2) Review applicable national pollutant discharge elimination system (NPDES) permit issues. Rules for NPDES stormwater discharge permits are still being written and may change. Review the most recent permit rules before choosing a method to assess nonpoint source water quality issues. The installation environmental manager may need to contact the state NPDES coordinator before starting a detailed water quality monitoring program.

Figure 2. Steps for Assessing Nonpoint Source Water Quality.

(3) Perform hazardous materials audit.

(a) A first step in assessing nonpoint source water quality problems is to find potential sources and locations of pollutants. Obvious potential sources are areas where hazardous and/or flammable materials are used and stored. To locate these areas, contact the base environmental manager, who is required to audit and develop a management plan for hazardous materials used and stored onsite. Although most of these areas require containment for spills and collected stormwater, they are still a potential source of pollution, especially large motor pool areas, where paved areas or hardstands can generate large volumes of stormwater runoff.

(b) It is also important to check areas where hazardous materials have been spilled and/or discarded in the past. These old materials often stay underground until stormwater carries them into groundwater.

(4) Identify potential nonpoint source pollution. Identify sources of nonpoint source pollution other than areas with hazardous and flammable materials. At this point, land uses on the facility site have been identified in assessing stormwater flow volumes. Use table 1 to identify potential water quality pollutants for each category of land use. This listing outlines pollutants consistently found in runoff from specified land uses, and can help to qualitatively identify potential problems. Table 1 can also help identify water quality parameters to use in a monitoring program.

Table 1

Potential Water Quality Pollutants by Land Use Category

Land Use	BOD	TSS	Fecal Coli-form	Nutri-ents	Metals**	Toxic Organics***	Radio-nucli-des†
Residential*	×	×	×	×	×	×	
Commercial/ indus-trial	×	×	×	×	×	×	×
Agricultural		×	×	×		×	
Office areas	×	×		×	×	×	
Roadways		×			×	×	
Motor pools		×			×	×	
Natural grassland/-forest	×	×					

* Includes barracks, family housing, officers quarters, etc.
** Arsenic, boron, cadmium, chromium, copper, lead, nickel, silver, zinc, selenium, thallium, mercury.
*** Specific organic analysis should be performed depending on the type of activity taking place in the drainage basin. TOC and TOX are recommended indicator parameters. A priority pollutant scan is recommended.
† Gross alpha and gross beta.

(5) Calculate potential nonpoint source pollution. Some environmental managers may want to calculate pollutant loadings from their installations. Calculation of the nutrient mass loadings from specific sites is common practice where a watershed drains into a lake that is sensitive to the effects of eutrophication.

(a) Use table 2 to calculate potential nutrient loading due to stormwater runoff for the listed land uses. Multiply the area of land (in acres) for each use by the unit area loading for that land use to calculate potential nutrient loading. If the effects of nutrients and/or BOD are significant, start a sampling and monitoring program to gain more precise data.

(b) Note that the unit area loadings given in table 2 estimate only pollutants generated during storms, and do not consider baseflow runoff and associated pollutant loads. Furthermore, the unit area loadings can vary depending on a number of factors including the percentage of site imperviousness, annual rainfall, type and age of development, and other specific activities.

(c) Some local governments may be able to provide specific unit area loadings for planning purposes.

Table 2

Unit Area Loadings

Land Use	Phosphorus (lb/acre/yr)*	Nitrogen (lb/acre/yr)	BOD (lb/acre/yr)
Multi-family residential	0.9-1.2	5-7	20-30
Single-family residential	0.5-0.7	4-6	10-20
Commercial/industrial	1.3-1.8	10-14	30-35

(6) Determine if sampling is required. In most cases, a cursory water quality monitoring program can tell if stormwater quality from Army installations is potentially damaging. Small installations with only general urban activities may use published values for anticipated stormwater quality concentrations to calculate nutrient loading and determine water quality impacts.

(7) Establish water quality sample points. Water quality monitoring of stormwater runoff has been practiced for the past 20 years. Further references on the topics of monitoring techniques, network design, statistical inferences, laboratory analyses, and quality control are listed at the end of this PWTB.

