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Storm Water Best Management Practices (BMPs) Field Trials of Erosion Control Compost in Reclamation of Rock Quarry Operations

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1 Introduction

Citizens in Texas have recently expressed concern about the amount of sediment and other constituents being conveyed to receiving waters in stormwater runoff from quarries. Quarries include a variety of disturbed areas that are often almost completely lacking in vegetation including active mining areas, process areas, spoils piles, and locations that were previously sedimentation ponds used to treat process water. Runoff from areas of bare soil, such as these, can convey extremely large amounts of suspended solids compared to other rural land uses. Consequently, the Texas Commission on Environmental Quality (TCEQ) initiated this project to evaluate various methods for stabilizing disturbed areas at quarry sites.

In addition to quarries, areas disturbed by construction activities also generate large amounts of sediment during storms, which leads to very visible impacts on nearby surface waters. To protect these waters, the United States Environmental Protection Agency (USEPA), through the Construction General Permit, requires disturbed areas to be vegetated and stabilized before a Notice of Termination can be submitted to regulators. Establishing vegetation proves to be time consuming and expensive on many projects. To this end, research has shown that compost applied to disturbed lands substantively reduces sediment loss and enhances vegetation establishment (Bresson et al., 2001; Block, 2000).

Composting is the aerobic biological degradation of waste in the solid state (Rittman and McCarty, 2001). In recent years, composting has become popular for dairy manure, poultry litter, and wastewater treatment biosolids. The composting process consumes biodegradable organic matter and releases carbon dioxide among other products. Due to the destruction of organic matter and the associated reduction in volume, compost has higher phosphorus concentrations than the original waste material (Sharpley and Beegle, 2001). The reduced volume makes the compost less costly to transport, but the higher phosphorus concentrations in the compost may leach into runoff, potentially impairing the quality of receiving waters (Easton and Petrovic, 2004).

The Texas Department of Transportation (TxDOT) has used compost on construction projects since 1998 (Cogburn, 2007), and currently uses two specifications (161 & Special 1001) for compost in erosion control applications. Both specifications blend equal volumes of wood chips and compost to create Erosion Control Compost (ECC) for application to disturbed areas, but differ in the organic content of the compost. Specification 161 requires compost containing 25 percent - 65 percent organic matter by mass, while Special Specification 1001 allows organic content as low as 10 percent by mass for manure compost (TxDOT, 2004).

The aim of this study was to compare the vegetation establishment, runoff volume, and water quality of the two types of TxDOT approved compost with a common industry best management practice (BMP), wood based hydromulch, and a seeded bare soil control. These four treatments were applied to test plots. Vegetation density and runoff volume were sampled on selected occasions throughout the year. Runoff was analyzed for five water quality parameters: total suspended solids (TSS), total Kjeldahl nitrogen (TKN), nitrite-nitrogen plus nitrate-nitrogen (henceforth referred to as nitrate), dissolved phosphorus as orthophosphate-phosphorus (dissolved-P), and total phosphorus (total-P). Sampled events provided the basis for a comparison between treatments of the annual runoff volume and mass loss of each water quality constituent.

2 Literature Review

Previous studies evaluating the effect of compost on water quality and vegetation establishment may be categorized according to the compost source material, how precipitation was applied (natural or simulated), and the type of test area. Test areas have included columns and trays of various sizes as well as field studies.

Bresson et al. (2001) compared erosion from a compost amended soil with a control soil using simulated rainfall over small trays, none of which had vegetation. Test soils were compacted into 50 x 50 x 15 cm test trays such that the bulk density ranged from 1,000 to 1,200 kg/m^3. The trays were set at a 5 percent slope. Simulated rainfall was applied at 19 mm/h for 60 minutes, corresponding to a 3-year return period for the study area near Paris, France. Runoff was collected continuously during rainfall simulation. The compost amended soil delayed the onset of runoff from 2.5 to 9.2 mm of cumulative rainfall. The average TSS concentration in the incipient runoff was 11,000 mg/L and 36,400 mg/L for the amended and control soils, respectively. Total sediment load was 18.3 g or 732 kg/ha for the amended soil and 54.6 g or 2184 kg/ha for the control soil.

Kirchoff et al. (2003) analyzed leachate from compost filled columns subjected to simulated rainfall. Several blends of compost were studied; the results summarized here pertain to erosion control compost from dairy manure. Rainfall was applied on eight occasions such that the total rainfall was equivalent to the annual average rainfall for Austin, Texas (31.5 inches or 800 mm). Nitrate and total nitrogen concentrations in leachate decreased by an order of magnitude between the first and second rainfall applications. In subsequent rainfall applications, concentrations stabilized around 2.5 mg/L for nitrate and 8.6 mg/L for total nitrogen. Total phosphorus concentrations were relatively stable at around 3.3 mg/L throughout the study.

Kirchoff et al. (2003) also investigated erosion control properties of compost. A precipitation depth of 67 mm was applied to a 275 x 91 cm test tray as the hyetograph of a 2-year, 3-hour storm for Austin, Texas. Runoff from the tray was monitored continuously. Compared to the clay loam control soil, the runoff hydrograph for the dairy compost was flatter and shifted to the right. This result indicates that dairy compost delays the onset of runoff and reduces the peak flow rate. A water quality analysis of one sample contained the following concentrations: nitrate-N 0.73 mg/L, TKN 8.98 mg/L, total-P 4.17 mg/L, and TSS 645 mg/L.

Easton and Petrovic (2004) performed a two year field study to determine the effect of nutrient source on turfgrass runoff and leachate under natural rainfall. Fertilizers were applied to 1 x 2 m plots situated on a 7-9 percent slope. Treatment plots received repeated applications of fertilizer, totaling 100 or 200 kg-N/ha for the two year study. Three organic composts were investigated (dairy, swine, and biosolids) with results presented as the average of the three. Test plots experienced 33 precipitation events totaling 536 mm. Nitrate concentrations in runoff generally decreased with time, but appear to be influenced by repeated fertilizer application. Nitrate concentrations ranged from 13 mg/L for the unfertilized control plot in the second month to 0.1 mg/L for the compost plots in month 17. Nitrate concentrations in runoff from the treatments were significantly different, with the control plot producing the highest concentrations. Concentrations of phosphate (PO_4^{3-}-P) in compost runoff fluctuated between 0.1 and 1.5 mg/L, but exceeded 2.5 mg/L on two occasions following fertilizer application. Phosphate concentrations from the control plots appeared fairly stable and averaged 0.3 mg/L and 0.5 mg/L for years 1 and 2, respectively. The study found that nutrient concentrations and mass losses were highest in the 20-week period following turfgrass seeding, with compost treatments having greater phosphorus loss on a percent applied basis. The nutrient losses declined significantly once turfgrass cover was established. The reduced nutrient runoff was related to overall plant growth and shoot density.

Faucette et al. (2004) studied the runoff from several composts and mulch blankets under simulated rainfall. Composts used for the project were derived from poultry litter, municipal solid waste, biosolids, food waste, and yard waste. The treatments were placed into a 92 x 107 cm frame on a 10 percent incline. Rainfall was applied at 160 mm/hr for one hour. This storm event exceeds the 1-hour, 100-year storm event for Athens, Georgia. Solids loss from composts were less than bare soil, ranging from 111 g for yard waste compost to 552 g for poultry litter compost, compared with 646 g for bare soil. Losses of nitrogen and phosphorus from most of the compost treatments were higher than those from bare soil or mulch treatments.

Xia et al. (2007) studied the leaching of nitrogen and phosphorus from compost filled columns subjected to simulated rainfall. Rainfall was applied at 20.4 mm/hr for 100 min. For one month, 10 of these events were conducted every other day such that the total amount of water leached was equivalent to 25 percent of the mean annual rainfall in Fort Pierce, Florida. Compost for this study consisted of a 1:1 mix of biosolids and yard waste. Over the study period, nitrate concentrations dropped from 2000 mg/L to near 0 mg/L. Concentrations of total dissolved P in leachate rose from 10 mg/L to 35 mg/L before declining to around 28 mg/L. Concentrations of phosphate in leachate rose from 10 mg/L to 30 mg/L before declining to 25 mg/L.

In addition to the experimental results presented above, other authors (Block, 2000; Goldstein, 2002) have summarized compost demonstration projects from around the USA. Block (2000) summarizes projects in Texas and Connecticut where compost helped establish vegetation in resistant or difficult areas. The Connecticut study applied different rates of compost to test plots. Compared to a control plot, the compost significantly improved turf establishment. Differences among the treated plots were subtle, suggesting that a small amount of compost helped establish vegetation. Four demonstration projects in Texas showed that compost blended with wood chips could establish vegetation in areas where other methods were unsuccessful. Goldstein (2002) summarizes three studies of compost for erosion control and observes that “Positive results are also found when establishing vegetation on a slope with seeded compost.”

In summary, previously published studies indicate that:

- Compost can help establish vegetation in difficult locations (Block, 2000; Goldstein, 2002)
- Compost reduces sediment loss in runoff (Bresson et al., 2002; Faucette et al., 2004) and reduces peak discharge (Kirchoff et al., 2003).

- Nitrate concentrations in leachate or runoff from composted areas tend to decrease dramatically after the initial rain event before stabilizing. (Kirchoff et al., 2003; Xia et al., 2007; Easton and Petrovic, 2004).
- Total phosphorus and phosphate observations did not exhibit a readily apparent trend. Kirchoff et al. (2003) observed relatively constant phosphorus levels in leachate, while Xia (2007) observed increasing concentrations. Easton and Petrovic (2004) observed decreasing phosphorus concentrations in leachate, but varying concentrations in runoff because of repeated fertilizer application. Faucette et al. (2004) found that phosphorus losses in runoff from compost plots were higher than mulch treatments or bare soil.

3 Materials and Methods

3.1 Field Installation

Test plots for this project were constructed on the property of Vulcan Materials Company in southwest Parker County, Texas. The Texas Institute for Applied Environmental Research (TIAER) at Tarleton State University coordinated plot installation, sample analysis, and data collection with the company. Several sites within the quarry were considered for test plot construction. Several of the possible locations were very steep, making installation of treatments and monitoring equipment difficult (Figure 3-1).

Figure 3-1 Potential installation site

Ultimately, a site with more accessible terrain was selected for test plot installation. Plots were 40 feet long and 8 feet wide and had an average slope of 12 percent. The plot orientation and size were selected to encourage formation of erosive features such as rills that might distinguish the erosion control treatments. Plots were also sized to balance the runoff volume with the size of a readily available livestock water tank. To estimate the volume of runoff, plots were assumed to have an SCS curve number of 88, which is appropriate for pasture or rangeland with little vegetation coverage and underlain with silty clay soils.

The quarry staff at Vulcan provided assistance in construction of test plots and in various other areas of this project. Contributions of quarry personnel time, labor, and expertise were instrumental to the overall success of the project. These contributions included assistance in site selection, transportation of overburden to the test plot area, test plot grading (Figure 3-2), formation of earthen berms between each plot and above the plot area to isolate runoff, periodic site access repairs, watering of plots to aid vegetative establishment during the first few months, and arrangement of on-site meetings and tours. Coordination of these endeavors with quarry staff was effortless as quarry personnel were very supportive of the project and willing participants.

Figure 3-2 Construction of Test Plots

Each plot was equipped with a runoff collection system consisting of a gutter and tank. A 6-inch PVC pipe was cut lengthwise to function as a gutter. Metal flashing prevented water from flowing under the gutter. Flow from the gutter was collected in a 160 gallon livestock water tank. Prior to installation, the relationship between depth and volume for each tank was calibrated by measuring the depth associated with a known volume of water. A tipping bucket rain gauge recorded every time 0.01 inches of rainfall accumulated in the gauge. Figure 3-3 shows the overall installation.

Figure 3-3 Test Plots with Runoff Collection System and Rain Gauge

Three different erosion control treatments were applied in May 2006 to eight of the 10 test plots, with two plots left untreated for experimental control. Treatments were assigned to plots as shown in Figure 3-4. Two treatments utilized a 1:1 blend of composted dairy manure and wood mulch. One of these treatments utilized compost with relatively low organic matter (OM) content consistent with TxDOT Special Specification 1001, while the other utilized compost with higher OM content in accordance with TxDOT Specification 161. The third treatment consisted of Biocover Daily Landfill hydromulch, manufactured by Profile Products LLC. Table 3-1 summarizes the composition and nutrient content of the erosion control treatments

Table 3-1 Erosion Control Treatments

Treatment	Application Rate (kg/ha)	Total Nitrogen[a] (kg/ha)	Total Phosphorus[a] (kg/ha)	Composition	
				Wood Fiber	Other
Low OM[b]	282,454[c]	1375	585	50%	50% composted dairy manure (12.8% organic matter)[d]
High OM[e]	282,454[c]	3249	1565	50%	50% composted dairy manure (29.6% organic matter)[d]
Hydromulch	2,242	18	22	67%	20% corrugated carton fiber, 10% Tackifier

[a] Nutrients in compost-blend based on laboratory analysis. Nutrients in hydromulch based on information from the manufacturer on the addition of liquid fertilizer.
[b] Organic content meets TxDOT specification 1001.
[c] Assumes compost-blend applied at a rate of 141 kg/ha (126 ton/acre) based on 2.5 cm (1-inch) compost and 2.5 cm (1-inch) wood chips.
[d] TSU/TAES Compost Analysis Laboratory using TMECC methods
[e] Organic content meets TxDOT special specification 161.

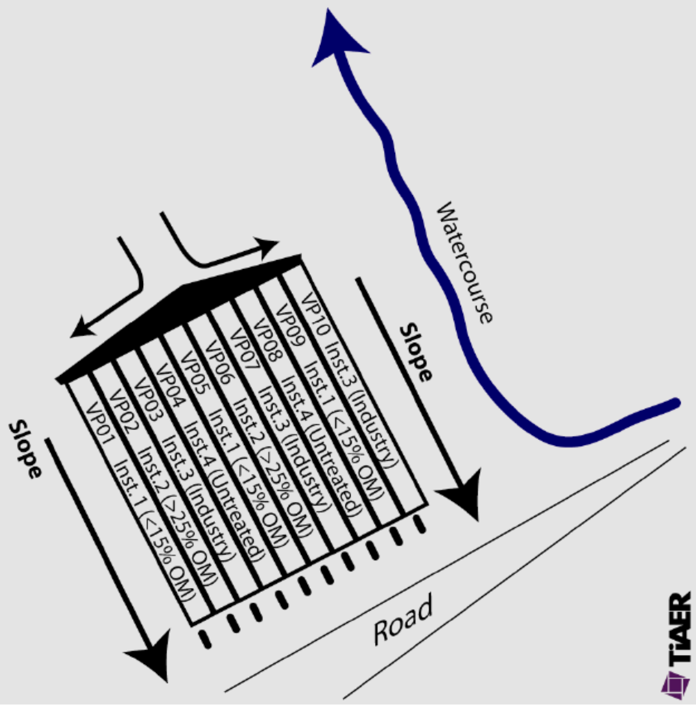

Figure 3-4 Schematic of Test Plot Installation

The designated treatment was blown onto compost-treated plots using a hose (Figure 3-5). The compost treated plots were then hand seeded with grass and lightly raked to incorporate the seed. The hydromulch plots were hand seeded with grass prior to treatment application. Ernie Parker of Finish Line Supply applied the hydromulch. All plots were seeded with Giant bermudagrass (*Cynodon dactylon*, var. *aridus*) at a rate of 17.6 kg/ha and Common bermudagrass (*Cynodon dactylon*) at a rate of 6.4 kg/ha.

Figure 3-5 Installation of Erosion Control Compost

3.2 Compost Testing

Compost installed on test plots was analyzed in accordance with requirements for use by the TxDOT. Two compost samples were analyzed for percent organic matter, total nitrogen (total- N), and total phosphorus (total-P) by the Tarleton State University/Texas Agriculture Extension Service (TSU/TAES) Compost Analysis Laboratory following certified Test Methods for the Examination of Composting and Compost (TMECC) methodology (Table 3-2). The TSU/TAES Compost Analysis Laboratory participates in the United States Composting Council (USCC) Seal of Testing Assurance program. The two compost samples were also analyzed by the TIAER Laboratory for percent organic matter, total Kjeldahl nitrogen (TKN), extractable nitrate nitrogen (Ext-NO_3-N), total-P, and Mehlich III extractable phosphorus (ext-P) in order to provide consistency between the methods used and results obtained for the compost and soil testing portions of the project. Two additional samples were collected after blending of the compost with mulch. These blended-compost samples were only analyzed by the TIAER Laboratory.

Table 3-2 Analysis Methods and Reporting Limits for Compost and Soil Parameters.

Parameter	Method [a]	Reporting Limit [b]	Laboratory	Matrix
Organic Matter (%)	TMECC 05.07A	0.1	TSU/TAES	Compost
Total Nitrogen (mg/kg)	TMECC 04.02D	20	TSU/TAES	Compost
Total Phosphorus (mg/kg)	TMECC 04.03A	4	TSU/TAES	Compost
Organic Matter (%)	SM2540G	1.0	TIAER	Compost and Soil
Total Kjeldahl Nitrogen (mg/kg)	EPA 351.2 modified [c]	2.0	TIAER	Compost and Soil
Total Phosphorus	EPA 365.4 modified [c]	1.0	TIAER	Compost and Soil
Extractable Nitrate (mg/kg)	EPA 353.2 [d]	0.5	TIAER	Compost and Soil
Extractable Phosphorus (mg/kg)	EPA 365.2 [c]	0.1	TIAER	Compost and Soil

[a] TMECC refers to Test Methods for the Examination of Composing and Compost (TMECC, 2004), SM refers to Standard Methods for the Examination of Water and Waste Water (APHA, 1998), and EPA refers to USEPA Methods for Chemical Analysis of Water and Wastewater (USEPA, 1983).

[b] Reporting limits for solids are estimated on percent dry solids. All soil and compost parameters are reported on a dry weight basis as calculated.

[c] Modification of the TKN and TP methods involves using copper sulfate as the catalyst instead of mercuric sulfate.

[d] Extraction procedures for NO_3-N (deionized water) and P (Mehlich III) follow Soil Science Society of America, Methods of Soil Analysis (SSSA, 1996).

The following protocol was followed for field sampling of compost and the compost-blend. Using a collection device (e.g., hand trowel or spade), at least 15 representative samples were collected from the compost pile and placed in a plastic bucket. Representative composite sampling of blended stockpile was conducted per TMECC Method 02.01-A, “Compost Sampling Principles and Practices.” After thorough mixing, a composite sample of the compost was taken from the bucket, placed in a plastic bag (labeled with date, time, and sample pile), and stored in an iced chest for transport to the TIAER Laboratory. Of note, the compost-blend samples were collected from the applicator hose during treatment installation to ensure quality control. Splits of the compost samples were analyzed by the two laboratories, while the compost-blend was analyzed only by the TIAER laboratory.

3.3 Water Sample Collection and Laboratory Analysis

All storm events were monitored for runoff volume and TSS during the first few months after treatment application. Beginning September 1, 2006, the monitoring strategy was altered to only sample events when there was sufficient runoff from all 10 plots to conduct the required chemical analyses. In late November 2006, due to the larger than expected number of events that had occurred to date, the monitoring strategy was further amended to sample only one event (where all 10 plots responded) every two months starting January 2007. These modifications were necessary to spread out the 16 budgeted events over the project to track changes over time as well as differences between treatments.

Upon completion of a storm event selected for sampling, TIAER personnel tabulated the rainfall depth and runoff volume and collected a water sample. Stock tanks were covered between storms to prevent contamination. The TIAER lab analyzed water samples to determine the concentration of the following water quality parameters: TSS, nitrate, TKN, dissolved-P, and total-P. Table 3-3 provides a detailed listing of the laboratory methods utilized for this project.

Table 3-3 Laboratory Analysis Methods

Parameter	EPA Method[a]	AWRL[b]	RL[c]
Total Suspended Solids (TSS)	160.2	4	4
Nitrate-plus-nitrite as nitrogen, dissolved, lab filtered[d] (nitrate)	353.2	0.04	0.04
Total Kjeldahl Nitrogen[d] (TKN)	351.2 (modified)[e]	0.02	0.02
Orthophosphate Phosphorus, dissolved, lab filtered[d] (dissolved P)	365.2	0.04	0.005
Total Phosphorus[d] (total P)	365.4 (modified)[e]	0.06	0.06

[a] USEPA (1983)
[b] AWRL = Ambient Water Reporting Limit
[c] RL = Reporting Limit
[d] Due to the amount of sediment in the samples, all samples were filtered and preserved, as necessary, in the TIAER lab.
[e] Method modified to use copper sulfate as the catalyst instead of mercuric sulfate

3.4 Soil Collection and Analysis

Soil samples were collected annually from each plot and represent a depth of 0-6 inches from the surface using a standard soil probe. When soil samples were collected, any treatment material (compost or hydromulch) or vegetation was scraped aside prior to inserting the soil probe. Ten 0-6 inch soil plugs were taken randomly within each plot and composited to represent the soil sample for a plot. Soil parameters evaluated included percent organic matter (OM), total Kjeldahl nitrogen (TKN), extractable nitrate nitrogen, total phosphorus (TP), and extractable phosphorus (ExtP) as outlined in Table 3-2. An initial set of soil samples was collected June 8, 2006 after treatment installation. The second set was collected June 18, 2007 and the third set April 17, 2008.

