Report for 2001HI2141B: An Accurate Evaluation of Water Balance to Predict Surface Runoff and Percolation

There are no reported publications resulting from this project.

Report Follows:

Problem and Research Objectives

Hawaii, like many other states, has a number of unlined landfills that are potential groundwater contamination sources. Infiltration control is a major means of reducing leachate generation at unlined landfill sites. Use of synthetic materials for the closure of landfills is quite expensive, especially for small rural communities. Use of alternate capping technologies, such as vegetation caps, is not suitable in humid areas where the annual precipitation exceeds the evapotranspiration demand of growing crops. However, a combination of natural soil caps and runoff-enhancing structures can be a feasible capping method. Local plants growing on natural clay caps could transpire a large part of the percolating water. Making a portion of the landfill surface impervious (e.g., by use of rain gutters) and diverting the surface runoff offsite could reduce the entry of water through the landfill cap, thus reducing the potential for leachate generation. A recent demonstration by the U.S. Navy showed that, in tropical areas such as Hawaii, it is possible to cap landfills with natural soil cover if 20% to 40%of the surface area can be covered with rain gutters. However, the amount of error in the prediction was high. The model used daily water balance for calculating runoff and infiltration. In reality, rainfall in Hawaii occurs over a relatively short period of time. Higher-intensity rains cause significant surface runoff. Averaging a storm event over a day would significantly reduce the intensity, making it appear as if there is no runoff and all water is infiltrating the ground. For groundwater recharge studies, this may provide a false sense of security from modeling that a large part of the rainwater is entering the soil in source water areas and less water is lost through runoff. It is clear that an accurate estimate of partitioning of rainwater to surface runoff and infiltration and the subsequent movement of infiltrated water through subsoil media are quite important for a variety of applications.

The objectives of the first year (phase-1 effort) of this study are to measure percolate and runoff at frequent intervals daily at each of six test plots and to keep all instruments in working order. Our main focus is to calibrate and test a recharge model and a runoff-producing model against the collected data. These models will provide some insight into the mechanisms of percolate and runoff production in response to specific storm events. They will also indicate if improvements in modeling strategy are needed for better calibrate against the collected data.

The effort in the second year (March 2002 through February 2003) will focus on the validation of a regulatory model that is commonly used for the closure of landfill caps. The data will also help in the recalibration of the surface runoff and percolate production models and in the study of chemical transport through the soil.

Methodology

The study site is located at the Marine Corps Base Hawaii in Kaneohe, Hawaii. The site, located near a landfill site, has six test plots—all instrumented to collect surface runoff, percolate at a depth of 2 to 3 feet, and soil moisture data. In addition, weather data such as temperature, wind velocity, solar radiation, and rainfall are measured at the test site. The site is instrumented with pressure transducers, flow meters, soil moisture probes, and other sensors that are connected to data-logging devices to collect data at intervals ranging from a few minutes to twice daily. All collected data from the data loggers are downloaded to a computer (remotely located anywhere) via a modem and a cellular phone daily.

The year-1 activities include (1) repair and replacement of aging and malfunctioning sensors and instruments, (2) recalibration of instruments, (3) automated data collection, and (4) setting a framework for water balance calculations.

Although the plots were available to us at the start of the first year's effort, most instruments and sensors were not operational, so time was spent repairing and replacing them. Solar panels that charge batteries and nearly all batteries (12 of them) were replaced. Two sump pumps (which pump water out of runoff or leachate tanks) were repaired, while most flow counters (which record the pumpage out of the tanks) and level switches (that activate the pumps) were replaced. Erosion was quite severe on two faces of the project site, so gravel riprap and erosion cloths were installed on the slopes to reduce erosion. In addition, a watertight wall was installed at the north end of the plots to prevent the flow of surface water toward the plots. Other items replaced include the moisture packs in pressure transducers and in various storage areas of data loggers and sensors, the malfunctioning cellular phone, and the switch of one tipping-bucket rain gage.

After replacing the sensors, the instruments were recalibrated. This included the recalibration of the pressure transducers in runoff and leachate tanks. Pressure readings were calibrated against tank volumes. The flow counters on the outflow lines of the sump pumps were calibrated for the amount of flow passing through the flow meters. Sensors on weather station were recalibrated.

Three CR21x data loggers, available from Campbell Scientific, Inc. (CSI), is used for the collection of data from the sensors at various intervals. A Windows-based software, also available from CSI, is used to download the data to a computer on the Manoa campus of the University of Hawaii using a cellular phone at the landfill site. All data are downloaded on a daily basis. The frequency of data collection for various sensors is 15 minutes, with the exception of the TDR probes, which are programmed to collect data twice a day. The frequency of data collection can easily be reprogrammed.

Precipitation, runoff, percolation, and change in storage are measured to determine the water balance. The only unknown parameter for the site is evapotranspiration, which can be estimated from the water balance equation.

Principal Findings and Significance

The primary effort for the first year was to set up instrumentation and revitalize the site. We found the durability of several sensors and instruments to be quite satisfactory, however. For example, the pressure transducers are still functional after seven years of service, and most of the rain gages are still working nicely. All sensors and equipment must be serviced at proper intervals for reliable operation, however. For example, because the domes of net radiometers crack in three to six months, allowing rainwater to easily get into the cracks, the domes need to be replaced every three months. A maintenance schedule was developed for all the equipment at the study site.

Preliminary data show that all sensors are working well. We are in the process of evaluating the collection of soil water data from TDR probes at more frequent intervals. All TDR probes are installed in the top 6 inches of soil. We plan to move some of these probes to deeper depths to obtain a moisture profile for the entire 24-inch cap.

Details of water balance analysis will be the focus of second year’s effort. We will also conduct a vegetation survey twice a year for each of the six plots.