(a) A first step in any water quality monitoring program is to determine sample locations. Water quality records collected by the U.S. Geological Survey, the State, or other public agencies may help locate good sample points. An inventory of each sub-basin should already have been completed, including the drainage area, present and projected land use, physical catchment characteristics, and relationship to streams, lakes, or estuaries within the area of interest. Each drainage sub-basin should be considered for water quality sampling.

(b) In general, water quality should be sampled at the outlet of each drainage sub-basin. Sub-basins that are potential sources of hazardous materials will require specific stormwater quality monitoring. For example, landfill disposal sites should be monitored just downstream from the site to measure the impact on surface water quality.

(c) Groundwater monitoring should be considered in this step. Groundwater contamination can occur when surface stormwater runs off from a polluted site and later infiltrates into the groundwater. On the other hand, nonpoint source surface water pollution could occur from contaminated groundwater that surfaces in a drainage channel.

(d) It is most economical to select several priority water quality sample points from a number of potential sites. Water quality sample points should be ranked to identify potential water quality problems associated with handling hazardous materials at the site.

(e) All water quality sample points must be accessible, safe for personnel and equipment, and free from vandalism. Usually the site should be accessible by vehicle. The site should have good access during bad weather conditions and during flood periods. Avoid locating sites on bridges with heavy traffic unless there is suitable protection for personnel and equipment. Before locating sites at streams, determine historical flood marks and place access facilities and equipment above flood level.

(f) Construct separate groundwater sampling wells for water quality monitoring. Do not use the same well for both water supply and sampling since this often leads to sample contamination. If trace organic contaminants are to be monitored, construct groundwater sampling wells of metal with sturdy, locking caps to maintain sample integrity and to minimize vandalism.

(g) Vandals can cause costly damage to equipment and data. Select sites in open, lighted areas to reduce vandalism. Attempts to hide or camouflage equipment generally do not reduce vandalism, but may help. However, if the equipment is placed in the open, then a combination of traffic cones, sawhorses, and caution tape around the equipment may help prevent curious passersby from touching or vandalizing equipment. Also, military policy should be notified of activities; they can provide drive-by surveillance of equipment.

(8) Develop sampling and analysis program. The sampling and analysis program must identify the water quality parameters to be analyzed in samples obtained from each location and the frequency of sample taking at each location. Choose sampling equipment and sampling techniques in this phase of program development.

(a) Each stormwater runoff sample should have several laboratory analyses to measure the concentration of the various chemical constituents. Routine field measurements at sampling include tests for pH, dissolved oxygen, and water temperature. For groundwater samples, the elevation of free water surface should be recorded before flushing the well casing with three volumes of water. (Note: the flush water is not suitable for analysis.)

(b) Analyze every water sample for total organic demand (BOD or the equivalent), suspended solids, and fecal coliform. Whether to monitor other water quality parameters will depend on the type of land use upstream from the sample point.

Table 1 can provide a guide to determine addition-al laboratory analyses for each sample, based on land use (table 2).

(c) Note that table 1 does not list all types of activities on Army installations. Specific organic and inorganic compounds may need to be added to the water quality parameter analyses depending on the activities in the drainage basin.

(d) The sampling frequency depends on the variations of the drainage system and the expected nature of the pollutants. The chosen frequency should account for variation in the stormwater flows. Rainstorms vary throughout the year in total quantity and even in rain intensity during storm. Distribution and amount of rainfall can affect runoff quality. For example, a gentle but protracted rain may result in low levels of pollutants because the particles that are associated with pollution are too heavy to be moved by the relatively slow rates of runoff. On the other hand, a short, intense rainfall may result in far greater pollutant loads to local receiving waters. How wet the soil is before a rain can vary greatly and can directly affect runoff quality and amount. Winter storms also have much different runoff characteristics than summer storms. Therefore, a number of storms should be monitored in a given year.

(e) A number of samples should be analyzed at each site during storms and during dry periods. Sonnen (1983) suggests that sampling five or six storms at each sample point should be enough to find out if stormwater runoff at that place is potentially polluting. Further, it is recommended that one sample be taken at each sample point each season during dry periods to sample base flow.