3.5 Vegetation and Erosion Monitoring

Narrative and digital photographic documentation of the test plots during installation and at least once per quarter afterward were used to document visible evidence of the relative success of the different BMP systems in establishing vegetation and in containing erosion, sediment, and other nonpoint source pollution. Percent vegetation cover was recorded at 30-day intervals based on visual observation (beginning within 60 days of initial installation) until 70 percent cover was attained on both compost-treated BMP systems and at 60-day intervals thereafter.

Encroachment of vegetation between plots was managed manually by installation of metal edging and use of a gas powered trimmer (e.g. weedeater). The trimmer was used to remove vegetation that had clearly encroached from an adjacent plot rather than grown from within the plot itself. This approach to controlling encroachment was deliberately selected over manually pulling-up the runners, or using an herbicide such as glyphosate.

3.6 Runoff Data Analysis

Analysis of storm runoff data focused on the following four areas:

- Comparison of runoff response between treatments and estimation of runoff volumes for storms not monitored using multiple regression techniques,

- Evaluation of concentration data for outliers and changes in concentration over time,
- Comparison of event concentrations between treatments using paired t-tests, and
- Estimation of treatment loadings.

The runoff response of each treatment was evaluated to determine the amount of rainfall required to initiate runoff and the amount of rainfall retained by the treatment once runoff began. This information was used to estimate runoff volumes for unmonitored events. Estimation of runoff volume for storms not monitored was important for evaluating overall runoff volumes and treatment loads. While the project was designed to monitor only 16 rainfall-runoff events, nearly 65 inches of rainfall occurred of which only about 20 inches or 30 percent was monitored. Rainfall was measured throughout the project using a tipping bucket rain gauge logging at one-minute intervals. Multiple regression techniques were implemented to estimate runoff volume for events not monitored based on the relationship of measured runoff volume for each treatment with rainfall depth, time, and peak rainfall intensity for each treatment. Rainfall depth represented the total rainfall associated with a runoff event. Time was defined as the number of days since the first storm event. Rainfall intensity was computed on a 15 minute basis, with the peak intensity being the maximum value for a given storm event. In some cases, runoff overflowed the tank used for volume measurement. These overflow events were excluded from the regression analysis. To compare derived coefficients between treatments, 95 percent confidence intervals were calculated on the regression coefficients.

To initially assess water quality, concentrations were plotted over time to visually observe changes between and within treatments, particularly with the establishment of vegetation, and to determine outliers that should be removed prior to further data analysis. Once outliers were determined, concentrations were averaged for plots within the same treatment. It was anticipated that concentrations of runoff parameters would stabilize over time. To determine if treatments obtained relatively stable runoff concentrations, the time series of concentration for each water quality parameter was divided into regions of changing and steady state concentration by visual inspection. A regression line was fitted to data points within the hypothesized region of relatively constant concentration. If the 95 percent confidence interval for the slope of the regression included zero, indicating no significant relationship, the concentration was considered steady state. The steady state concentration was reported as the average of data points within that region representing the prevailing concentration after establishment of vegetation. Where a stabilized region was not visually evident, no steady-state regression was performed and no concentration was reported.

To compare runoff concentrations between treatments, paired *t* testing was applied to all events. Treatments were compared based on the event average concentration of plots representing each treatment with outliers removed. A p-value from a paired *t* test was calculated for each pair of treatments, so that each water quality parameter had six p-values. These p-values estimate the probability that observations come from the same population. Treatment pairs with a p-value less than 0.05 were considered statistically different.

Measured and estimated nutrient and sediment loadings were calculated for the study period (June 2006 – May 2008) for measured and unmeasured rainfall events. For measured events, the concentration was multiplied by the volume, except when overflow was indicated. For unmeasured events, the runoff volume was estimated using the multiple regression model based on rainfall depth, intensity and time since the first event. Concentrations were linearly interpolated between sampled events based on the date of the unmeasured event. Total loadings were calculated as the sum of measured and unmeasured events.

4 Results and Discussion

4.1 Overview

This project required several types of measurements:

- Nutrient concentrations in soil and compost,
- Vegetation density,
- Rainfall depth and runoff volume, and
- Nutrient and suspended solid concentrations in runoff.

Each measurement relates to the mass of TSS or nutrient exported from the test plots. In the following sections, the categories of data are presented independently. Runoff volume and concentration data are combined to estimate the mass loss of each constituent. The impact of nutrient losses on receiving waters is quantified by deriving export coefficients (kg/ha/yr) for each nutrient and treatment.

4.2 Compost and Soil Testing

Nutrient levels were measured in the soil underlying test plots and of the compost applied to treatments. Nutrient levels in compost relate to the amount of nutrient applied with an erosion control treatment. Levels in soil relate to the nutrient available to all treatments. The level of organic matter was also measured to investigate its relationship with vegetative performance.

Compost alone was tested by two different laboratories. One lab used methods specifically for compost testing, while the other lab used methods for testing soil (Table 3-2). Compost treatments (compost blended with wood mulch) were only tested by the laboratory that used the soil methods.

Analysis of compost samples prior to blending with mulch indicated desired values of about 13 percent OM for the low OM compost and 30 percent OM for the high OM compost following TMECC methods (Table 4-1). Total-N concentrations in the low OM compost were about half that of the high OM compost, while total-P concentrations were about a third as much in the low OM compost as in the high OM compost.

Table 4-1 Analysis of Compost Conducted by TSU/TAES Compost Analysis Laboratory using TMECC methods.

Sample Description	OM(%)	Total-N (mg/kg)	Total-P (mg/kg)
Low OM Compost	12.8	7,100	2,380
High OM Compost	29.6	15,300	6,770

In comparison to the TMECC methods run by the TSU/TAES Laboratory, distinctly lower concentrations for OM were indicated by the TIAER laboratory for split samples (Table 4-2) using Standard Methods (Table 3-2). The ratio of percent OM between the low and high OM compost piles was similar regardless of the method used. The total-N and total-P concentrations for the two types of compost showed fairly similar differences with the TIAER analysis as with the TSU/TAES analysis. Because only one sample of low and high OM compost was split and analyzed, these results cannot be used to definitively make any statements about the different analysis methods used by the different laboratories but are meant to provide background information about the OM and nutrient content of the compost.

Table 4-2 Analysis of Compost and Compost-Blend Samples Conducted by TIAER Laboratory.

Sample Description	OM (%)	Extractable P (mg/kg)	Extractable NO_3-N (mg/kg)	TKN (mg/kg)	Total-P (mg/kg)
Low OM Compost	8.5	133	549	5,150	2,600
High OM Compost	19.0	207	227	10,900	5,880
Low OM Compost-Blend	17.1	99.4	7.34	4,860	2,070
High OM Compost-Blend	22.6	129	3.02	11,500	5,540

After blending with the mulch, the OM associated with both types of compost increased notably (Table 4-2). Total-P and TKN concentrations of the blended compost stayed fairly similar to the unblended, while a very sharp drop in NO_3-N occurred along with a small drop in extractable-P concentrations (Table 4-2).

Soils underlying each treatment plot indicated very low extractable P and NO_3-N concentrations (Table 4-3). All extractable P concentrations were below 3 mg/kg and except for the first year, extractable NO_3-N concentrations were less than 2 mg/kg. On the untreated and hydromulch plots, concentrations of TKN and total-P stayed essentially constant over the study period (Figure 4-1). Mean TKN and total-P concentrations in the soil under the compost treated plots doubled over the study period, though the increase was not statistically significant due to the wide range of values measured in 2008.

Table 4-3 Soil analysis results for 0-6 inch samples collected annually.

Treatment	Site	Date	Ext P (mg/kg)	Ext NO_3-N (mg/kg)	TKN (mg/kg)	Total-P (mg/kg)	OM (%)
Untreated	VP04	6/8/2006	< 0.9[a]	9	390	233	1.4
		6/18/2007	< 0.9	< 2[b]	540	239	2.7
		4/17/2008	< 0.9	< 2	484	236	< 1.0[c]
	VP08	6/8/2006	< 0.9	11	423	227	3.0
		6/18/2007	< 0.9	< 2	520	256	2.7
		4/17/2008	< 0.9	< 2	507	271	< 1.0
High OM	VP02	6/8/2006	< 0.9	9	453	238	1.8
		6/18/2007	< 0.9	< 2	749	351	2.9
		4/17/2008	1.1	< 2	644	297	< 1.0
	VP06	6/8/2006	< 0.9	9	411	227	2.1
		6/18/2007	< 0.9	< 2	634	310	3.0
		4/17/2008	1.5	< 2	1053	453	1.1
Hydromulch	VP03	6/8/2006	< 0.9	9	376	304	1.8
		6/18/2007	< 0.9	< 2	620	359	2.7
		4/17/2008	< 0.9	< 2	646	380	< 1.0
	VP07	6/8/2006	< 0.9	12	498	328	2.2
		6/18/2007	< 0.9	< 2	565	308	2.9
		4/17/2008	< 0.9	< 2	626	298	< 1.0
	VP10	6/8/2006	< 0.9	13	480	300	2.3
		6/18/2007	< 0.9	< 2	578	327	2.8
		4/17/2008	< 0.9	< 2	528	300	< 1.0
Low OM	VP01	6/8/2006	< 0.9	15	576	294	2.2
		6/18/2007	< 0.9	< 2	757	309	2.9
		4/17/2008	< 0.9	< 2	709	272	< 1.0
	VP05	6/8/2006	< 0.9	12	387	211	2.0
		6/18/2007	< 0.9	< 2	659	306	3.0
		4/17/2008	1.1	< 2	1024	400	1.1
	VP09	6/8/2006	< 0.9	19	419	234	2.3
		6/18/2007	< 0.9	< 2	763	279	3.2
		4/17/2008	2.2	< 2	1506	507	1.4

[a] Measured values are less than the Ext P method detection limit of 0.9 mg/kg.

[b] Measured values are less than the Ext NO_3-N method detection limit of 2 mg/kg.

[c] Measured values are less than the OM reporting limit of 1.0 %.

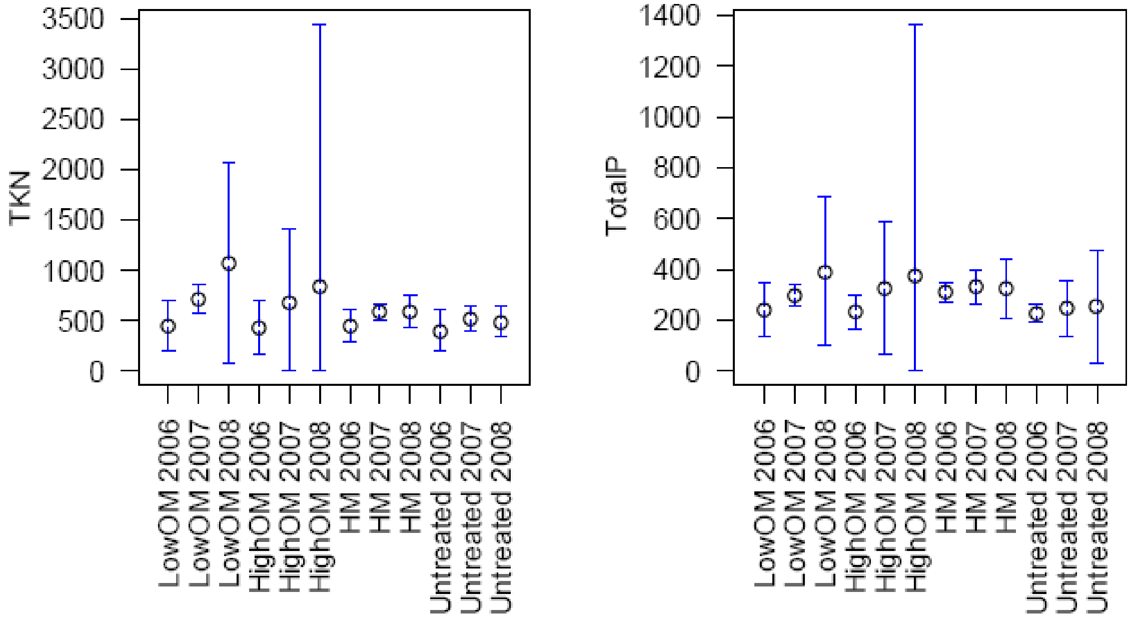

Figure 4-1 Soil test values and 95 percent confidence intervals by treatment and year

Nutrients from the compost materials clearly are leaching into the soils increasing the nutrient content of the underlying soil. While TKN and total P in the soils are increasing, the extractable nutrient concentrations in year 3 were near or below the laboratory reporting limit. The calcareous nature of the soils associated with the mining operation tightly binds most phosphorus making it unavailable in runoff unless moved with eroded sediment.

4.3 Vegetation

Vegetative cover was monitored throughout the study to see how quickly the different treatments established vegetation. The fraction of vegetative cover was estimated on thirteen occasions after treatments were established (Table 4-4 and Figure 4-2). Compost plots established vegetation faster than other treatments, achieving complete (100 percent) cover in about four months.

Table 4-4 Monthly Vegetative Cover Estimated as Percent of Plot

	Treatment and Plot Numbers									
	Low OM			High OM		Hydromulch			Untreated	
Date	1	5	9	2	6	3	7	10	4	8
7/14/06	10	10	<10	10	<10	10	25	15	<1	0
8/14/06	20	20	10	15	15	10	25	15	<1	0
9/14/06	70	80	55	60	70	15	35	30	<1	0
10/14/06	100	99	100	100	100	30	50	60	<1	<1
12/14/06	100	100	100	100	100	45	65	75	1	1
2/21/07	100	100	100	100	100	45	65	75	1	1
4/19/07	100	100/99[a]	100	100	100/95[a]	45	70	75	1	1
6/18/07	100	100/99[a]	100	100	100/99[a]	95	99	99	10	20
8/20/07	100	100	100	100	100	100	100	100	50	80
10/16/07	100	100	100	100	100	100	100	100	95	100
1/3/08	100	100	100	100	100	100	100	100	95	100
2/14/08	100	100	100	100	100	100	100	100	95	100
4/17/08	100	100	100	100	100	100	100	100	95	100

[a] Represents percent coverage of new vegetative growth.

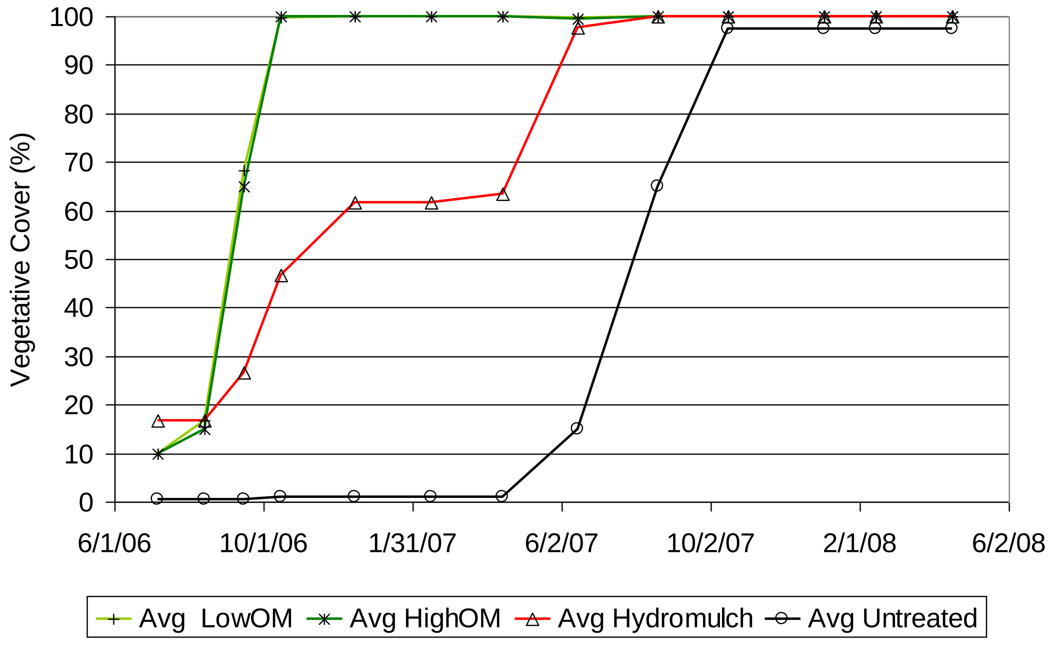

Figure 4-2 Vegetative Cover (average of replicate plots) over time

Based on visual observation, the compost plots appeared to establish vegetation at the same rate. However, visual observation cannot detect small differences in vegetation density, so the two types of compost treatments may actually establish vegetation at different rates. The hydromulch plots took almost three times longer than the compost plots, establishing complete coverage after a year. Even after a year, the seeded bare soil plots had little vegetation, which was consistent with the higher nutrient levels present in the hydromulch and compost and agrees with observations of Bresson (2002). The advantage of compost over hydromulch is that compost provides a better place for seeds to germinate and retains more water (Kirchoff et al., 2003).

Harsh climactic conditions inhibited the vegetative establishment of all treatments during the first summer of the study. Severe drought conditions existed from June 2006 through August 2006, with less than 1 inch of rain during this period. Furthermore, extreme temperatures were experienced during August 2006 with several days over 100ºF. Due to drought conditions, supplemental watering of test plots was performed by Vulcan staff throughout June, July, and August 2006 to help establish vegetation.

Rainfall events occurring in September and October 2006 substantially increased vegetative growth on compost treated plots (see Appendix C – Monthly and Bimonthly Narrative Observations for September/October 2006). This growth resulted in the unanticipated encroachment of compost plot vegetation onto nearby hydromulch and untreated plots. Metal landscape edging (about 4 inches in height) was installed between each plot on April 19, 2007 to curtail the encroaching vegetation (Figure 4-3). Also, beginning in June 2006, periodic grass trimming along the metal edging was performed to help control runner advancement between each plot. These combined efforts proved to be effective in controlling further vegetative encroachment between the plots.

Figure 4-3 Example of vegetation encroachment

4.4 Runoff Volume

The volume of runoff produced by each test plot was measured to determine the amount of rainfall retained by each treatment, facilitate the computation of mass losses during monitored events, and provide a basis for estimating runoff volumes for events that were not monitored. During this project, the field site had 136 rain days with 65 inches of total rainfall. Complete volume and water quality observations—nonzero data for each of the 10 plots—were collected from 16 storm events throughout the project. Partial data, usually runoff volume, were measured for seven additional events. Table 4-5 summarizes average runoff volumes for the events for which data were collected. Appendix B contains all the runoff volume and water quality data collected for this project. Rainfall from events with complete data totaled 19.77 inches or 30 percent of the total rainfall. Relatively large storms (> 1.9 inches) in September, October, and November 2006 caused the runoff collection tanks to overflow, so runoff volume could not be determined for those events.

Table 4-5 Storm Events with Volume or Water Quality Data

Date			LowOM	HighOM	Hydromulch	Untreated
6/17/2006	0.36	No	0	3	4	22
6/17/2006	1.23	Yes	77	94	124	152
6/23/2006	0.28	No	0	0	0	13
6/24/2006	0.40	No	2	2	37	54
7/4/2006	1.11	Yes	65	62	135	159
8/12/2006	0.11	No	0	0	0	3
8/14/2006	0.45	Yes	12	8	50	59
8/27/2006	1.25	Yes	40	19	140	154
9/3/2006[a]	2.68	No	n/a	n/a	n/a	n/a
9/17/2006[a]	1.92	Yes	n/a	n/a	n/a	n/a
10/10/2006	0.45	No	0	0	25	100
10/15/2006[a]	2.51	Yes	n/a	n/a	n/a	n/a
10/24/2006	0.26	No	0	0	8	7
11/5/2006[a]	2.56	Yes	n/a	n/a	n/a	n/a
1/3/2007	0.70	Yes	10	10	82	73
3/11/2007	0.59	Yes	2	2	19	21
4/30/2007	0.97	Yes	7	4	67	83
6/1/2007	0.76	Yes	2	2	59	76
10/22/2007	0.65	Yes	2	2	2	13
11/25/2008	1.78	Yes	9	9	60	135
2/15/2008	1.10	Yes	9	15	83	126
3/18/2008	1.37	Yes	9	14	115	144
4/9/2008	0.87	Yes	11	19	122	158
Total:	24.36		257	261	1132	1546

[a] Overflow event--volume not applicable (n/a)

For each treatment, the relationship between runoff and rainfall, time, and peak rainfall intensity was explored using multiple regression. The regression analysis excluded overflow events, but included data from the seven additional storms where only some but not all 10 plots responded. The regression equations have the form

Runoff = A + B*Rainfall + C*Day Number + D*Peak Intensity **Equation 1**

where Runoff is the depth of runoff in inches,

Rainfall is the depth of rainfall in inches,

Day Number is the number of days since the first event to account for changing vegetation coverage, Peak Intensity is the peak rainfall intensity for a 15 minute period in inches per hour, and

A, B, C & D are coefficients determined by the regression.

Equation 1 uses runoff depth which is calculated as the runoff volume divided by the plot area. Using depth rather than volume facilitates comparisons between watersheds of different sizes.