(f) At least three samples should be taken during each storm at each sample point: one just after the beginning of stormwater runoff, one at the approximate peak of stormwater runoff, and one taken during the end of the stormwater runoff.

(g) There are many methods available for taking water samples, ranging from taking manual grab samples to using elaborate sampling equipment. To assess nonpoint source water quality, grab sampling is usually acceptable. If a facility engineer chooses automatic sampling, the USACERL POC can provide references.

(h) The volume of sample required for each water quality analysis should be established by contacting the laboratory that will do the analysis. Instrument detection levels for each water quality parameter should also be estimated and reported by the laboratory. In most cases, the concentrations of pollutants in nonpoint source runoff are dilute, meaning that lower detection levels should be used in the method of analysis.

(i) Sediment samples should be taken in any program, especially if toxic metals or organics are suspected in the drainages. This sampling can be performed at any time at locations in the streambed where suspected drainages occur. The laboratory analyses should analyze sediment samples for all priority pollutants. A semi-quantitative GC/MS scan should also be considered.

(j) Logistics of sampling during a precipitation event must also be considered. Even with automatically initiating equipment, installation personnel (or contractor) will have to be on-site during the rain event to collect grab samples and to ensure that equipment is working. The rain event may occur outside of typical working hours. The AEHA reference described earlier will be of assistance for this activity.

(k) The cost of sampling and analyzing for the number of parameters and samples indicated here may be prohibitive as installation environmental budgets are limited. Other, less expensive, methods may enable the environmental staff to obtain a limited indication of the quality of runoff from sites. For example, turbidity meters may provide relatively good data on nutrient concentrations and some metals. However, for regulatory purposes such as to comply with Storm Water Permit Regulations, the federal or state regulator will define permissible analytical techniques.

(9) Develop water quality data base. How long a sampling and analysis program to assess nonpoint source water quality should last may range from a single grab sample during one storm to several years of monitoring each storm event. Sampling one storm event is usually not enough to establish if there are potential nonpoint source pollution problems at a specific site. The intensities of different storms cause different levels of pollution. While five or six storms at each site should be enough to discover if storm runoff is potentially polluting at a given site (Sonnen 1983), sampling should be distributed throughout the rainy season. In most cases, the sampling and analysis program should collect data for an entire year. The

goal should be to sample different types of both rain- and snowstorms over the year.

(10) Evaluate data. The first task in evaluating the water quality data from a nonpoint source sampling and monitoring program is to record and organize the data so it compares easily with water quality goals.

(a) Several computer programs can help with this task. In most cases, the data can be organized in any spreadsheet program that has the capability of quickly plotting the data. Potential nonpoint source water quality problems can be related to a concentration of pollutant or to a mass loading of a pollutant (usually pounds per year) where the total number of pounds of a pollutant is more important than concentration. Therefore, data should be organized for each sample point to show statistical variations, maximum and minimum concentrations, and calculation of mass loadings.

(b) Data evaluation begins when the water quality data from the first sampling is reported. Any needed modifications to the sampling and analyses program should be made before the next sampling. For example, if the water quality results report some potential pollutants that are below accurate detection limits, then methods for lower detection levels should be used on the next water samples.

(11) Assess water quality impact. The assessment of water quality data obtained from a nonpoint source sampling and analysis program is site-specific. A general assessment of the impacts of the nonpoint source water quality can be performed with some basic description of the potential problems. Making a detailed assessment can be complicated, and is usually done by a specialist.

A-3. Application example. The following example uses the hypothetical U.S. Army Installation, Camp Heart, which has potential NPS pollution problems. Camp Heart's environmental manager wants to identify the NPS pollution from the Camp and develop a data base to eventually assess downstream water quality impacts.

a. Installation description. Camp Heart is located in the watershed of the Rolling River Reservoir approximately 5 miles upstream of the reservoir.[2] There are two creek beds on the property. Dry Creek has intermittent flow only during storm events and drains an area with multifamily housing and motor pool activities. Flushing Creek has a continuous baseflow during dry periods, and flow increases considerably during storm events. Dry Creek is a tributary of Flushing Creek, and Flushing Creek drains into Rolling River. Figure 3 is a plan of the installation that shows the relative locations of the drainages.

b. Installation function. The installation currently serves as a small training base for ground troops. A munitions factory was once in use, but has since been abandoned. One area of the property had been used as a landfill; however, this has also been abandoned.

c. Beginning the program. The facility's environmental manager begins the assessment by following steps shown in figures 1 and 2.