In Equation 1, the date and intensity terms can be thought of as adjustments to the intercept. Once these terms are known, the multiple regression becomes a line in two dimensions. Figure 4-4 shows results from the rainfall-runoff multiple regression relationship for varying rainfall depths or storm sizes occurring halfway through the monitoring period (day number = 332) with the median observed precipitation intensity of 0.554 inches/hr. If the values for day number and rainfall intensity are changed, the lines in Figure 4-4 would have the same slope, but move vertically depending upon the date and the precipitation intensity input into the regression model.

The runoff characteristics of each treatment may be conceptualized as an initial abstraction and a continuous abstraction. The initial abstraction is the rainfall depth after which runoff begins. In Figure 4-4, the initial abstraction corresponds to the intersection of the regression line for each treatment with the abscissa (x-axis). Since the compost lines in Figure 4-4 move vertically with time, the initial abstraction also changes, though changes with time were not significant for the hydromulch and untreated plots (Table 4-6). After 180 days, runoff from the compost plots begins after nearly 0.5 inches of rainfall but after 540 days (18 months) requires 1 inch to initiate runoff. The hydromulch and untreated plots had an initial abstraction of nearly 0.2 inches. These differences matter because the median rainfall depth for this study was 0.31 inches. The compost plots do not produce runoff for more than half of the storm events. Bresson et al. (2001) and Faucette et al. (2004) also showed that compost delayed runoff compared to bare soil.

The continuous abstraction is the fraction of rainfall that becomes runoff after the initial abstraction. In Figure 4-4, the continuous abstraction corresponds to the slope of the line. Slopes associated with rainfall depth ranged from 0.22 for the low OM compost treatment to 0.5 for untreated plots (Table 4-6). Even after the initial abstraction, a smaller volume of runoff is expected from the compost plots than the other treatments, because the slope of the line is flatter.

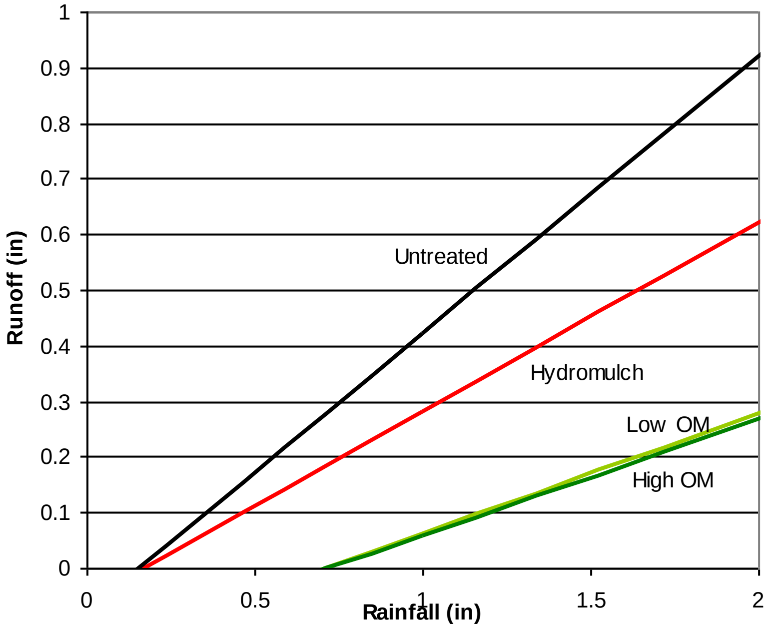

Figure 4-4 Illustrative rainfall-runoff relationship for varying rainfall depths assuming storms occurred halfway through the monitoring period with the median observed precipitation intensity

Table 4-6 Multiple Regression Summary by Treatment for Equation 1

Regression Coefficient or Statistic	Treatment			
	Low OM	High OM	Hydromulch	Untreated
A (inches)	-0.066 9	-0.080 2	-0.111	-0.154
B (no units)	0.215	0.207	0.341	0.500
C (inches)	-0.000363	-0.000327	-0.000165[a]	-0.0000917[a]
D (hours)	0.0610	0.0739	0.189	0.187
Residual Standard Error	0.0573	0.0775	0.130	0.089
Adjusted R^2	0.823	0.731	0.733	0.909

[a] Parameter estimate for the regression coefficient was not statistically significant at level 0.05

Also presented in Table 4-6 are the residual standard error and adjusted R^2 values for the regression analysis. The adjusted R^2 estimates the fraction of variability in the data that is accounted for by the model, after adjusting for the number of model parameters. Adjusted R^2 values ranged from 0.731 for the high OM plots to 0.909 for the untreated plots. The residual standard error is a measure of how well the multiple regression equation reproduces measured values. The low OM plots had the lowest residual standard error (0.0573) of all treatments while the hydromulch plots had the highest residual standard error (0.130).

One impact of a higher residual standard error is wider confidence intervals for the regression coefficients. While the other variables were important in characterizing the amount of runoff, rainfall depth was the primary variable driving the regression equation results. The confidence intervals about the estimated regression coefficient for rainfall depth (parameter B) are shown in (Figure 4-5). The widest confidence interval (Figure 4-5) and the highest residual standard error for the overall multiple regression equation (Table 4-6) were indicated for the hydromulch treatment. The confidence intervals shown in Figure 4-5 in part confirm that the compost plots offer similar runoff performance because the confidence intervals overlap. The confidence intervals about parameter B (rainfall depth) also indicate that the industry BMP (hydromulch) was not statistically different from untreated plots or the compost plots for this parameter. It should be noted however, that the small overlap of the hydromulch interval with the compost and untreated plots represents a very small chance that the slope coefficients are actually the same.

All of the regression coefficients were statistically significant ($p<0.05$) except for day number (coefficient C) on the hydromulch ($p=0.06$) and untreated plots ($p=0.21$). The p-value for hydromulch is very close to the cutoff value of 0.05, suggesting that the treatment probably does produce less runoff as time passes and vegetation grows. The p-value for untreated plots is further from the cutoff making any inferences difficult. Additional statistical results regarding the multiple regression models are provided in **Appendix C: Statistical Details**.

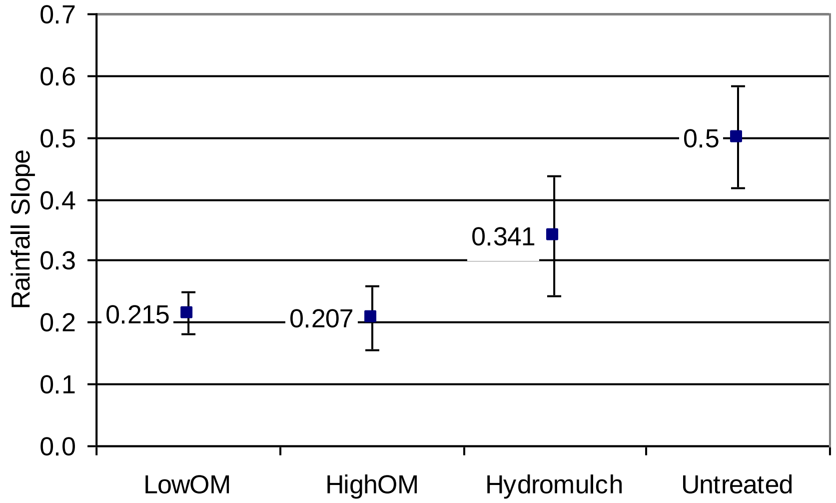

Figure 4-5 Regression coefficients for rainfall slope and 95 percent confidence intervals

The regression coefficients shown in Table 4-6 were used to project runoff volumes for unmeasured events and those events during which the tanks overflowed. In some cases the runoff volume measured for an overflow event (i.e., the volume of the tank) exceeded the volume predicted by the regression equation, suggesting that the overflow was small. The volume of the collection tank was used in these cases. Table 4-7 shows the estimated runoff volume from each treatment for events where only rainfall was recorded.

Table 4-7 Projected Runoff Volumes for Events Not Measured

Date and Time Rainfall Began	Rainfall (inches)	Day Number	Peak 15 min. Intensity	Runoff Volume (gallons per plot)			
				Low OM	High OM	Hydromulch	Untreated
8/11/2006 15:52	0.07	56	NA[a]	0	0	0	0
9/1/2006 17:36	0.13	77	0.147	0	0	0	0
10/14/2006 11:11	0.18	119	0.24	0	0	0	0
11/29/2006 17:37	0.52	166	0.64	5	4	32	42
12/1/2006 9:22	0.08	167	0.126	0	0	0	0
12/19/2006 10:05	0.58	185	0.58	5	4	33	45
12/25/2006 5:27	0.01	191	NA	0	0	0	0
12/29/2006 5:43	0.59	195	0.528	4	3	32	44
1/12/2007 13:17	0.48	210	0.328	0	0	16	26

Date and Time Rainfall Began	Rainfall (inches)	Day Number	Peak 15 min. Intensity	Runoff Volume (gallons per plot)			
				Low OM	High OM	Hydromulch	Untreated
1/17/2007 12:07	0.02	215	NA	0	0	0	0
1/18/2007 11:43	0.2	215	0.124	0	0	0	0
1/19/2007 5:45	0.97	216	0.131	14	12	42	67
1/21/2007 9:23	0.01	218	NA	0	0	0	0
2/1/2007 4:23	0.32	229	0.12	0	0	0	1
2/2/2007 8:54	0.01	230	NA	0	0	0	0
2/12/2007 6:22	0.13	240	0.084	0	0	0	0
2/24/2007 5:26	0.1	252	NA	0	0	0	0
3/22/2007 12:17	0.01	278	NA	0	0	0	0
3/23/2007 3:50	0.01	279	NA	0	0	0	0
3/26/2007 9:24	1.88	282	1.04	59	58	136	191
3/29/2007 5:16	2.28	285	1.44	81	81	178	245
4/7/2007 10:24	0.12	294	0.091	0	0	0	0
4/10/2007 1:28	0.02	297	NA	0	0	0	0
4/13/2007 16:28	0.33	301	0.52	0	0	10	16
4/17/2007 8:27	0.67	304	1.281	9	11	62	78
4/24/2007 9:01	2	311	1.638	70	70	166	224
5/2/2007 16:09	1.31	320	2.4	49	53	147	184
5/5/2007 10:16	0.01	322	NA	0	0	0	0
5/7/2007 7:56	0.05	324	NA	0	0	0	0
5/9/2007 1:46	0.22	326	0.22	0	0	0	0
5/9/2007 17:15	0.04	327	NA	0	0	0	0
5/10/2007 6:09	0.12	327	0.24	0	0	0	0
5/12/2007 14:03	0.38	330	0.843	0	0	25	33
5/14/2007 16:00	0.01	332	NA	0	0	0	0
5/24/2007 13:58	0.53	342	0.726	0	0	30	43
5/25/2007 15:26	1.51	343	1.08	40	40	110	154
5/26/2007 16:11	0.09	344	NA	0	0	0	0
5/27/2007 11:10	0.01	344	NA	0	0	0	0
5/29/2007 4:57	2.28	346	3.2	98	103	242	310
5/31/2007 0:22	0.06	348	0.162	0	0	0	0
6/3/2007 6:54	0.31	351	1.164	0	0	31	37
6/10/2007 22:04	0.02	359	NA	0	0	0	0
6/14/2007 0:48	0.02	362	NA	0	0	0	0
6/14/2007 12:42	0.52	362	0.42	0	0	17	30
6/15/2007 6:10	1.86	363	1.607	60	61	153	208
6/15/2007 22:19	0.35	364	0.46	0	0	7	15
6/16/2007 23:33	2.37	365	1.6	81	81	188	259
6/20/2007 3:20	0.49	368	0.373	0	0	13	25
6/21/2007 15:31	0.16	370	0.241	0	0	0	0
6/24/2007 18:36	0.03	373	NA	0	0	0	0
6/25/2007 10:43	0.01	373	NA	0	0	0	0
6/26/2007 5:32	2.73	374	1.333	93	92	202	285
6/27/2007 17:05	0.19	376	0.112	0	0	0	0
6/29/2007 16:48	0.81	378	1.34	10	12	71	93
7/1/2007 13:19	0.2	380	0.4	0	0	0	0
7/2/2007 13:08	0.27	381	0.463	0	0	1	7

				Runoff Volume (gallons per plot)			
Date and Time Rainfall Began	Rainfall (inches)	Day Number	Peak 15 min. Intensity	Low OM	High OM	Hydromulch	Untreated
7/3/2007 11:01	0.35	381	0.68	0	0	15	23
7/4/2007 15:23	0.32	383	0.245	0	0	0	3
7/5/2007 13:59	0.02	384	0.01	0	0	0	0
7/8/2007 15:33	0.01	387	NA	0	0	0	0
7/23/2007 15:42	0.11	402	0.099	0	0	0	0
7/28/2007 16:55	0.04	407	NA	0	0	0	0
8/2/2007 7:40	1.12	411	1.4	22	24	93	126
8/17/2007 15:50	0.58	427	0.743	0	0	31	47
8/30/2007 18:31	0.09	440	NA	0	0	0	0
9/1/2007 14:28	0.36	442	0.702	0	0	14	23
9/2/2007 13:46	0.52	443	1.104	0	0	40	54
9/3/2007 14:17	0.19	444	0.61	0	0	0	3
9/4/2007 18:18	0.72	445	0.304	0	0	24	44
9/9/2007 20:14	0.02	450	NA	0	0	0	0
9/10/2007 8:46	1.85	450	1.16	47	48	133	189
9/18/2007 21:28	0.07	459	0.056	0	0	0	0
10/15/2007 5:25	0.43	485	0.62	0	0	15	26
11/22/2007 22:12	0.11	524	0.061	0	0	0	0
12/1/2007 10:15	0.01	532	NA	0	0	0	0
12/10/2007 17:50	0.01	542	NA	0	0	0	0
12/11/2007 6:42	0.22	542	0.12	0	0	0	0
12/12/2007 8:14	0.26	543	0.134	0	0	0	0
12/14/2007 15:19	0.1	546	0.031	0	0	0	0
12/26/2007 3:02	0.04	557	0.047	0	0	0	0
1/22/2008 11:12	0.01	584	NA	0	0	0	0
1/25/2008 1:40	0.18	587	0.28	0	0	0	0
1/26/2008 9:20	0.01	588	NA	0	0	0	0
2/12/2008 3:09	0.06	605	NA	0	0	0	0
2/17/2008 6:21	0.01	610	NA	0	0	0	0
3/3/2008 0:29	1.51	625	1.173	20	23	104	152
3/6/2008 9:37	0.19	628	0.224	0	0	0	0
3/6/2008 22:12	0.49	629	0.213	0	0	0	15
3/9/2008 20:49	0.32	632	0.405	0	0	0	5
4/4/2008 0:15	0.44	657	0.98	0	0	23	38
4/8/2008 21:06	0.52	662	0.662	0	0	16	34
Total:	40			768	780	2,452	3,444

[a] NA indicated not applicable. The rainfall event was less than 15 minutes.

The compost plots were projected to produce much less runoff than hydromulch or untreated plots (Table 4-8). This result is consistent with the work of Bresson et al. (2001), Kirchoff et al. (2003), and Easton and Petrovic (2004). The availability of nutrients and ability of the compost material to hold water on the plots greatly aided the speed with which vegetation was able to establish on the compost plots compared to the hydromulch and untreated plots. Even when all 10 plots were totally vegetated, the compost treated plots continued to have much lower runoff.

Table 4-8 Estimated Total Runoff Volume

	Total Runoff Volume (gallons per plot)				Fractional Difference from Untreated			
	LowOM	HighOM	Hydromulch	Untreated	LowOM	HighOM	Hydromulch	Untreated
Observed	257	261	1,132	1,546	-83%	-83%	-27%	0%
Estimated	768	780	2,452	3,444	-78%	-77%	-29%	0%
Overflows[a]	449	450	608	802	-44%	-44%	-24%	0%
Total	1,474	1,491	4,192	5,792	-75%	-74%	-28%	0%

[a] runoff volume for overflow events is the larger of the estimated value or the tank volume

4.5 Runoff Concentrations

Like runoff volume, concentrations of the water quality parameters were measured to detect differences between treatments and estimate mass losses. Trends in runoff concentrations were also analyzed to estimate what nutrient levels might be expected in the future.

4.5.1 Variation within and between Treatments over Time

Time series graphs of concentration for each constituent were used to visually evaluate the data for outliers and to assess variations in concentration within and between treatments over time. Time series plots represent the average concentration by event of plots within the same treatment. Points identified as outliers were not used in calculating the average for the treatment. Several points identified as outliers were associated with rodent activity at the field site. In these cases it is thought that rodent excrement in the collection tanks caused very high nutrient concentrations.

Average TSS concentrations from all plots tended to dramatically decrease with time (Figure 4-6), although an increase was noted on the untreated and hydromuch plots in the spring of 2007. These events occurred on April 30 and June 1, 2007, when vegetative cover was notable (45 to 75 percent) on the hydromulch plots and barely existent (1 percent) on the untreated plots (Table 4-4). These two events also occurred after fairly large unsampled rainfall events (see Tables 4-5 and 4-7). The April 30 event had 0.97 inches of rain, and occurred only six days after a 2-inch event (April 24) that was unsampled. Similarly the June 1 event had 0.76 inches of rain , and occurred only three days after a 2.28-inch event (May 29) that was unsampled. The fairly large unsampled rainfall events prior to the sampled events probably helped create soil moisture conditions leading to more sediment runoff from plots with less vegetation. Average TSS concentrations were very high for untreated plots, reaching a maximum of 80,000 mg/L. The second highest TSS concentrations occurred from the hydromulch treated plots. No outliers were identified for event TSS concentrations by plots, so all measured values were used in calculating average TSS concentrations by treatment.

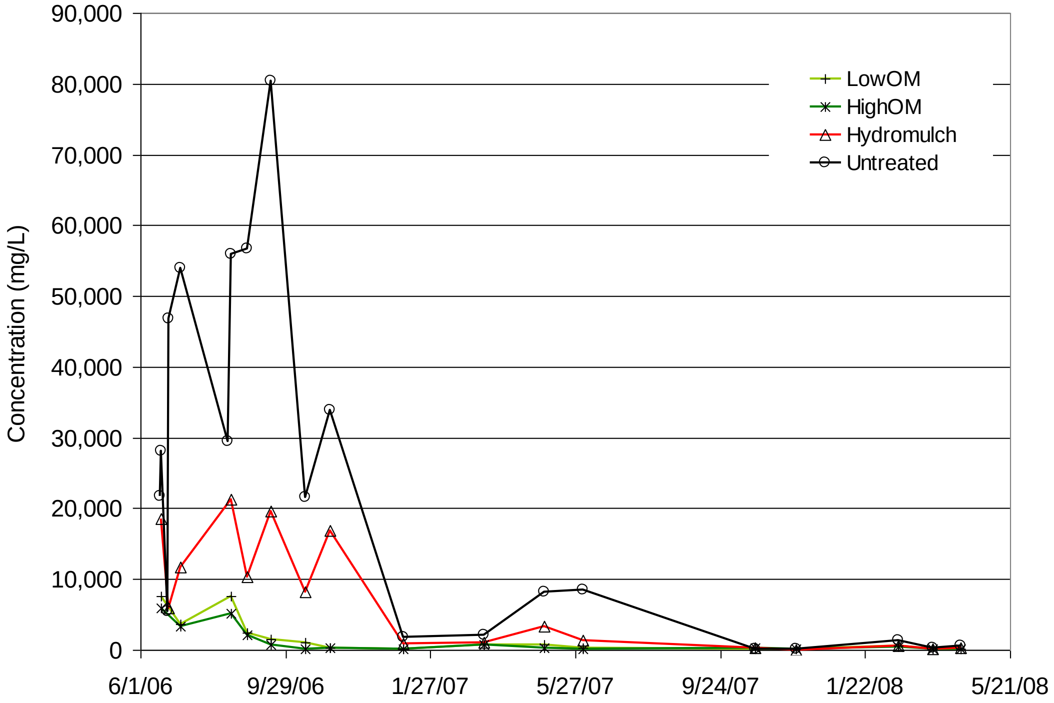

Figure 4-6 Average TSS Concentrations

For TKN, untreated plots tended to have the highest concentrations (Figure 4-7), although all values generally decreased over time. Because fertilizer or nutrients were not applied to the untreated plots, the TKN in runoff appears to have come from the organic content of the soil. High concentrations of TKN were related to the high TSS values, particularly for the untreated plots. Early in the study, the high OM compost plots had higher TKN concentrations than the low OM compost plots, which was consistent with the higher TKN concentrations in the high OM compost blend (11,476 mg/kg) compared with the low OM compost blend (4,863 mg/kg). While obscured by the scale in Figure 4-7 by the end of the study, the low OM plots exhibited slightly higher TKN concentrations. A few TKN concentrations were excluded as outliers in association with events monitored in October and November 2007. These outliers in October and November 2007 may have been related to rodent activity noted within the plots. The inexplicably high TKN concentration reported for an untreated plot in February 2008 was also excluded as an outlier in calculating treatment averages.