(1) Define drainage areas and sub-basins. From a topographic map of the installation, the drainage boundaries were established. Two sub-basins were defined: the Dry Creek sub-basin and the Flushing Creek sub-basin, which includes Dry Creek as a tributary. By using a planimeter on the map, the areas were determined (table 3). This task helped to develop an

[2] 1 mi = 1.61 km.

Figure 3. Map of Camp Heart.

Table 3

Camp Heart Drainage Area

Location	Area
Dry Creek	360 acres
Flushing Creek	830 acres
Total	1190 acres

Table 4

Camp Heart Land Use Areas

	Area (acres)	
Land Use	Dry Creek Sub-Basin	Flushing Creek Sub-Basin
Multi-family	100	–
Motor pool	20	–
Training area	–	180
Abandoned munitions	–	10
Old landfill	–	15
Natural grassland	240	625
Total	360	830

installation map (figure 3).

(2) Categorize land use. Land uses were determined and plotted on the map, and areas were calculated using a planimeter (table 4).

(3) Determine if local drainage regulations exist. The facility's environmental manager contacted the Urban Drainage Authority to determine status of drainage regulations. Regulations are currently being developed for new development in the Rolling River watershed. A stormwater drainage study has been performed and is in preliminary form. The study identified potential problems in the Rolling River watershed relating to erosion and flooding during large storms. Sediment from erosion will affect the aquatic life in the river and downstream reservoir.

(4) Obtain criteria. Local regulations did not specify

drainage criteria; however, the preliminary drainage study indicates that erosion will occur in Rolling River in the area of Flushing Creek when peak flows reach approximately 15,000 cubic feet per second (cfs). This has been estimated to be a 6 hour, 9.4 in.* storm.

(5) Calculate stormwater runoff. The contribution of the peak flows in Rolling River due to the stormwater flow in Flushing Creek should be assessed. The environmental manager uses the SCS method to calculate the peak flow in the entire Flushing Creek/Dry Creek drainage during the critical storm. The peak flow from Flushing Creek was estimated to be approximately 3400 cfs, occurring approximately 2-1/2 hours after the storm begins.

(6) Determine if onsite calibration is required. The drainage area for Camp Heart is not complex and the contribution of stormwater flow from the installation is not considered excessive. Therefore, stream flow measurement is not required at this time. A rain gauge should be installed to monitor the length and rain depth within the drainage basin. This information will help determine the annual stormflow volume contributed to the Rolling River.

(7) Assess downstream impacts. Peak Stormwater flow from Camp Heart contributes 3400 cfs to Rolling River during critical conditions. Peak flow in the river during these conditions is a total of 15,000 cfs. Therefore, the installation contributes approximately 20 to 25 percent of the peak flow that may result in the erosion in the river. This is a significant contribution. Stormwater flow detention should be considered to lessen the erosion and flooding potential.

d. Assessing NPS water quality.

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*1 cu ft = 0.028 m^3; 1 in. = 25.4 mm.

(1) Review state and local management plans. The EPA Regional Coordinator and State NPS Contact were consulted to obtain the State NPS Assessment Report and Management Plan. The environmental manager reviewed these documents.

(a) The Assessment Report identified potential eutrophication problems in Rolling River Reservoir. The reservoir is a drinking water supply and the water quality may be affected by nonpoint source pollution.

(b) A reservoir water quality monitoring program has identified that algae growth in the reservoir is phosphorus-limited. Therefore, the more phosphorus that reaches the reservoir from nonpoint sources, the more eutrophic the reservoir will become. The water quality monitoring program has established that an average annual phosphorus loading of 10,000 lb has occurred for the past 3 years.