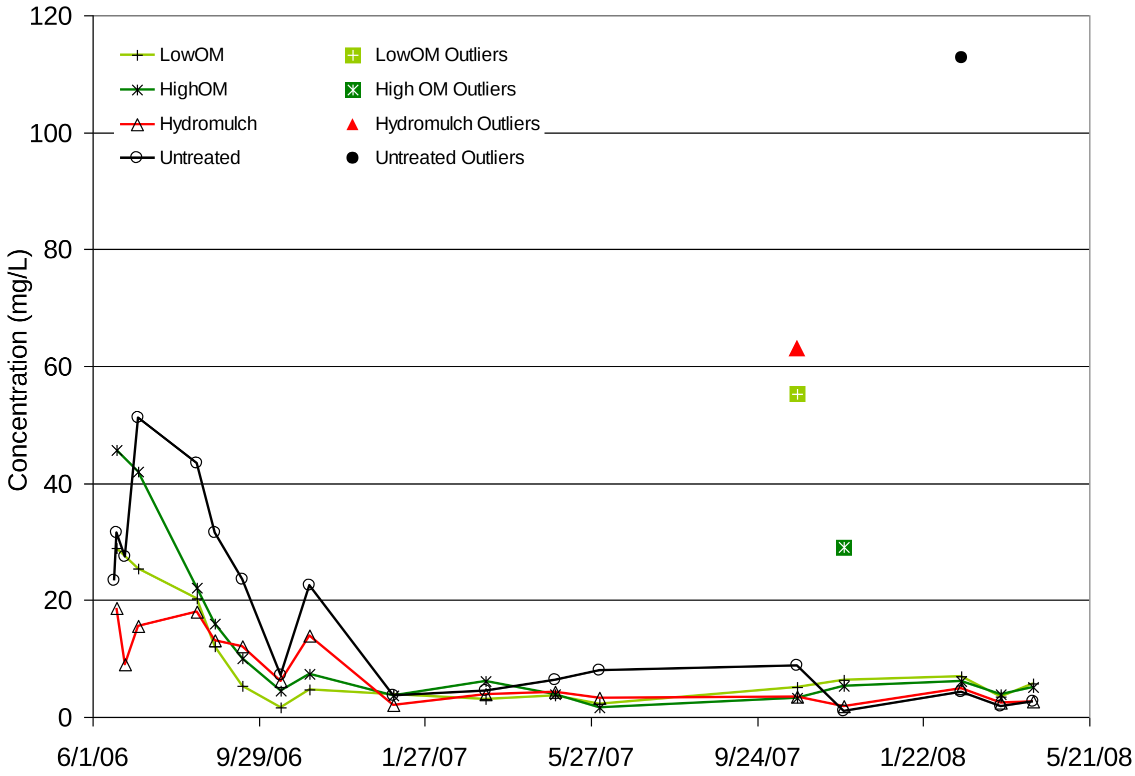

Figure 4-7 Average TKN Concentrations and Outlier Concentrations

For nitrate, the variation in concentrations over time showed a different pattern than TKN or TSS (Figure 4-8). After the first few events, nitrate concentrations tended to show an increasing pattern over time, particularly for the compost treatments. The very high nitrate concentration associated with the low OM compost treatment during the first runoff event (Figure 4-8) is most likely related to the high amount of extractable nitrogen measured in the compost (Table 4-2) and soil test values (Table 4-3). Initial soil test values of nitrate were also slightly higher on two of the low OM plots (VP01 = 15.1 mg/kg and VP09 = 19.5 mg/kg), while the average across all plots was 11.8 ± 3.5 mg/kg. The low OM compost also had a higher extractable nitrate concentration (7.34 mg/kg) than the high OM compost blend (3.02 mg/kg). These higher soil and compost nitrate concentrations most likely explain this spike for the low OM treatment. Nitrate concentrations excluded as outliers occurred in October 2007 were most likely caused by rodent activity. As with TKN, the inexplicably high nitrate concentration reported for an untreated plot in February 2008 was excluded as an outlier.

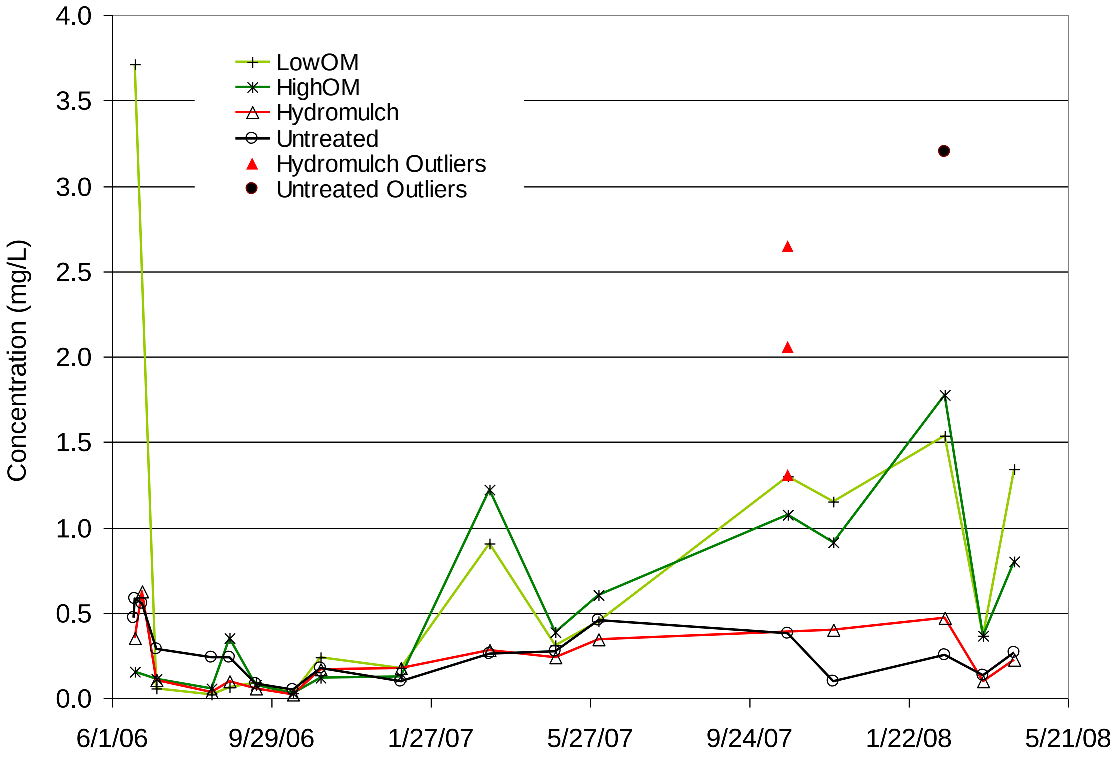

Figure 4-8 Average Nitrate Concentrations and Outlier Concentrations

When nitrate and TKN concentrations were added together to calculate total-N (Figure 4-9), the pattern of runoff concentrations was most similar to those for TKN (Figure 4-7). Nitrate as a percent of total-N ranged from a high of about 10 percent for the compost plots to about 3 percent for the untreated plots, so the dominance of TKN concentrations as part of total-N was not unexpected.

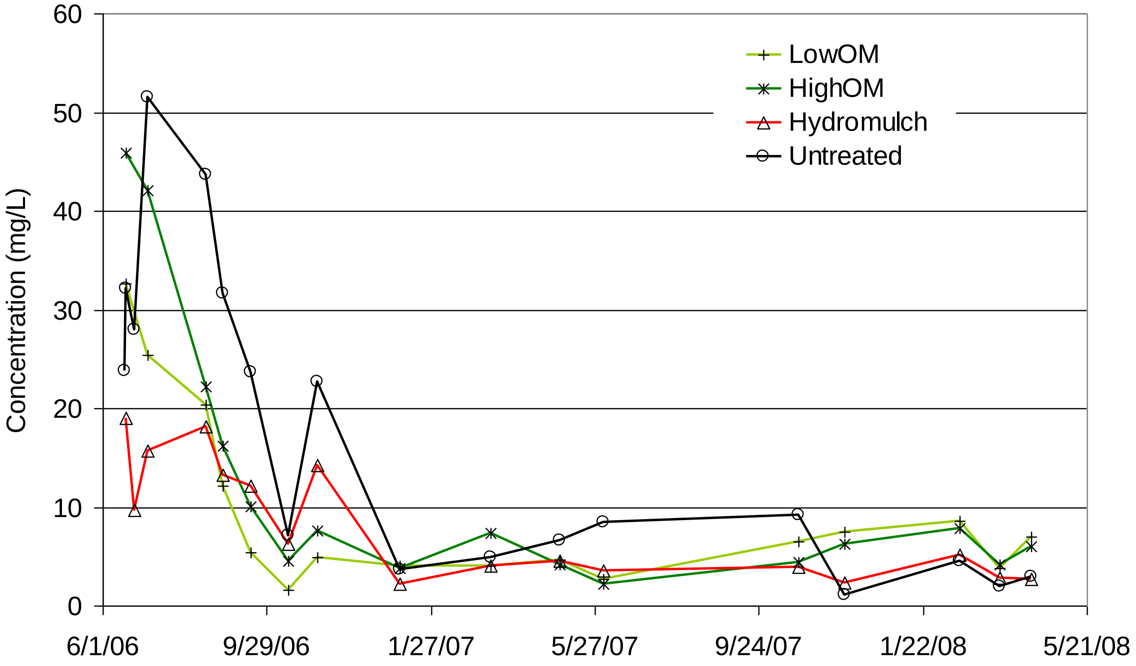

Figure 4-9 Average Total N Concentrations

Compost plots generally produced much higher dissolved phosphorus concentrations than hydromulch or untreated plots (**Error! Reference source not found.**). Both compost treatments exhibited two peaks in dissolved-P concentration in the first six month of monitoring, while the other treatments showed a general decline. During the later part of the monitoring, dissolved-P concentrations in runoff showed a general increasing trend from the compost treatments, while concentrations from the untreated and hydromulch plots showed more stable concentrations over time. Dissolved-P concentrations excluded as outliers from the treatment averages occurred only in October 2007. As noted before, rodent activity was noted as the most likely cause for these outliers.

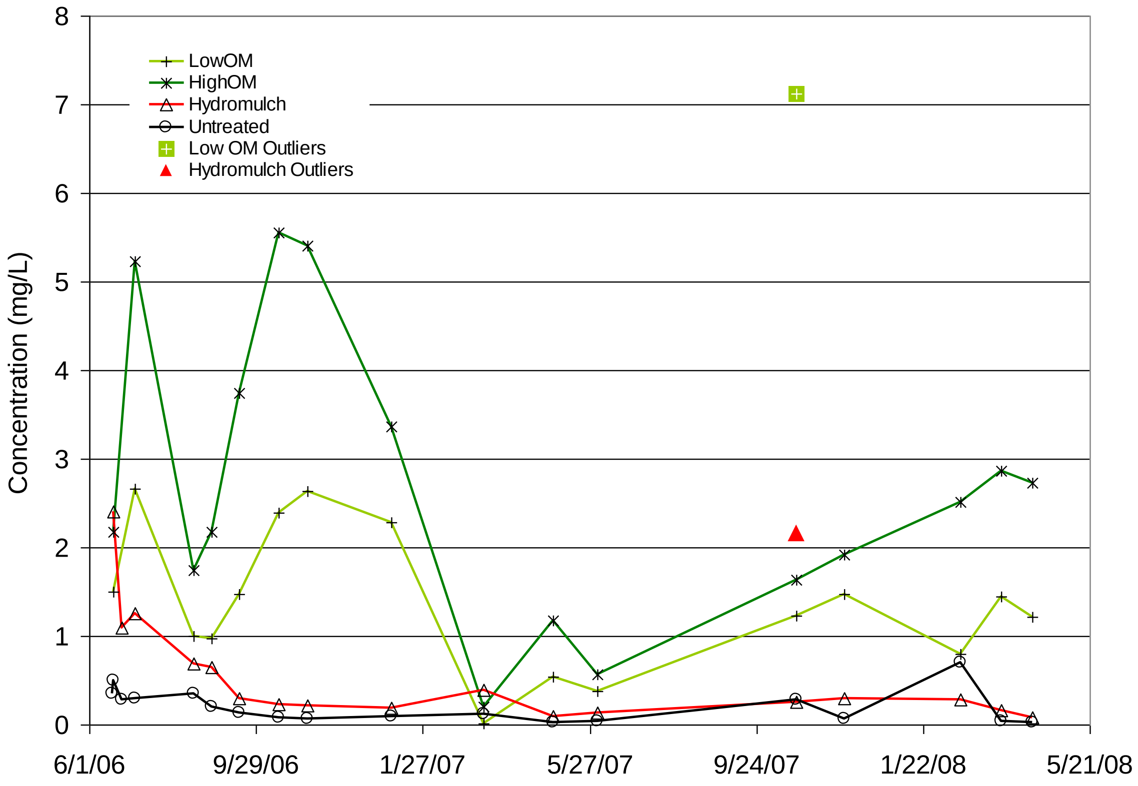

Figure 4-10 Average Dissolved Phosphorus Concentrations and Outlier Concentrations

Total phosphorus concentrations demonstrated the combined effect of TSS and dissolved-P because phosphorus sorbs to soil particles. Like TSS, total phosphorus concentrations generally declined through the study period (Figure 4-11), although as with dissolved-P, a general increase in total-P concentrations was shown for the low and high OM compost treatments. Untreated plots often had the highest total-P concentrations in runoff, particularly early in the study, but for all but one of the last five events monitored, the highest concentrations were from the compost treated plots.

One might expect total P concentrations in the runoff to reflect the concentration in the surface matrix. The compost treatments considered here have much higher surface concentrations (2000-5500 mg/kg; Table 4-2) than the untreated plots (200-300 mg/kg; Table 4-3). Despite this difference, total P concentrations are similar because the P has different sources. For the untreated plots, most of the P is sorbed to soil particles and thus associated with total suspended solids. Due to the erosion control provided by the compost treatments, compost plots lost much less sediment and slightly less total P. Of the P exported from the compost plots, most was in dissolved form, suggesting that some P leaches from the compost into the runoff.

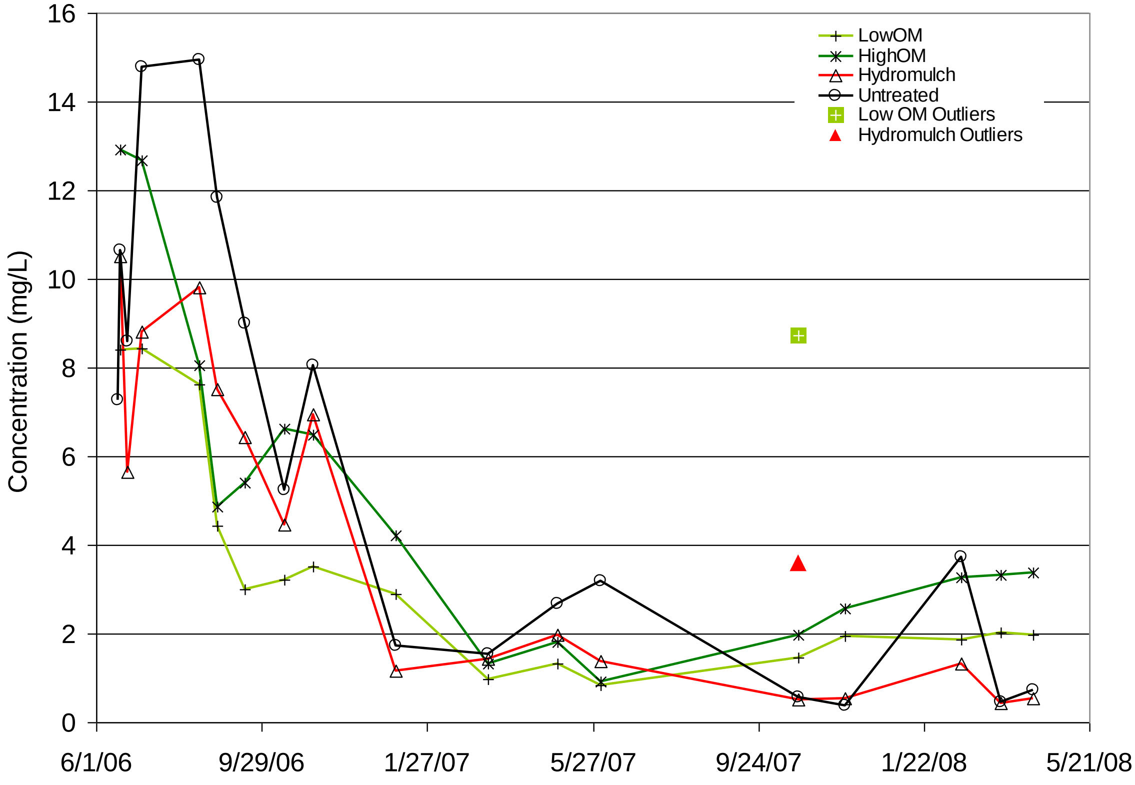

Figure 4-11 Average Total Phosphorus Concentrations and Outlier Concentrations

As another means of comparison, the average concentration for each constituent was calculated for the study period (Table 4-9). To maintain a fair comparison, only the sixteen storms with complete data were used for averaging. The standard deviation is also presented to quantify the variability in concentrations. The standard deviations are wide, often as large as the mean, because there is a strong time variation in the data.

Table 4-9 Mean and (standard deviation) of concentration for each treatment (mg/L)

Parameter	LowOM	HighOM	Hydromulch	Untreated
TSS	1710	1270	7080	22900
	(2730)	(1900)	(7780)	(25200)
TKN	8.76	11.9	8.08	17.2
	(8.50)	(14.3)	(6.01)	(15.6)
Nitrate	0.733	0.511	0.231	0.273
	(1.04)	(0.537)	(0.175)	(0.167)
Dissolved P	1.38	2.69	0.517	0.21
	(.843)	(1.73)	(.668)	(.258)
Total P	3.41	4.99	4.15	5.86
	(2.59)	(4.00)	(3.66)	(4.96)

Trends over time in water quality parameters were evaluated to see if concentrations reached a steady state. Considering the entire study period, each treatment exhibited a steady or declining trend over time except nitrate for the high OM plots, which tended to increase slightly, and dissolved phosphorus from the compost plots.

Each treatment and constituent reached a steady state except total phosphorus on high OM plots, where concentrations tended to increase over time. Total phosphorus on the low OM plots appears to increase at the end of the study, but this trend was not significant at the 0.05 level. The overall behavior of the compost plots with respect to dissolved phosphorus remains unclear. The time series were not readily divisible into regions of declining and steady concentration. Furthermore, dissolved phosphorus from the compost plots appears to increase in the second half of the study, making future concentrations difficult to estimate.

The time that steady state behavior was reached was inferred from visual inspection of the time series plots. In each case, the 95 percent confidence interval for the regression slope (of data within the hypothesized steady state region) included zero, indicating no significant relationship with time. Concentrations in the steady state region were averaged and reported in Table 4-10 along with the prevailing conditions when steady state occurred.

Table 4-10 Prevailing Conditions and Mean Concentrations at Steady State

		Prevailing Conditions			Steady State Concentration (mg/L)
		Elapsed Time (days)	Vegetative Cover	Cumulative Rainfall (in)	
TSS	LowOM	119	100%	10.68	415
	HighOM	119	100%	10.68	271
	Hydromulch	200	60%	17.82	887
	Untreated	200	0%	17.82	2,600
TKN	LowOM	91	70%	10.02	4.36
	HighOM	91	70%	10.02	5.09
	Hydromulch	200	60%	17.82	3.22
	Untreated	200	0%	17.82	4.56
Nitrate	LowOM	200	100%	17.82	0.84
	HighOM	119	100%	10.68	0.67
	Hydromulch	0	0%	0	0.20
	Untreated	0	0%	0	0.24
Total N	LowOM	140	100%	13.7	5.37
	HighOM	119	100%	10.68	5.31
	Hydromulch	200	60%	17.82	3.47
	Untreated	200	0%	17.82	4.82
Dissolved P	LowOM	n/a	n/a	n/a	n/a
	HighOM	n/a	n/a	n/a	n/a
	Hydromulch	91	30%	10.02	0.22
	Untreated	91	0%	10.02	0.14
Total-P	LowOM	492	100%	54.66	1.87
	HighOM	n/a	n/a	n/a	n/a +slope
	Hydromulch	200	60%	17.82	1.03
	Untreated	200	0%	17.82	1.67

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Concentrations in the runoff of hydromulch and untreated plots stabilized by 7 months for all constituents. Nitrate concentrations did not exhibit a temporal trend and were considered stable throughout the study period. Dissolved-P stabilized in only three months for the hydromulch and untreated plots. In general, compost treatments reached stable concentrations sooner than hydromulch or untreated plots except for total-P, where low OM plots took sixteen months to stabilize and high OM plots never reached a steady state.

4.5.2 Comparisons between Treatment for Paired Event Concentrations

Average concentrations from each event (as shown in Figures 4-6 - 4-11) were calculated and compared to each other using a paired t-test to determine whether observed differences in concentration were significant. Outliers, as identified in the previous section, were excluded from calculations of event mean concentrations. In order to compare all treatments for all water quality parameters, only storms with water quality data from all plots were used for the tests. The shaded values in Table 4-11 indicate that two treatments were different at a 0.05 level of significance. The plus sign (+) indicates which of two different treatments had a significantly higher concentration.