(c) Toxic compounds may be entering the reservoir from nonpoint sources. This may affect the drinking water quality. Trace levels of several heavy metals and organics have periodically been detected.

(d) Best Management Practices (BMPs) in the Rolling River Basin have been proposed in the NPS Management Plan. A study to be done over the next 3 years will determine the best way to implement these practices.

(2) Review applicable NPDES permit issues. Camp Heart does not have any storm sewers; therefore it is not anticipated that an NPDES stormwater permit will be required. However, recently issued stormwater regulations define Camp Heart as an industrial source, and require action. Such regulations are outside the scope of this PWTB.

(3) Perform hazardous material audit.

(a) Camp Heart's environmental manager has performed an inventory of hazardous and flammable materials used and stored onsite, mostly in the motor pool area. A list of these materials is available for the planned sampling and analysis program.

(b) The environmental manager is concerned about the potential contamination around the old landfill and the abandoned munitions facility. There are no records to indicate what has been placed in the landfill in the past although it has been closed for 10 years. The munitions facility is a building shell. There are no hazardous materials in the area.

(4) Identify potential NPS pollution. The potential NPS pollutants were assessed by referring to table 1. Based on land use, the following potential contaminants were identified: BOD_5, suspended solids, coliforms, phosphorus, nitrogen, selected metals (arsenic, cadmium, chromium, copper, mercury, lead, iron), TOC, TOX, and pesticides.

(5) Calculate potential NPS pollution. The total phosphorus loading from Camp Heart was calculated to estimate the contribution of phosphorus loading to Rolling River Reservoir. The unit area loadings in table 2 along with the calculated land use areas determined the annual total phosphorus loading from Camp Heart to Rolling River Reservoir to be about 300 lb per year. This is approximately 3 percent of the average annual phosphorus loading to the reservoir (300/10,000).*

(6) Determine if sampling is required. The potential of toxic contaminants in the NPS runoff from the motor pool, the old landfill, and the abandoned munitions facility area justifies a water quality sampling program in those areas.

(a) Sampling may also be needed to measure suspended solids concentrations from the training area, to verify phosphorus loadings, and to estimate groundwater contamination from the landfill and munitions area. Sampling locations should be identified based on locations of land use, potential sources of water quality pollutants, and configuration of drainage sub-basins. Only two drainage sub-basins are located on the installation: the smaller Dry Creek sub-basin located in the larger Flushing Creek sub-basin. Since much of the activity on the installation occurs in the Dry Creek sub-basin, a water quality sample point will be established where this basin discharges into Flushing Creek (sample point no. 1 in figure 3). Water quality results from this sample point will determine if there are pollution sources in this sub-basin.

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*Similar calculations could be made for nitrogen and BOD_5.

(b) Stormwater runoff from the old landfill area and abandoned munitions facility may contain toxic compounds. These areas are located upstream from the mouth where Dry Creek pours into Flushing Creek. Sample point No. 2 will be placed on Flushing Creek, just upstream from this point to measure water quality before influence from Dry Creek.

(c) Sample point No. 3 will be located just before the point where Flushing Creek enters Rolling Reservoir to test water quality leaving the installation.

(d) The environmental manager also wants to check the groundwater at a point downgradient of the old landfill, which may affect the NPS surface water quality. Figure 3 shows where two groundwater monitoring wells will be located.

(7) Develop sampling and analysis program. The sampling and analysis program will characterize water quality on the property for the next year. Four rainfall events will be monitored and sampled during the different seasons. Automatic samplers will not be purchased, but three grab samples will be taken during the rainfall event at each of the three sample points. At least three people must be prepared to sample each storm event on a 24-hr basis.

(a) The water quality laboratory that will be performing the analyses is contacted to obtain the sampling equipment and containers. Temperature and pH will be monitored and recorded onsite during sampling. In addition to the storm events, base flow in Flushing Creek will be sampled four times over the year during the different seasons at Sample points 2 and 3 only, since there is not continuous flow at Sample Point No. 1. The groundwater monitoring wells will be sampled two times in the next year to identify potential pollutants.

(b) The entire sampling and analysis program is presented in table 5. The total number of samples to be analyzed for the monitoring year is shown in the right hand column. This tabulation will aid in determining costs for the program.

Table V

Sampling and Analyses Program for Camp Heart

Water Quality Parameter	Sample Point No. 1[1]		Sample Point No. 2[1,2]		Sample Point No. 3[1,2]		GW Monitoring Wells[2]	Total No. of Samples per Year
	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base flow		
pH	12/yr	–	12/yr	4/yr	12/yr	4/yr	4/yr	48
Temperature	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
BOD_5	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
TSS	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Total phosphorus	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	48
Ammonia	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Nitrate and nitrite	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Total dissolved solids	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Arsenic	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Cadmium	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Chromium	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Copper	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Mercury	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Lead	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Iron	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Total organic carbon	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Total organic halides	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Fecal coliform	12/yr	–	12/yr	4/yr	12/yr	4/yr	–	44
Pesticides	–	–	–	–	4/yr	4/yr	4/yr	12
Organic priority pollutants	1/yr	–	1/yr	1/yr	1/yr	1/yr	4/yr	9

Notes:
1. Each sampling point monitored four times a year during a storm event. Three samples taken during each storm event.
2. Each sampling point monitored for base flow once each season (except for Sampling Point No. 1, which has no base flow).
3. Two groundwater monitoring wells will be sampled in the next year.

(c) The pesticides and organic priority pollutants will be sampled only once per storm event, preferably during the storm, at the beginning of the runoff. Base flow will also be monitored for three parameters, four times during the year.

(8) Develop water quality data base. The sampling and analysis program will continue through a calendar year to establish water quality from several types of storms. The environmental manager shall notify the sampling team when the next storm event should be monitored.

APPENDIX B

REFERENCES

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APPENDIX C

GLOSSARY

Aquifer- An underground geological formation, or group of formations, containing usable amounts of groundwater that can supply wells and springs.

Benthic Community - Animal or plant life living on the bottom of a body of water.

Biochemical Oxygen Demand (BOD)- A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution.

Biological Oxidation- The way bacteria and microorganisms feed on and decompose complex organic materials. Used in self-purification of water bodies and in activated sludge wastewater treatment.

Biota - The animal or plant life of a region or area.

BOD_5 - A standard, 5-day test for biochemical oxygen demand. The amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter.

CBOD5- The amount of dissolved oxygen consumed in five days from the carbonaceous portion of biological processes breaking down in an effluent. The test methodology is the same as for BOD5, except that nitrogen demand is suppressed.

Chemical Oxygen Demand- A measure of the oxygen required to oxidize all compounds in water, both organic and inorganic.

Chlorinated Hydrocarbons- These include a class of persistent, broad-spectrum insecticides, that linger in the environment and accumulate in the food chain. Among them are DDT, aldrin, dieldrin, heptachlor, chlordane, lindane, endrin, mirex, hexachloride, and toxaphene. Other examples include TCE, used as an industrial solvent.

Coliform Organism- Microorganisms found in the intestinal tract of humans and animals. Their presence in water indicates fecal pollution and potentially dangerous bacterial contamination by disease causing microorganisms.

Combined Sewers- A sewer system that carries both sewage and storm-water runoff. Normally, its entire flow goes to a waste treatment plant, but during a heavy storm, the storm water volume may be so great as to cause overflows. When this happens, untreated mixtures of storm water and sewage may flow into receiving waters. Storm-water runoff may also carry toxic chemicals from industrial areas or streets into the sewer system.

Confined Aquifer- An aquifer in which groundwater is confined under pressure that is significantly greater than atmospheric pressure.

Contaminant- Any physical, chemical, biological, or radiological substance or matter that has an adverse affect on air, water, or soil.

Conventional Pollutants- Statutorily listed pollutants which are understood well by scientists. These may be in the form of organic waste, sediment, acid, bacteria and viruses, nutrients, oil and grease, or heat.

Direct Discharger- A municipal or industrial facility which introduces pollution through a defined conveyance or system; a point source.

Dissolved Oxygen (DO)- The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life and for the prevention of odors. Traditionally, the level of dissolved oxygen has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life.