Table 4-11 P Values from Paired *t* Tests of Event Mean Concentrations

Treatment:	Low[1]-High[2]	Low[1]-HM[3]	Low[1]-UT[4]	High[2]-HM[3]	High[2]-UT[4]	HM[3]-UT[4]
TSS	+ 0.029	0.004 +	0.005 +	0.004 +	0.005 +	0.009 +
TKN	0.053	0.558	0.015 +	0.129	0.095	0.010 +
Nitrate	0.347	0.051	+ 0.039	+ 0.024	0.051	0.467
Total N	0.054	0.306	0.037 +	0.109	0.172	0.009 +
Dissolved P	0.000 +	+ 0.001	+ 0.000	+ 0.000	+ 0.000	+ 0.042
Total P	0.000 +	0.198	0.015 +	0.057	0.457	0.005 +

[1] Low Organic Matter Compost
[2] High Organic Matter Compost
[3] Hydromulch
[4] Untreated Plot

As shown in Table 4-11, each treatment was different from the others with respect to TSS, although differences between the high and low organic matter compost treatments were significant only at α=0.05 and not α=0.01. For compost treatments, this result is obscured by the scale of Figure 4-6. The fact that the low OM plots had significantly higher TSS concentrations than the high OM plots suggests that the high OM plots had more vegetation, though this difference was not detected visually. Through July 2006, compost plots and hydromulch plots had approximately the same vegetative cover.

However, TSS concentrations from the compost plots remained lower than from hydromulch plots (Figure 4-6). This difference suggests that compost reduces erosion by dissipating rainfall energy as well as establishing vegetation.

For TKN, untreated plots showed the highest average concentration (Figure 4-7), but statistically the average concentration of TKN from untreated plots was similar to those from the hydromulch treatment based on the paired t-test (Table 4-11). Concentrations of TKN from the compost treatments were similar to those from the hydromulch treatment.

The two compost treatments had similar nitrate concentrations, and the hydromulch and untreated plots had similar nitrate concentrations (Table 4-9). The four p-values (0.051, 0.039, 0.024, 0.051) comparing between the compost, hydromulch, and untreated plots were all very close to the cutoff value of 0.05 indicating significant differences. Interpreting these four p-values with the time series plot (Figure 4-8) indicates that the compost treatments may produce higher nitrate concentrations in runoff than the hydromulch or untreated plots, although the statistics do not clearly show this difference.

The interpretation of total nitrogen concentrations between paired treatments follows that of TKN. Untreated plots had the highest concentrations, but the only significant difference was between the low OM and hydromulch treatments.

All of the treatments were significantly different from each other in dissolved-P concentration. The concentration of dissolved-P in runoff corresponded to the relative amount phosphorus applied to each plot, either as compost or fertilizer (Table 3-1).

For total-P, concentrations in runoff were similar between high OM compost and untreated plots, but untreated plots had significantly higher total-P concentrations than low OM or hydromulch plots. The high OM also had significantly higher total-P concentrations than the low OM treatment. Although total-P concentrations were positively related to TSS concentrations for all treatments and significantly lower TSS concentrations were observed from high OM than untreated plots, the fact that untreated plots were not significantly different from high OM plots for total-P was related to higher concentrations of dissolved-P observed from the high OM plots (Table 4-11 and Figure 4-10). On average across events, the concentration of dissolved-P represented over 50 percent of the total-P in runoff from the high OM plots and only about 3 percent of total-P from untreated plots. While the low OM treatment indicated higher TSS concentrations than the high OM treatment, the low OM plots had significantly lower concentrations of total-P than high OM plots. Again, the difference was in the amount of dissolved-P between the two treatments. Higher concentrations of dissolved-P were associated with runoff from the high OM treatment than the low OM treatment.

4.6 Nutrient and Sediment Loads

Runoff volume and concentration data were combined to estimate the mass loss—or load— of each constituent for monitored events. Nutrient and sediment exported during unmonitored events were also of interest. Continuous monitoring of rainfall allowed load estimates for the unmonitored and overflow events.

Runoff volumes were predicted using the regression coefficients shown in Table 4-6. In some cases the runoff volume measured for an overflow event exceeded the volume predicted by the runoff coefficient, suggesting that the overflow was small. The volume of the collection tank was used in these cases.

Constituent concentrations were predicted by linearly interpolating between the plot average of sampled events based on the date. Several methods to predict constituent concentrations were investigated, including linear regression, multiple regression, cubic spline interpolation, and moving averages. Ultimately, these methods poorly represented the data. As a compromise, linear interpolation based on storm date was used to predict constituent concentrations for unmonitored events.

The mass loss for each event was calculated as the product of the runoff volume and the average concentration for each treatment. The mass loss for sampled and unsampled events was summed to estimate the total load exported during the study (Table 4-12).

Values were expressed on a per hectare basis. The fractional difference from the untreated plot was also calculated to indicate the relative performance of compost and hydromulch treatments to the untreated plots.

Table 4-12 Comparison of Total Load for All Events, June 2006-May 2008

		Total Load, kg/ha				Fractional Difference from Untreated			
		LowOM	HighOM	Hydromulch	Untreated	LowOM	HighOM	Hydromulch	Untreated
Sampled	TSS	1864	1327	20329	79260	-98%	-98%	-74%	0%
	TKN	8.46	14.0	19.9	47.7	-82%	-71%	-58%	0%
	Nitrate	0.504	0.159	0.352	0.575	-12%	-72%	-39%	0%
	Dissolved-P	1.77	3.79	1.08	0.48	271%	692%	126%	0%
	Total-P	3.87	6.56	10.5	17.8	-78%	-63%	-41%	0%
Unsampled	TSS	708	578	9720	57400	-99%	-99%	-83%	0%
	TKN	4.42	5.07	15.6	46.3	-90%	-89%	-66%	0%
	Nitrate	0.571	0.717	0.825	1.687	-66%	-57%	-51%	0%
	Dissolved-P	0.667	1.247	0.788	0.540	24%	131%	46%	0%
	Total-P	1.64	2.15	6.86	16.7	-90%	-87%	-59%	0%
Total	TSS	2576	1905	30080	136700	-98%	-99%	-78%	0%
	TKN	12.9	19.1	35.6	94.1	-86%	-80%	-62%	0%
	Nitrate	1.074	0.876	1.178	2.256	-52%	-61%	-48%	0%
	Dissolved-P	2.44	5.03	1.87	1.02	139%	394%	84%	0%
	Total-P	5.51	8.73	17.4	34.5	-84%	-75%	-50%	0%

In terms of total performance, the high OM treatment had the lowest sediment loss. The high OM treatment exported less TSS than the low OM treatment, suggesting that the low OM plot had slightly less vegetation. The difference in vegetation is likely related to the level of organic matter and nutrients provided by the treatments (Table 4-2). The difference in sediment loss between compost treatments was very small relative to sediment losses from the hydromulch and untreated plots.

Sediment export from the hydromulch plots was about 15 times more than the compost plots, and the untreated plots exported about 60 times more TSS than the compost plots. The hydromulch treatment provided better erosion control than no treatment (4x), but compost was much more effective.

Total mass exported from sampled events was generally higher than from unsampled events. Sampled events represented a larger fraction of the mass loss, because events were sampled more frequently early in the study when concentrations were higher. The fact that most of the mass losses occurred during sampled events reduces the uncertainty in the estimate of total load.

Losses in TKN were highest for the untreated plots and associated with the highest TSS losses. The low OM treatment exported the least TKN. For nitrate, the untreated plots had much higher losses (2x) than the hydromulch or compost plots. Dissolved-P losses from all treatments were higher than from the untreated plots. These results indicate that the high phosphorus concentrations associated with the compost and hydromulch leach into the runoff. However, due to background levels of phosphorus associated with soil particles and higher sediment losses, the untreated plots had the highest losses of total phosphorus. The low OM plots exported the least total phosphorus.

Dissolved P is the only constituent for which losses were higher from compost and hydromulch plots than the untreated control plots. The time series of dissolved P load (Figure 4-12) shows that the total load from the compost plots is driven by three events in the fall of 2006. These three events comprise about 75 percent of the measured losses of dissolved P for the compost treatments. Except for these three events, dissolved P losses from the compost are very similar to those from hydromulch and untreated plots. Even though concentrations of dissolved P from compost plots rose late in the study, small runoff volumes lead to mass losses that are similar to the other treatments.

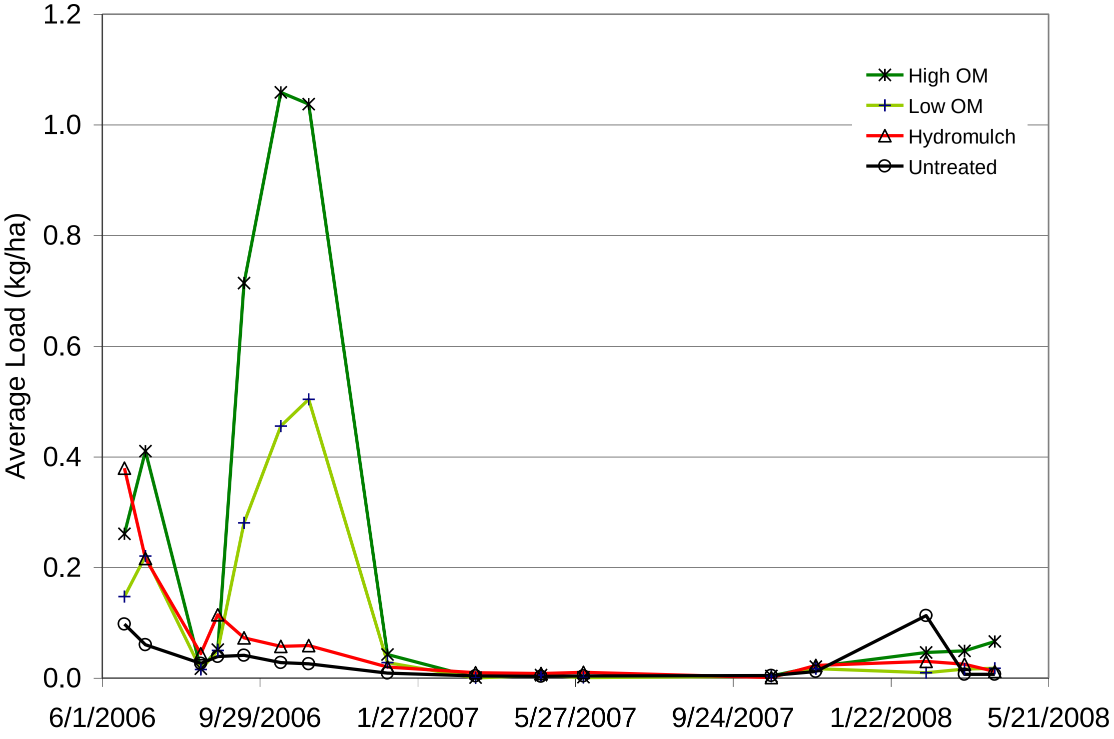

Figure 4-12 Average Loads of Dissolved P

The compost plots received far more nutrients than the hydromulch plots, but exported less total nitrogen and total phosphorus (Table 4-13). For total nitrogen, the compost plots exported about 1 percent of the mass applied, compared with 204 percent for the hydromulch plots. In terms of total mass, the compost plots still exported the least nitrogen. The untreated plots exported the most nitrogen, reflecting the high sediment losses. The relatively small nitrogen loss from the compost plots suggests that these treatments pose less risk of nitrogen pollution than hydromulch or bare soil. Results for total phosphorus were similar. The compost plots exported 1 percent of the mass applied, and the least total mass of the four treatments. The results for dissolved phosphorus were more complicated. Losses of dissolved phosphorus from high OM plots were about 50 percent more than that of low OM plots. This ratio reflects the difference in the amount of total phosphorus applied in the two compost treatments and suggests that some of the organic phosphorus in the compost became soluble through decomposition after the treatments were applied.

Table 4-13 Applied and Exported Nutrients

	Low OM	High OM	Hydromulch	Untreated
	Nitrogen Applied (kg/ha)			
Total N	1375	3249	18	--
	Total Nitrogen Exported (kg/ha)			
First Year	11.6	17.9	27.7	70.6
Second Year	2.4	2.1	9.0	25.8
Total	14.0	20.0	36.7	96.4
Fraction of Total N Exported	1.02%	0.62%	204%	--
	Phosphorus Applied (kg/ha)			
Total P	585	1565	22	--
	Total Phosphorus Exported (kg/ha)			
First Year	4.8	7.8	14.6	26.0
Second Year	0.7	1.0	2.8	8.5
Total	5.5	8.7	17.4	34.5
Fraction of Total P Exported	0.94%	0.56%	119%	--

Notes:
[a] Nutrient application rates assume compost-blend applied at a rate of 126 ton/acre

Average concentrations of dissolved nutrients continue to be higher off the compost plots than the untreated or hydromulch plots (Table 4-10) indicating a continuing release of nutrients from the compost. This continuing release of nutrients from the compost should be expected as the compost material slowly breaks down. The concentration of soluble nutrients in runoff from the compost plots will increase as nutrients are converted from relatively insoluble to more soluble forms. The decomposition of compost material may also allow fine compost particles to move, also moving attached nutrients.

4.7 Impacts on Receiving Waters

The previous sections provide analysis of data collected specifically for this project. This section considers how the treatments studied above compare with other land uses in terms of nutrient exported to receiving waters.

While it is clear that compost and hydromulch treatments greatly decrease sediment loading in runoff and runoff volume compared to untreated areas, there is a water quality tradeoff. The additional nutrients in these treatments, which benefit the establishment of vegetation, may negatively affect water quality if discharged into nutrient sensitive waterbodies. Because the compost treatments allowed quicker establishment of vegetation and less runoff, loadings were generally less, except for dissolved-P, compared to the untreated plots (Table 4-12) even though more nutrients were applied.

To put these nutrient loadings into perspective, values for years 1 and 2 were compared to export coefficients derived for common land uses (Table 4-14). Nutrient export coefficients are estimates of the mass of nitrogen or phosphorus that may be moved off an area of land over a period of time. Nutrient export coefficients are generally expressed as kg/ha/yr and are often used in watershed management planning to evaluate relative loadings from various land uses or estimate impacts of changing land uses on a given waterbody. Nutrient export coefficients are usually calculated for total nitrogen (total-N) and total-P, because the forms of these nutrients are likely to change as they are transported within the stream system. Because year 2 represented only 10 months, loadings were extrapolated to 12 months assuming similar loading rate during the remaining two months of the year (Table 4-15).

The range of the nutrient export coefficients for each land use is large, because of variations in management practices, such as fertilizer application rates, and the weather conditions under which data were collected to derive the values. The range of coefficient values and the relative ranking by magnitude for different land uses does, however, allow a general characterization of different land uses by their relative nutrient contributions (e.g., row crop will typically deliver more nutrients than forest). With regard to the study plots, nutrient export from year 1 was fairly comparable to row crop agriculture or fields fertilized using animal waste. By year 2, export from the compost plots had decreased to a level more similar to land associated with pasture or non-row crop agriculture or forested land even with fairly similar total rainfall conditions as in year 1. Nutrient export from the hydromulch and untreated plots also decreased, but continued to be more similar to nutrient export from intensive agricultural practices than less intensive practices.

Table 4-14 Range of literature values for nutrient export coefficients.

Land Use	TN (kg/ha/yr)	TP (kg/ha/yr)	Source
Animal Waste Appl. Fields	4.0 – 100	0.8 – 12	Loehr et al. (1989), Overcash et al. (1983), McFarland and Hauck (2001)
Row Crops	2.1 – 80	0.3 – 19	Reckhow et al. (1980)
Pasture/ Non-Row Crop	1.0 – 14	0.1 – 2.9	Loehr et al. (1989), Reckhow et al. (1980), McFarland and Hauck (2001)
Forest	1.0 – 6.3	<0.1 – 0.9	Loehr et al. (1989), Clesceri et al. (1986)
Range/Idle Land	0.5 – 6.0	0.1 – 0.3	Loehr et al. (1989), McFarland and Hauck (2001)
Urban	1.9 – 14	0.1 – 7.6	Loehr et al. (1989), McFarland and Hauck (2001)

Table 4-15 Derived nutrient export coefficients from study plots.

Treatment	TN (kg/ha/yr)	TP (kg/ha/yr)	Ratio Soluble N to TN[a]	Ratio Soluble P to TP[b]
			Year 1	
Low OM	11.6	4.8	0.06	0.43
High OM	17.9	7.8	0.02	0.56
Hydromulch	27.7	14.6	0.02	0.10
Untreated	70.6	26.0	0.01	0.02
			Year 2	
Low OM	2.9	0.8	0.17	0.56
High OM	2.6	1.2	0.24	0.71
Hydromulch	10.8	3.3	0.07	0.16
Untreated	30.9	10.2	0.05	0.05

[a] Soluble N represented only by nitrate N

[b] Soluble P represented only by dissolved P

While loadings of total-N and total-P from compost treatments were less than nutrient loadings from hydromulch and untreated areas, there is one area of concern. Loadings of dissolved P from compost treatments were higher than from hydromulch or untreated plots. Because about 40 to 50 percent of total-P loadings from compost treatments was measured as dissolved-P, a form readily available for algal growth, this could be a potential water quality problem if the runoff goes directly into a nutrient sensitive waterbody. In widely applying these treatments within a watershed, nutrient loadings should be considered with regard to the sensitivity of the waterbody that will be impacted. Of note, plots used in this study had a 12 percent slope. As the slope decreases, it is anticipated that the volume of runoff, and nutrient and TSS loadings should also decrease.

On a watershed level, the impact of these erosion control treatments will depend on the amount of land area involved, the slope of the reclaimed area, what other land area is contributing, the nearness of the treated area to the receiving waterbody, the type of receiving waterbody (stream or reservoir) and the sensitivity of that waterbody to the addition of nutrients, particularly soluble P. While these erosion control treatments, particularly the compost, greatly decrease the amount of sediment transported off these highly erodible reclamation sites, the tradeoff in potential nutrient loadings needs to be considered in implementation of these practices.

5 Conclusions

This study was initiated, in part, to address large sediment loads exported from quarry sites. The compost/mulch blends address this concern very well, providing a 98 percent reduction compared to untreated plots and 78 percent compared to hydromulch plots. The compost treatments achieve this reduction by establishing vegetative cover much faster than hydromulch (3x) or no treatment (4x), by retaining more rainfall, and by protecting soil from the energy of precipitation.

The compost treatments were found to export less total mass of nitrogen and phosphorus than hydromulch or bare soil. In comparison to bare soil, the compost treatments reduced the discharge of total phosphorus by 84 percent (low OM treatment) to 75 percent (high OM treatment), and reduced the discharge of total nitrogen by over 86 percent for the low OM treatment and about 80 percent for the high OM blend. The loads of total phosphorus and total nitrogen exported from the compost treated test plots were also substantially less than those from the hydromulch treated plots. Remarkably, the compost treated plots exported less than 1 percent of the nutrients applied in the initial treatment during the two years of this study, with annual loads similar to those produced by row crop agriculture.

On the other hand, the compost treatments exported notably more phosphorus in dissolved form than either the control or hydromulch treated plots, especially during a few storms near the beginning of the study. During the last 18 months of monitoring, dissolved phosphorus loads from the compost treatments were similar to the hydromulch and control plots. Dissolved phosphorus can contribute to eutrophication in streams and lakes because algae growth is usually limited by phosphorus availability. Phosphorus bound to soil particles requires dramatic changes in pH to de-sorb and become bioavailable. Therefore the bound fraction of total P poses less direct risk of eutrophication than the dissolved fraction. This increased export of dissolved phosphorus means that using one of the compost treatments to control erosion increases the potential for an algae bloom in the receiving waters, especially immediately after application. The exact risk of eutrophication depends on site-specific factors, such as the type of waterbody, distance to the waterbody, the relative size of the treated area in comparison to the watershed, slope of the treated area, and other factors. Compost treatments pose less risk when applied at a greater distance from the waterbody, when covering a relatively small portion of the watershed, on relatively gentle slopes, and outside of areas where concentrated runoff flows occur.

The benefits of using these compost treatments include their ability to promote rapid and enduring vegetation establishment and to protect the soil from erosive forces such as the impacts of rain drops even before and during the establishment of vegetation. Establishing vegetation by seed requires favorable conditions for germination (including adequate moisture, appropriate temperature, and a good matrix for root growth) as well as adequate nutrients for plant growth. The compost treatments provided a very favorable and protective environment for establishment of the Bermuda grass cover beginning with the fall rains following the intense heat and drought of the first summer. The other treatments, in contrast, experienced an extended delay in vegetation establishment following the hot dry summer, and were significantly assisted by the spread of grass runners from the compost plots.

Based on TSS losses, this study detected only a small difference in the ability of the two compost treatments to establish vegetation. This difference may be due to application rates of nutrients or organic matter, or both. The higher nutrient treatment (high OM) reduced losses of sediment, but provided more nitrogen, phosphorus, and organic matter. Since differences in establishing vegetation were small, the exact relationship between the compost recipe and erosion control performance is unclear.