Dissolved Solids- Disintegrated organic and inorganic material contained in water. Excessive amounts make water unfit to drink or use in industrial processes.

Downgradient - In the path of natural water flow.

Dystrophic Lakes- Shallow bodies of water that contain much humus and/or organic matter, that contain many plants but few fish and are highly acidic.

Effluent- Wastewater-treated or untreated-that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

Eutrophication - The process where water becomes better nourished, resulting in increased algae growth and eventual oxygen depletion.

Evapotranspiration - The discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, and soil surfaces, or by transpiration from plants.

Fecal Coliform Bacteria- Bacteria found in the intestinal tracts of mammals. Their presence is an indicator of pollution and possible contamination by the pathogens.

Fertilizer- Materials such as nitrogen and phosphorous that provide nutrients for plants. Commercially sold fertilizers may contain other chemicals or may be in the form of processed sewage sludge.

Fresh Water- Water that generally contains less than 1,000 milligrams per liter of dissolved solids.

Gray Water- The term given to domestic wastewater composed of washwater from sinks, kitchen sinks, bathroom sinks and tubs, and laundry tubs.

Ground Water- The supply of fresh water beneath the Earth's surface, usually in aquifers, which is often used for supplying wells and springs. Because ground water is a major source of drinking water there is growing concern over areas where leaching agricultural or industrial pollutants or substances from leaking underground storage tanks are contaminating ground water.

Interflow - Water derived from precipitation that infiltrates the soil surface and then moves laterally through the upper layers of soil above the water table until it reaches a stream channel or returns to the surface at some point downslope from its point of infiltration.

National Pollutant Discharge Elimination System (NPDES)- A provision of the Clean Water Act which prohibits discharge of pollutants into waters of the United States unless a special permit is issued by EPA, a state, or (where delegated) a tribal government on an Indian reservation.

Nutrient- Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorous in wastewater, but is also applied to other essential and trace elements.

Outfall- The place where an effluent is discharged into receiving waters.

Overland Flow- A land application technique that cleanses waste water by allowing it to flow over a sloped surface. As the water flows over the surface, the contaminants are removed and the water is collected at the bottom of the slope for reuse.

Pesticide- Substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant. Pesticides can accumulate in the food chain and/or contaminate the environment if misused.

pH- A measure of the acidity or alkalinity of a liquid or solid material.

Phenols- Organic compounds that are by-products of petroleum refining, tanning, and textile, dye, and resin manufacturing. Low concentrations cause taste and odor problems in water; higher concentrations can kill aquatic life and humans.

Phosphates- Certain chemical compounds containing phosphorous.

Reservoir- Any natural or artificial holding area used to store, regulate, or control water.

Storm Sewer- A system of pipes (separate from sanitary sewers) that carry only water runoff from building and land surfaces.

Suspended Solids- Small particles of solid pollutants that float on the surface of, or are suspended in sewage or other liquids. They resist removal by conventional means. (See: Total Suspended Solids.)

Total Suspended Solids (TSS)- A measure of the suspended solids in wastewater, effluent, or water bodies, determined by using tests for "total suspended nonfilterable solids". (See: suspended solids.)

Turbidity- 1. Haziness in air caused by the presence of particles and pollutants. 2. A similar cloudy condition in water due to suspended silt or organic matter.

Unsaturated Zone- The area above the water table where the soil pores are not fully saturated, although some water may be present.

Urban Runoff- Stormwater from city streets and adjacent domestic or commercial properties that may carry pollutants of various kinds into the sewer systems and/or receiving waters.

Vadose zone - A subsurface zone containing water below atmospheric pressure and air or gases at atmospheric pressure.

Water Pollution- The presence in water of enough harmful or objectionable material to damage the water's quality.

Water Quality Criteria- Specific levels of water quality which, if reached, are expected to render a body of water suitable for its designated use. The criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water Quality Standards- State-adopted and EPA-approved ambient standards for water bodies. The standards cover the use of the water body and the water quality criteria which must be met to protect the designated use or uses.

Water Solubility- The maximum concentration of a chemical compound which can result when it is dissolved in water. If a substance is water soluble it can very readily disperse through the environment.