A major benefit of the compost-blend was its ability to hold water on the plots. For this reason, a blend with lower phosphorus levels (i.e., lower compost to mulch ratio and/or use of compost with lower P content) but with similar physical characteristics such as water-holding capacity would be expected to perform like the treatments studied here. Further research could confirm this hypothesis and provide an optimized recipe for erosion control compost that balances nutrient and organic content with vegetation establishment. In sum, the potential risk that compost treatments pose to surface waters by exporting bio-available phosphorus may be reduced by developing a lower nutrient formulation that would still provide the many benefits documented in this study.

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Appendix A -- Monthly and Bimonthly Pictorial Observations

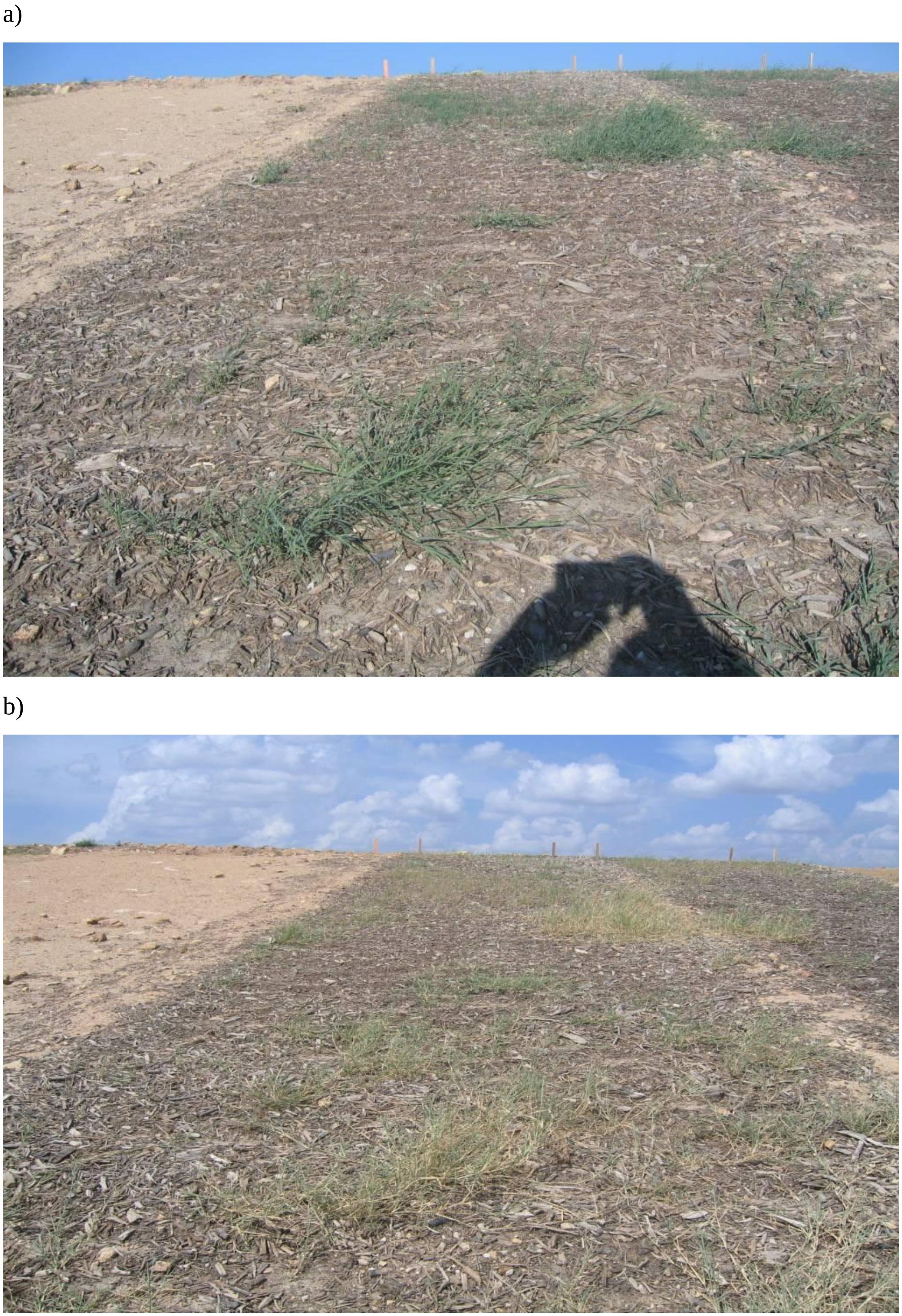


Figure A-1. Vegetative cover VP01 a) July 14, 2006 and b) August 14, 2006.

a)

b)

Figure A-2. Vegetative cover VP01 a) September 14, 2006 and b) October 10, 2006.

a)

b)

Figure A-3. Vegetative cover VP01 a) December 14, 2006 and b) February 21, 2007.

Figure A-4. Vegetative cover VP01 a) April 19, 2007 and b) June 18, 2007.

a)

b)

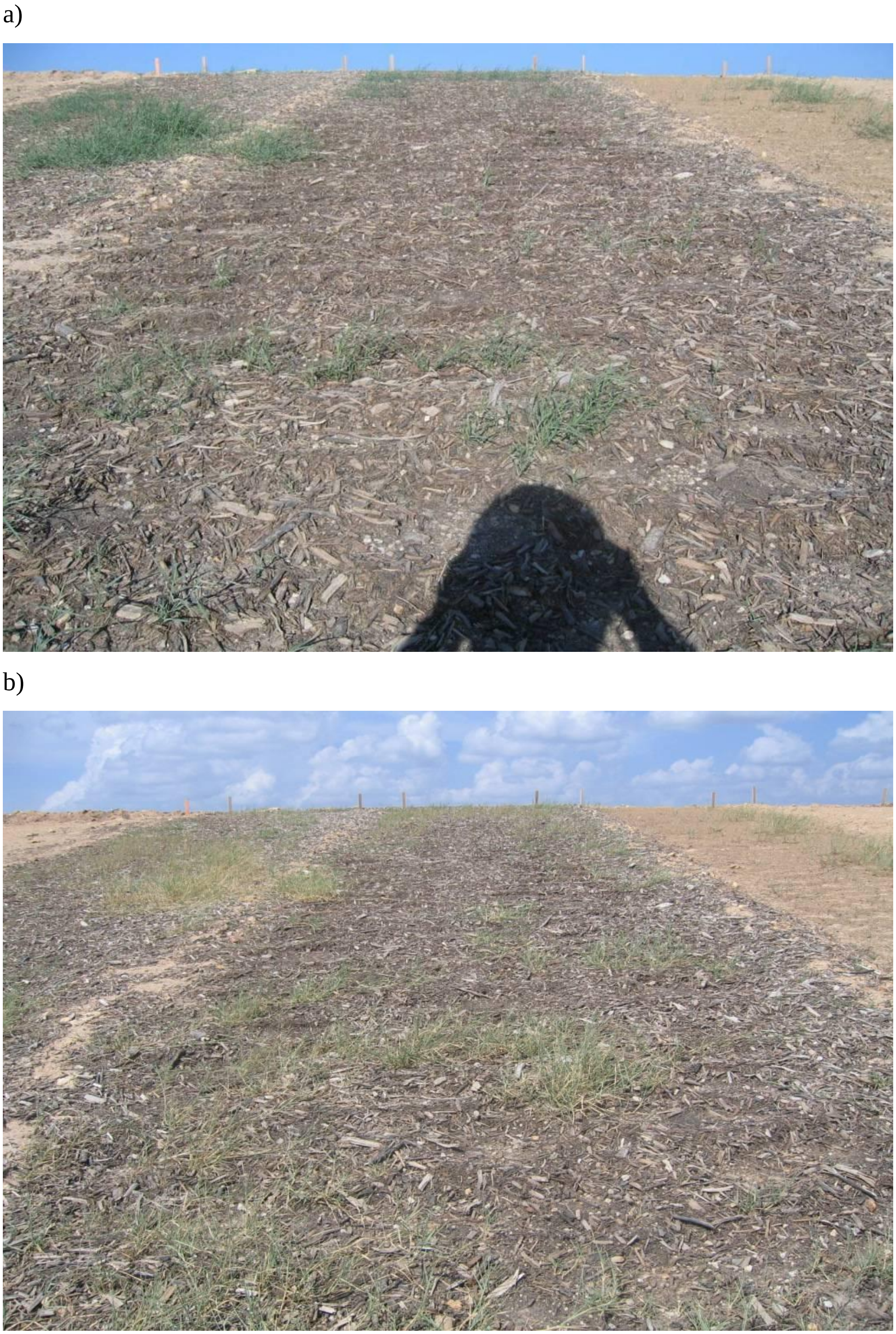
Figure A-5. Vegetative cover VP01 a) August 20, 2007 and b) October 16, 2007.

a)

b)

Figure A-6. Vegetative cover VP01 a) January 3, 2008 and b) February 14, 2008.

Figure A-7. Vegetative cover VP01 April 17, 2008.



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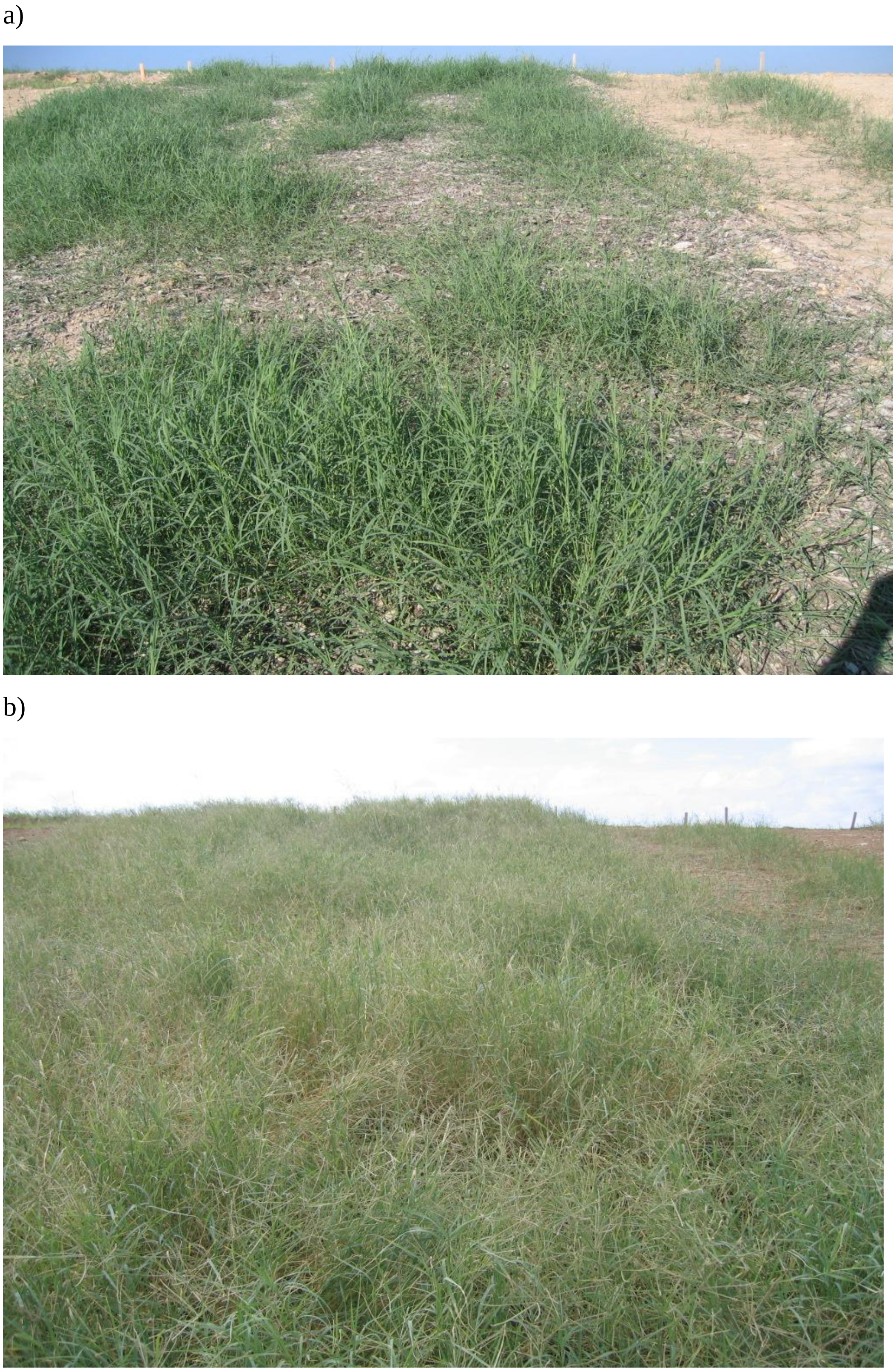

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a)

b)

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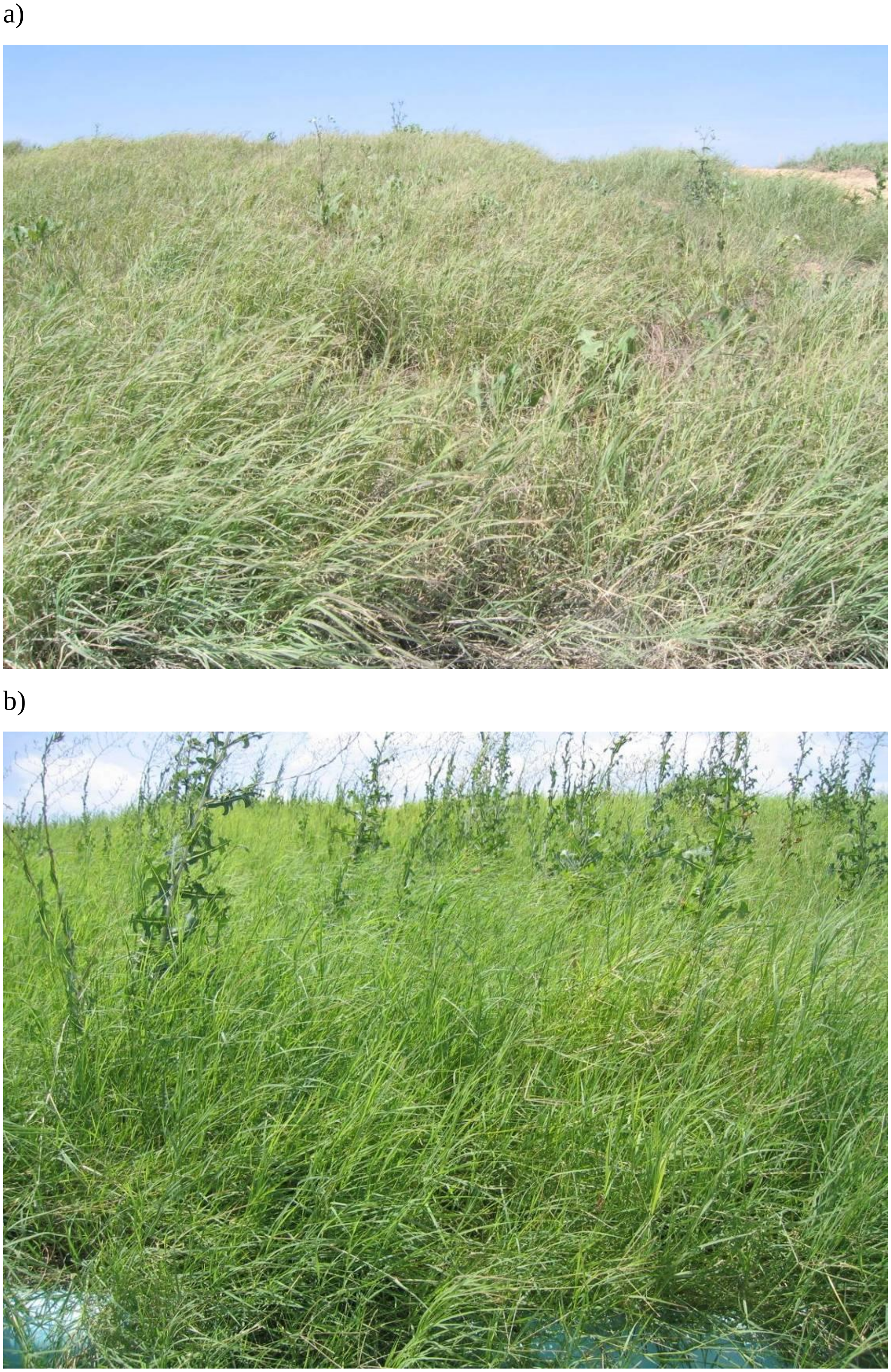

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a)

b)

Figure A-12. Vegetative cover VP02 a) August 20, 2007 and b) October 16, 2007.

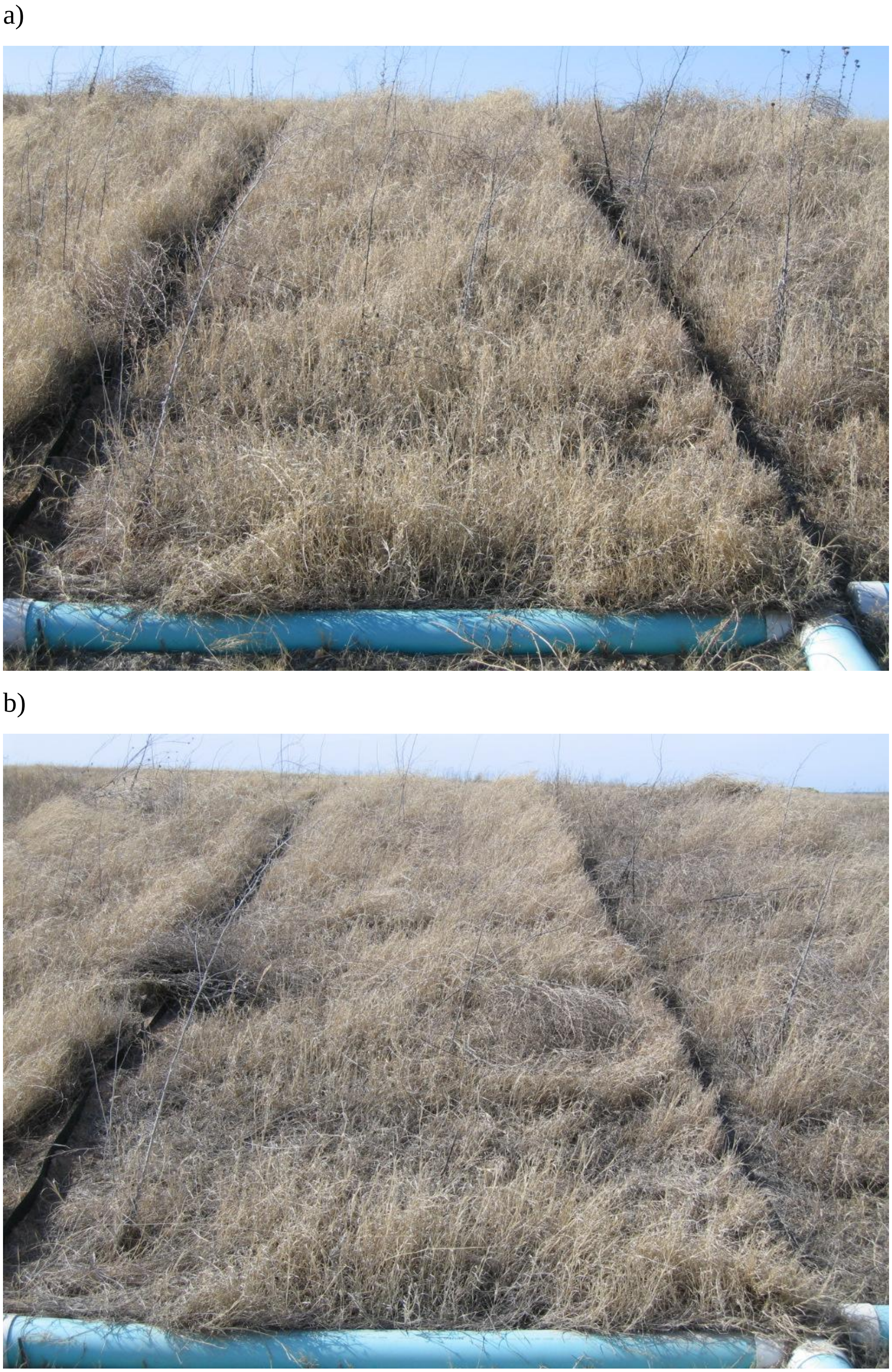

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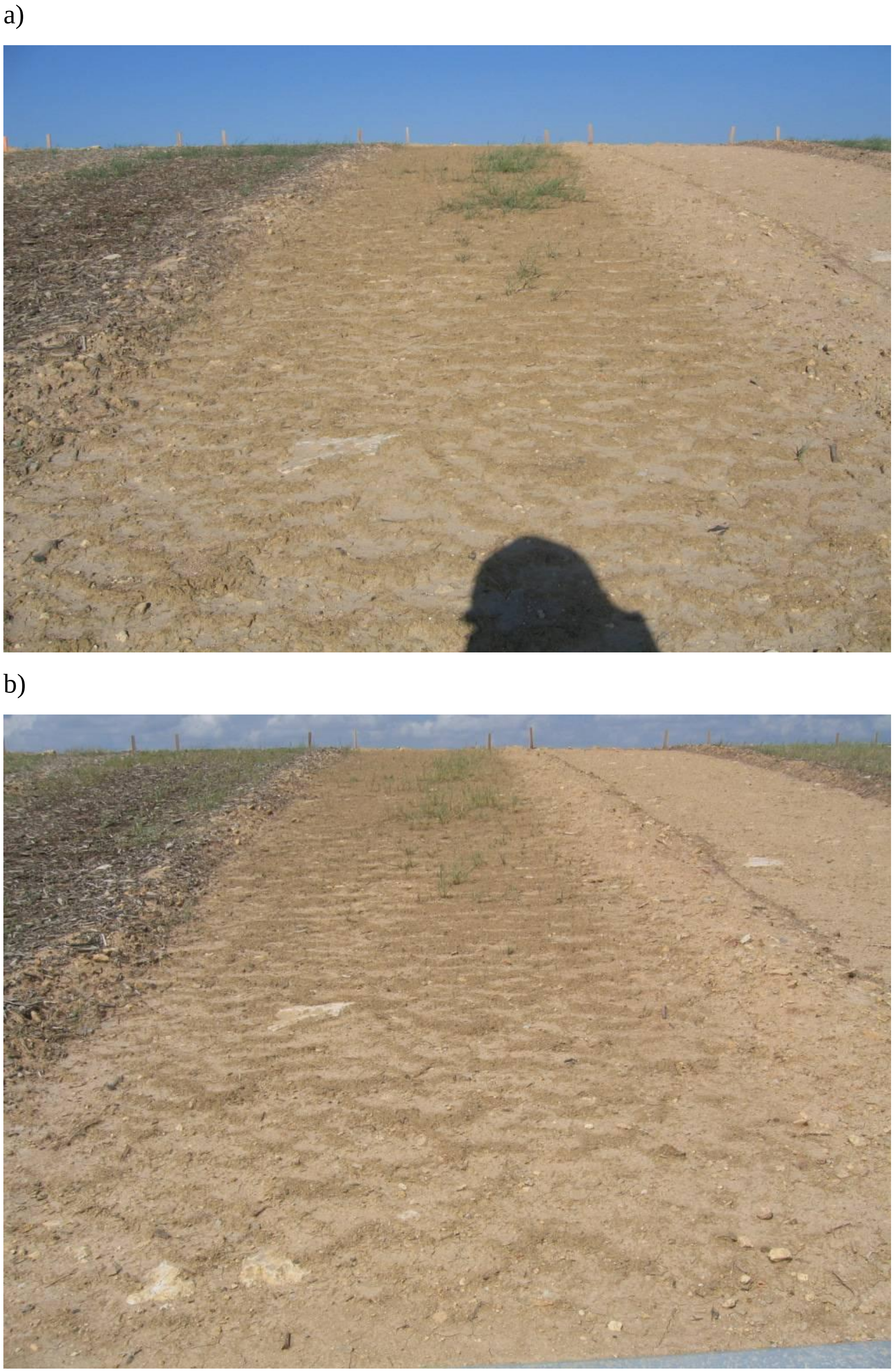
Figure A-14. Vegetative cover VP02 April 17, 2008.



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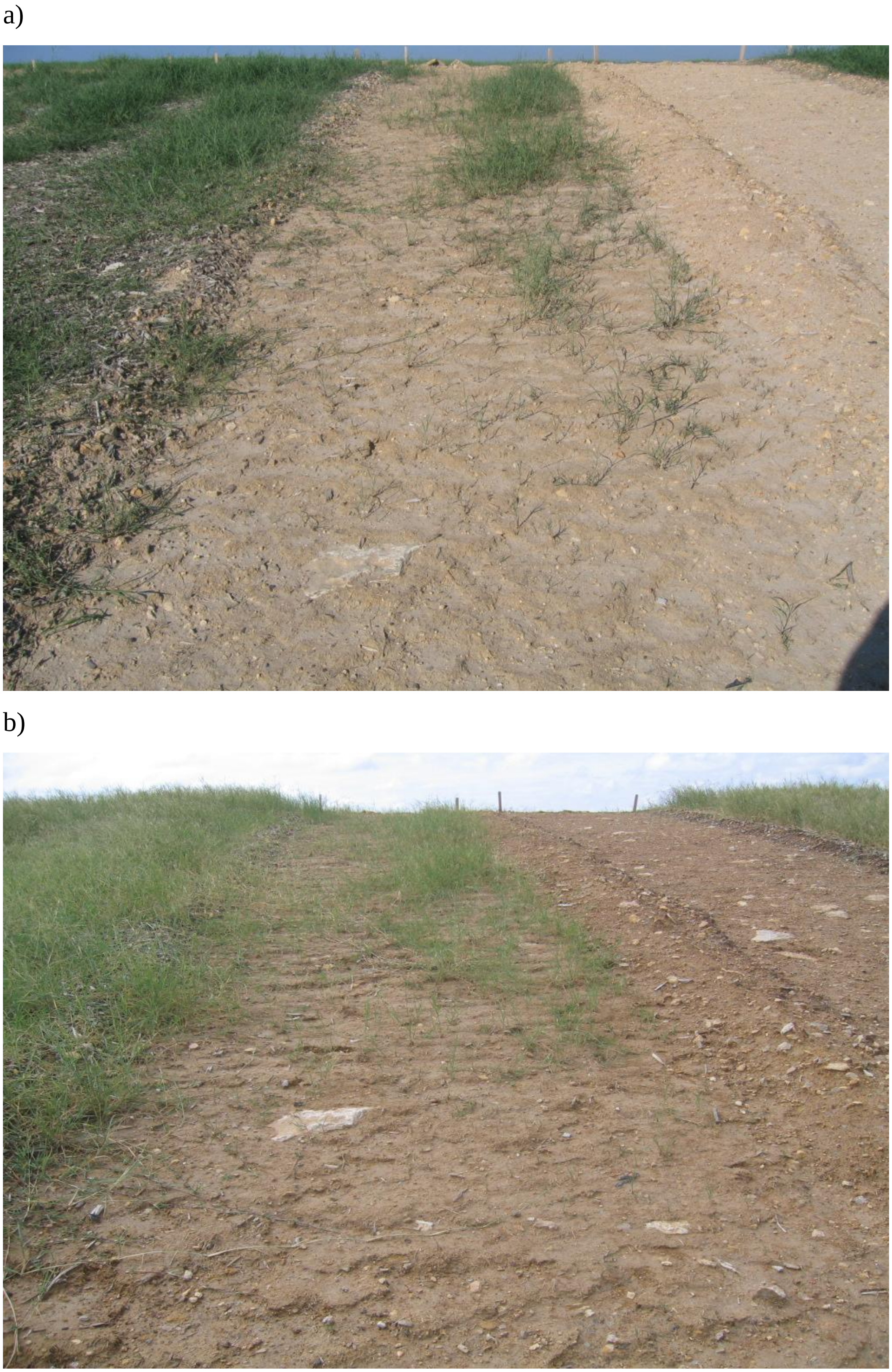

Figure A-16. Vegetative cover VP03 a) September 14, 2006 and b) October 10, 2006.

a)

b)

Figure A-17. Vegetative cover VP03 a) December 14, 2006 and b) February 21, 2007.

a)

b)

Figure A-18. Vegetative cover VP03 a) April 19, 2007 and b) June 18, 2007.

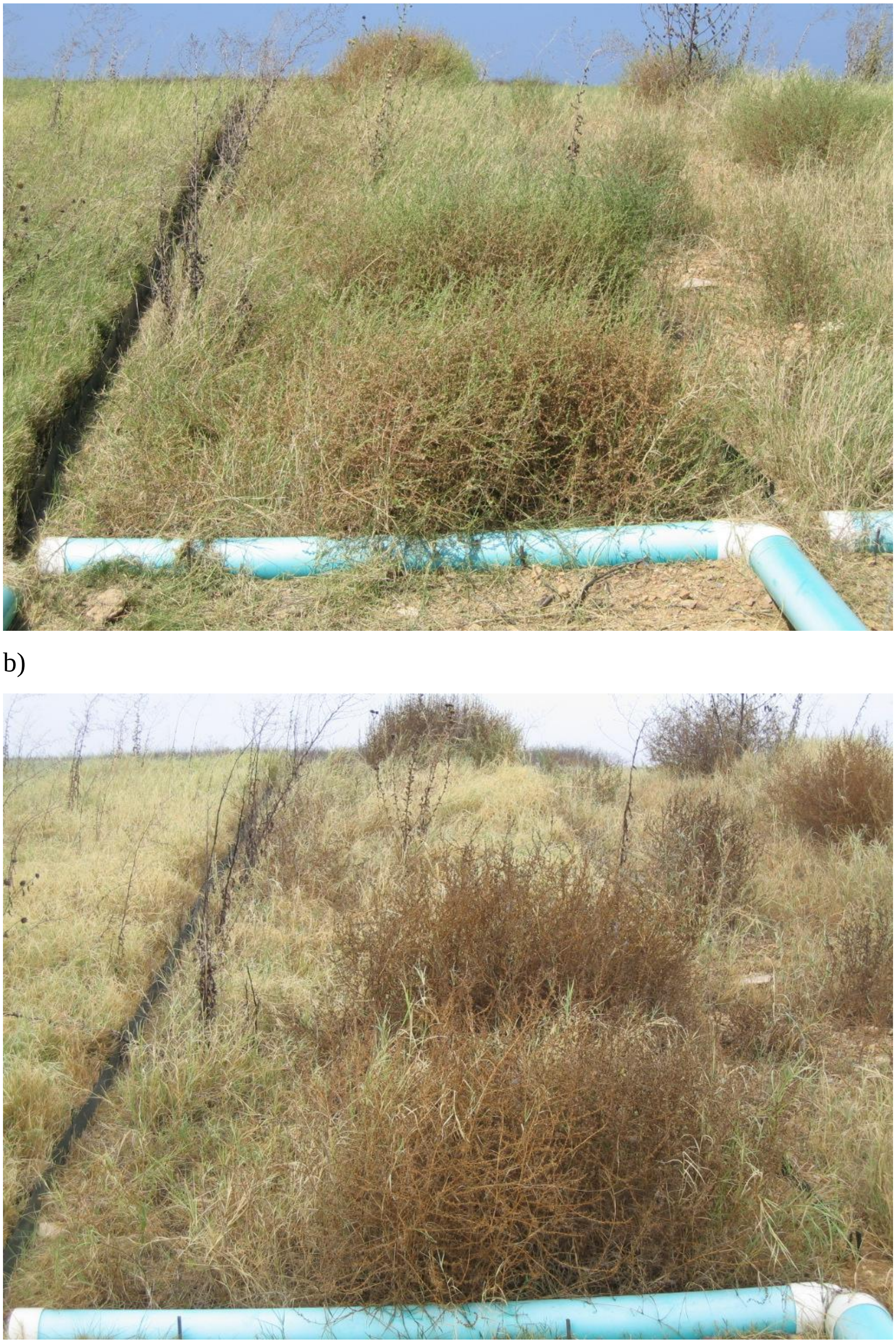

Figure A-19. Vegetative cover VP03 a) August 20, 2007 and b) October 16, 2007.

a)

b)

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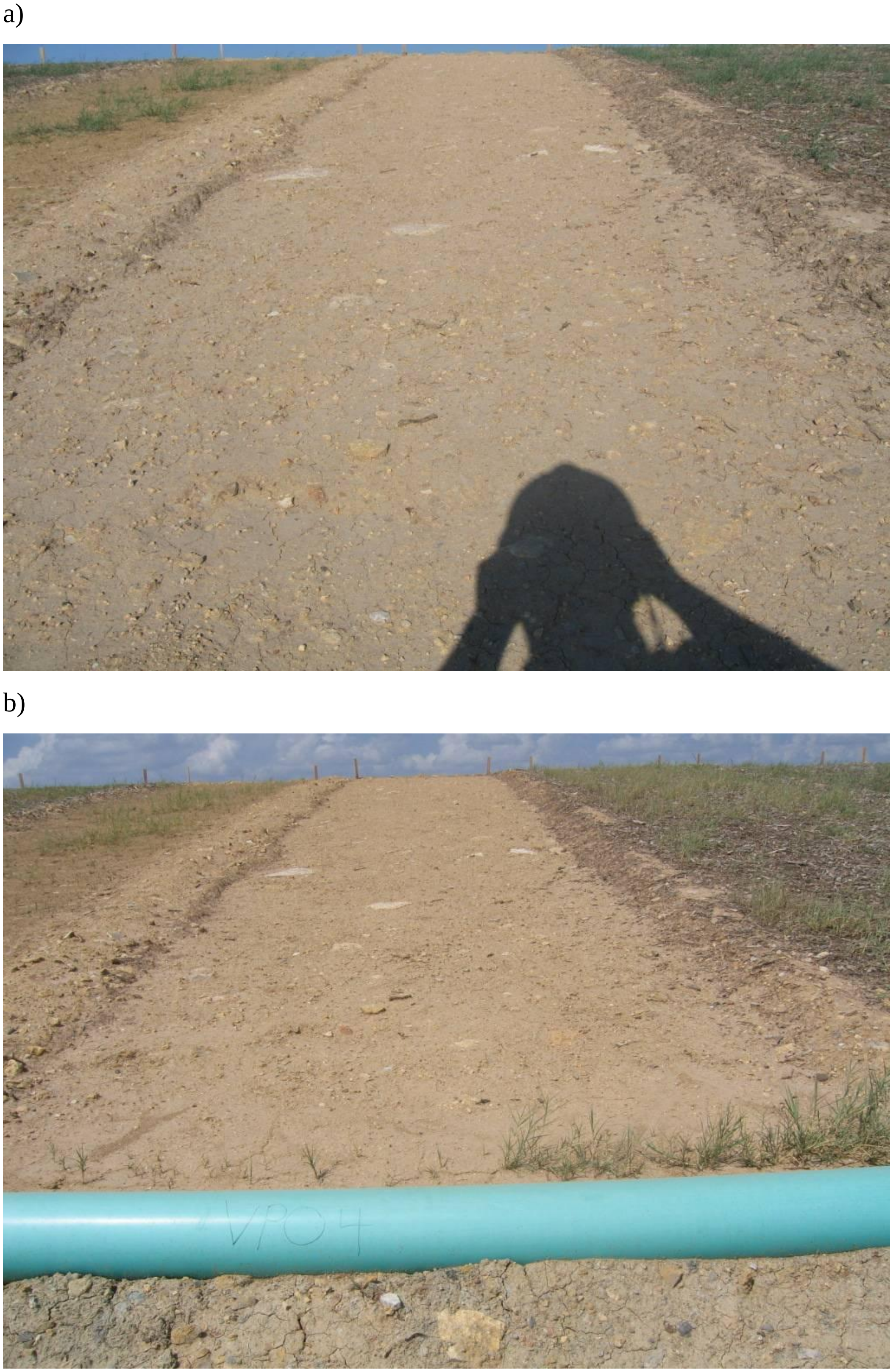
Figure A-21. Vegetative cover VP03 April 17, 2008.



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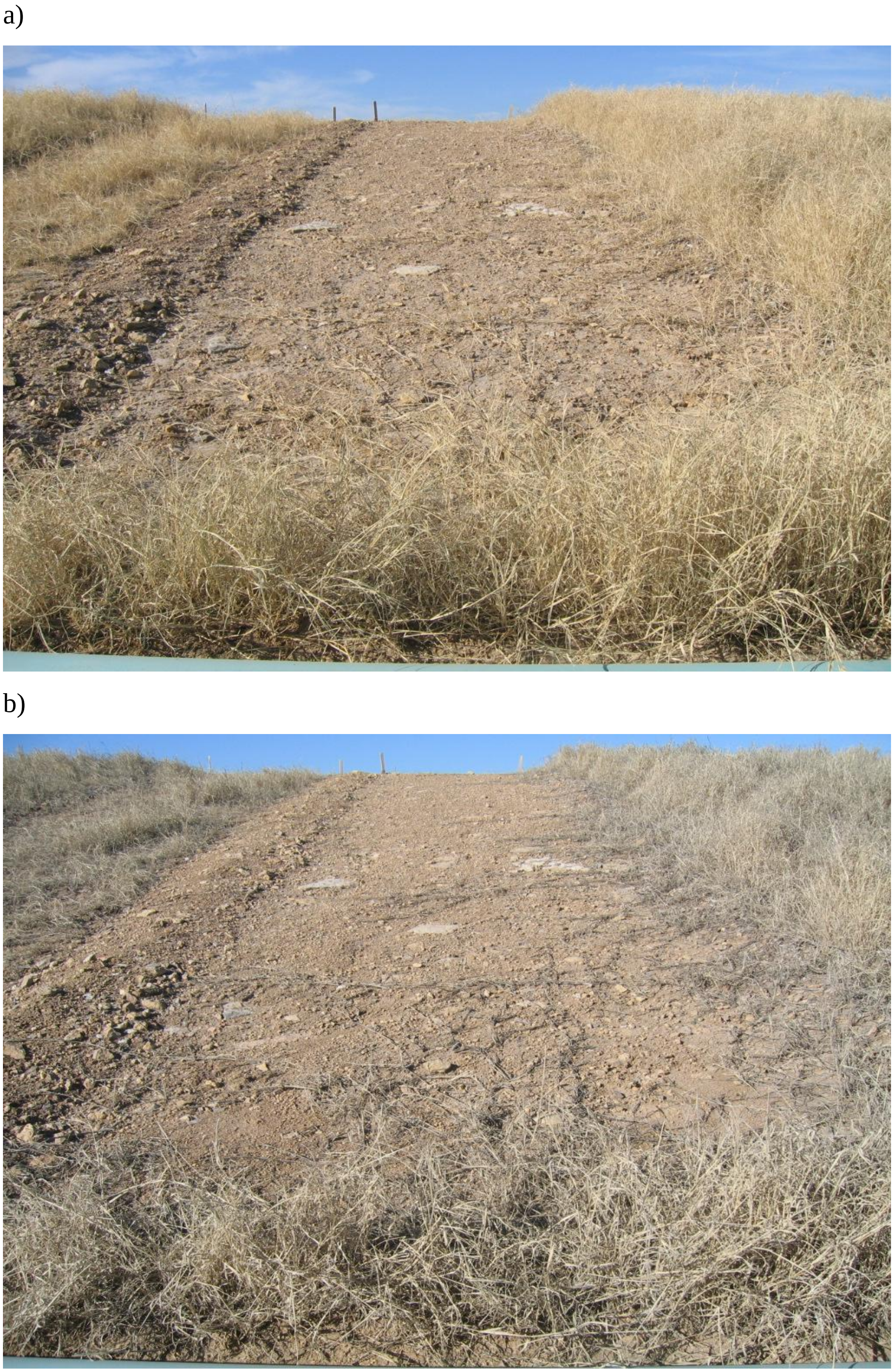

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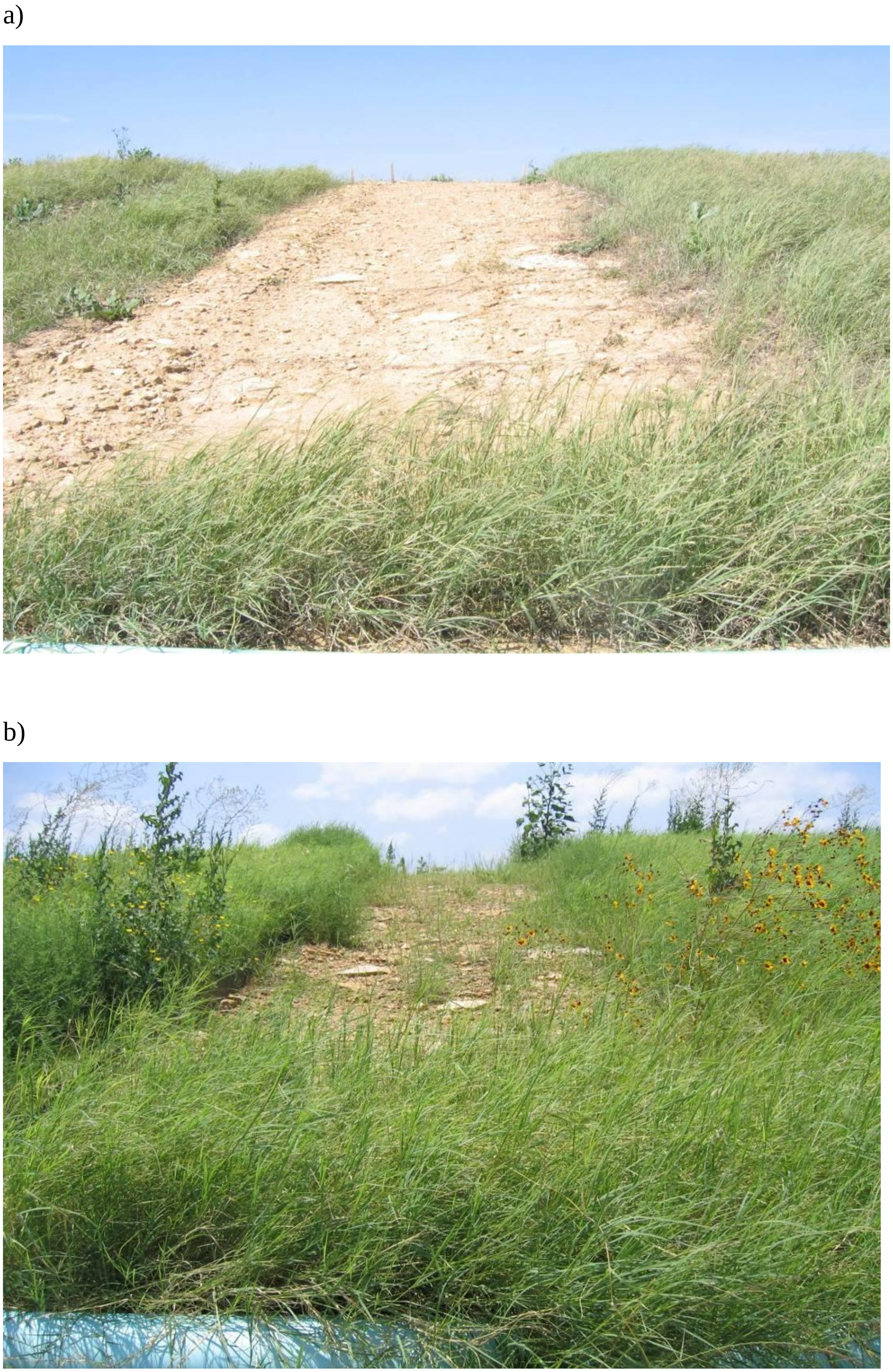


Figure A-25. Vegetative cover VP04 a) April 19, 2007 and b) June 18, 2007.

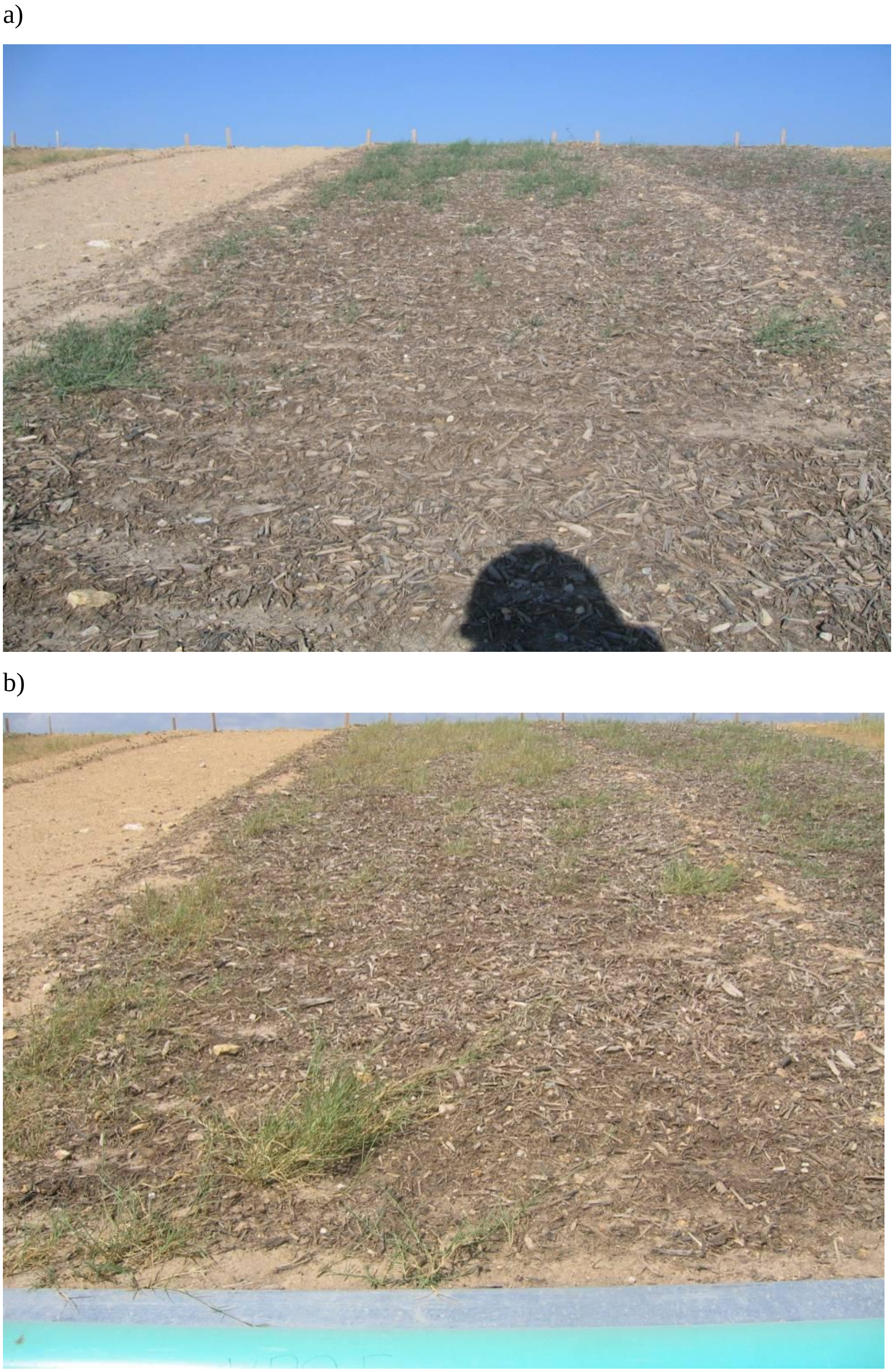
a)

b)

Figure A-26. Vegetative cover VP04 a) August 20, 2007 and b) October 16, 2007.

Figure A-27. Vegetative cover VP04 a) January 3, 2008 and b) February 14, 2008.

Figure A-28. Vegetative cover VP04 April 17, 2008.



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a)

b)

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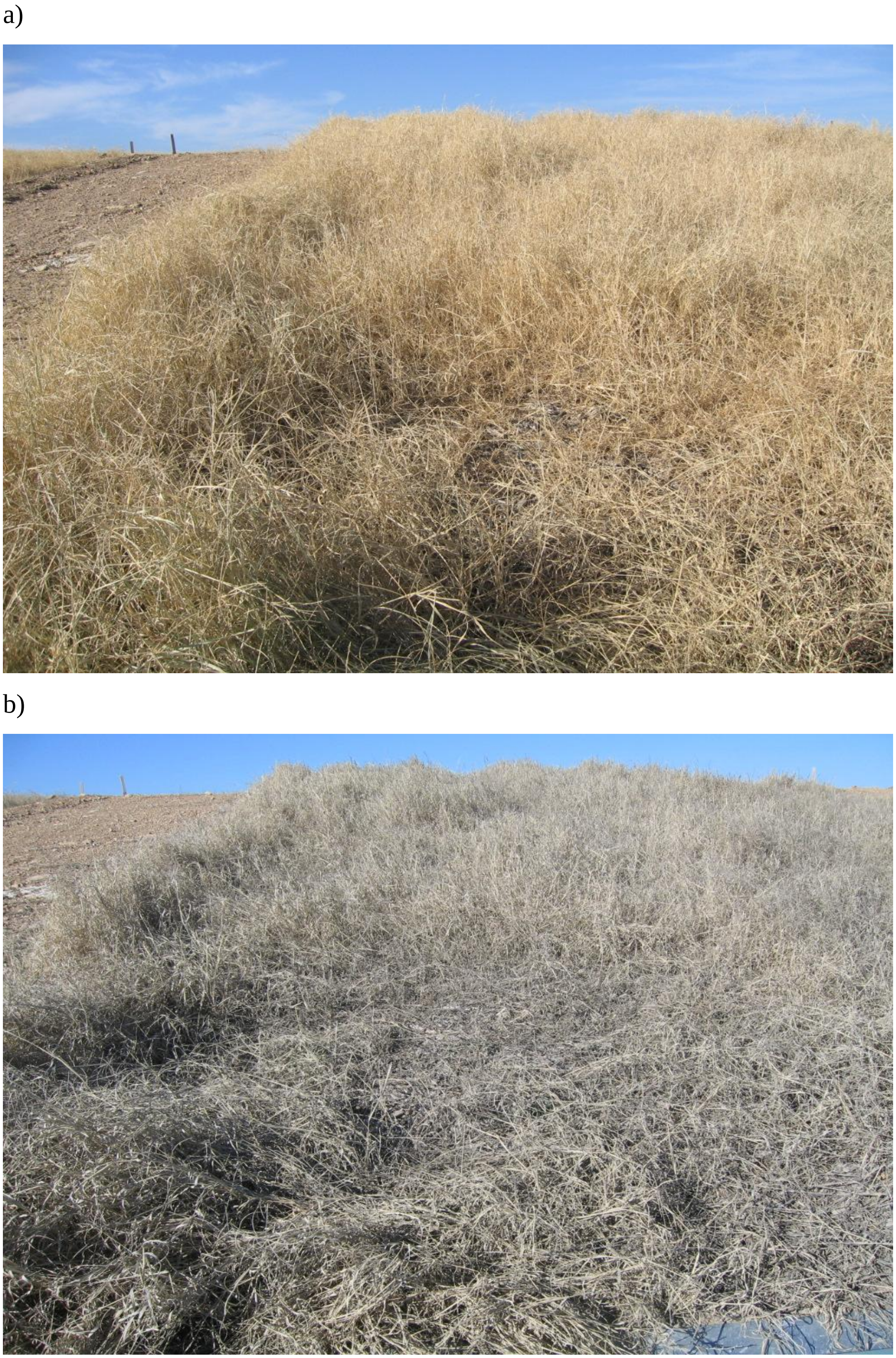

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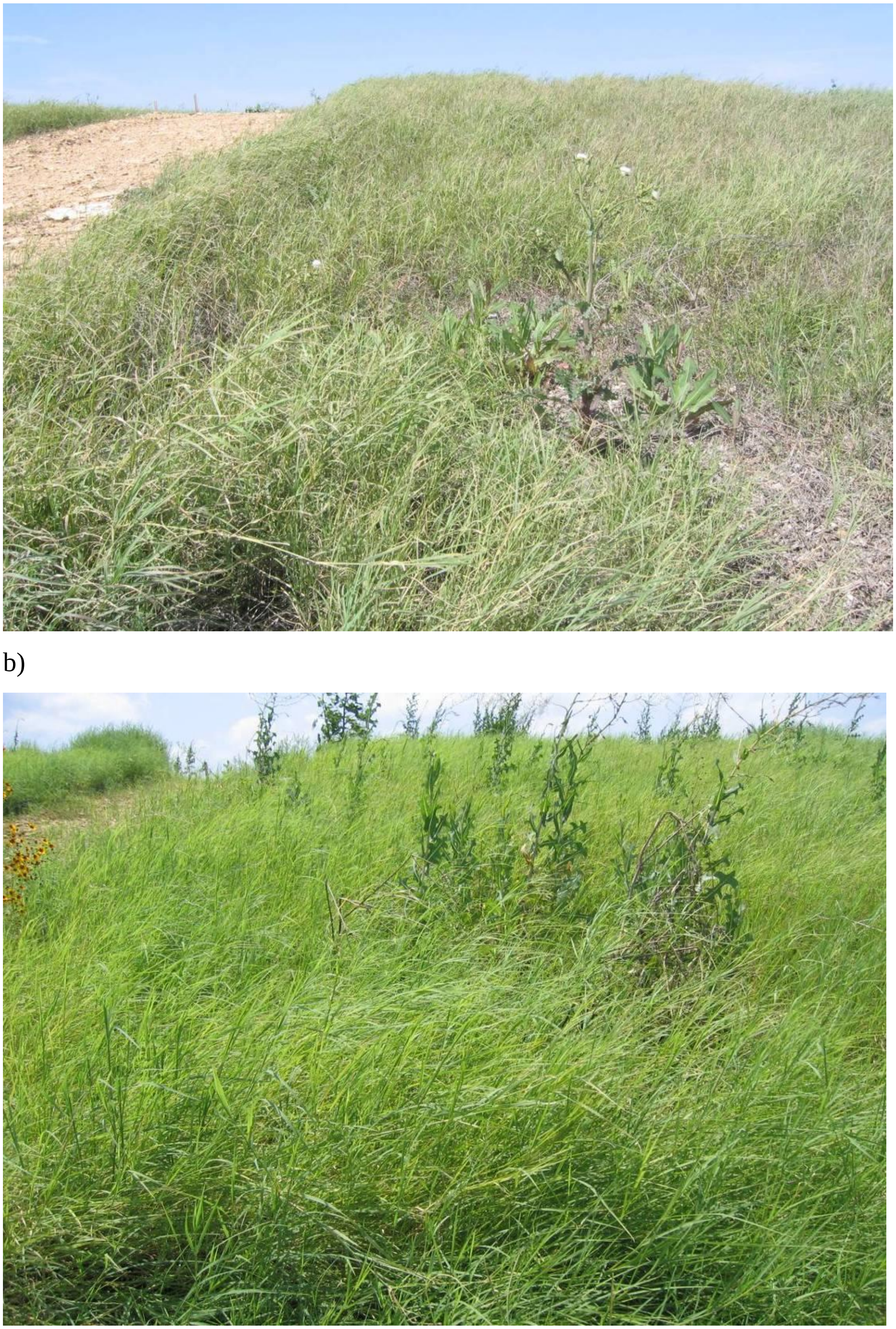


a)

b)

Figure A-32. Vegetative cover VP05 a) April 19, 2007 and b) June 18, 2007.

a)

b)

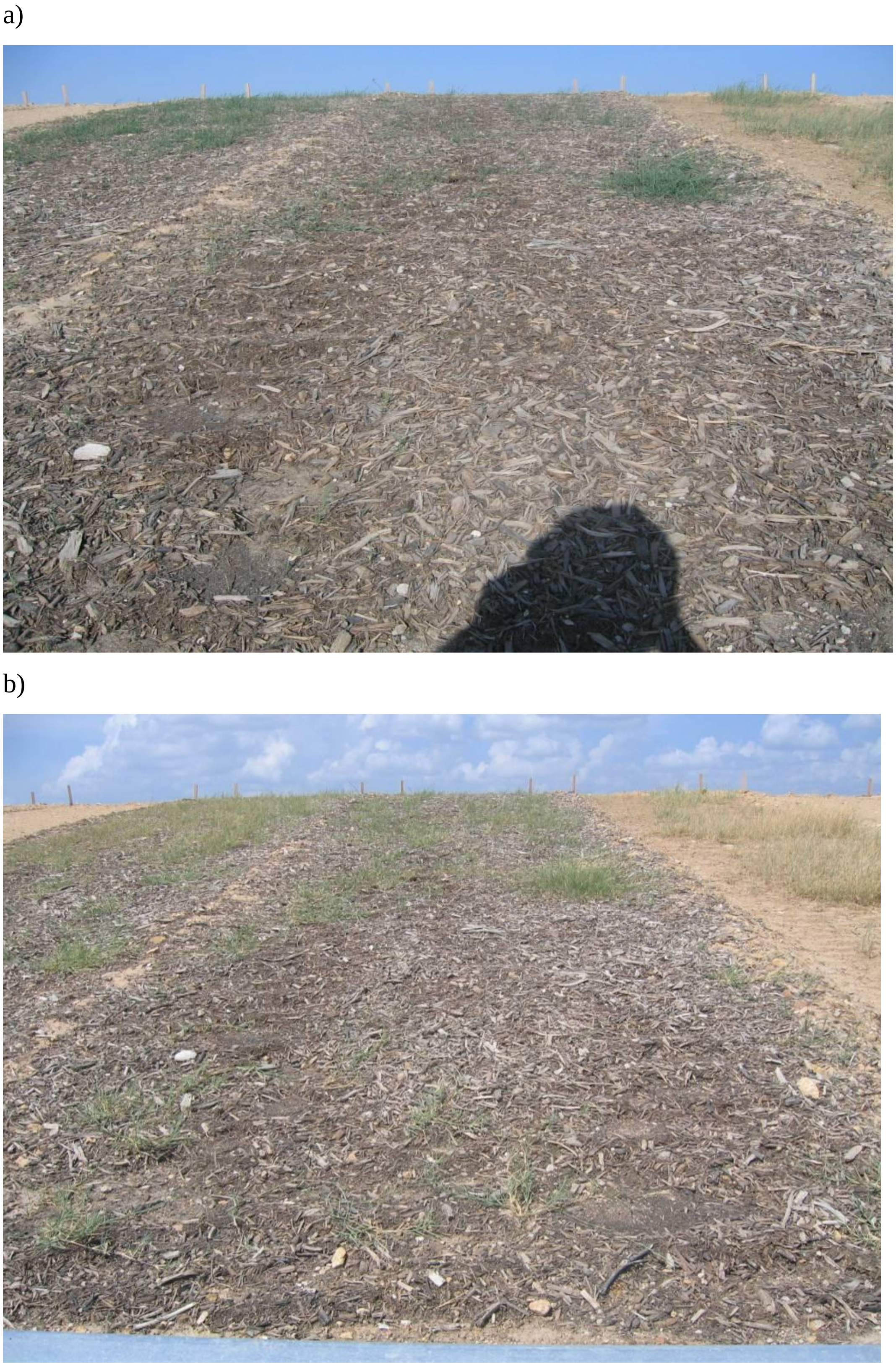
Figure A-33. Vegetative cover VP05 a) August 20, 2007 and b) October 16, 2007.

a)

b)

Figure A-34. Vegetative cover VP05 a) January 3, 2008 and b) February 14, 2008.

Figure A-35. Vegetative cover VP05 April 17, 2008.



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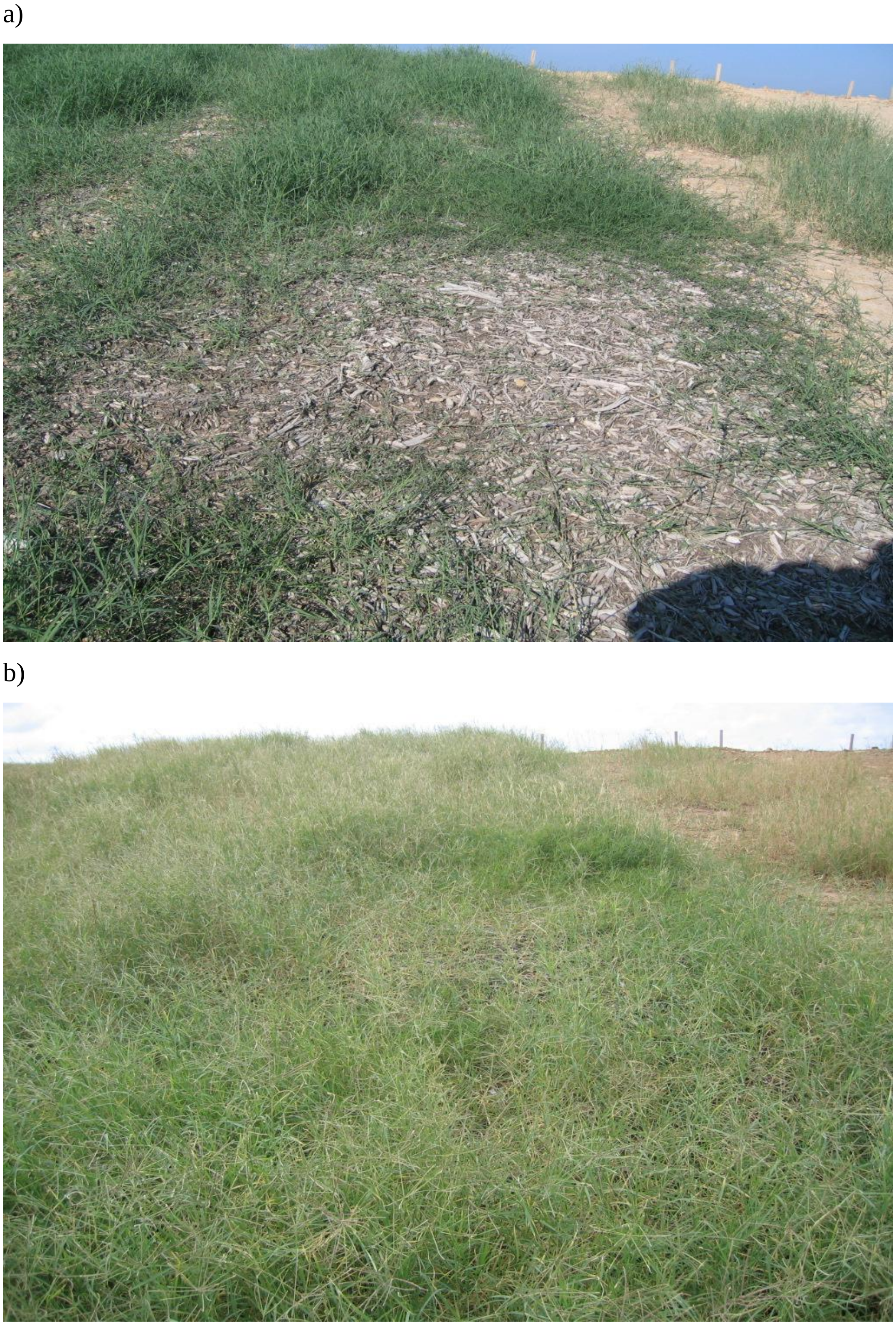

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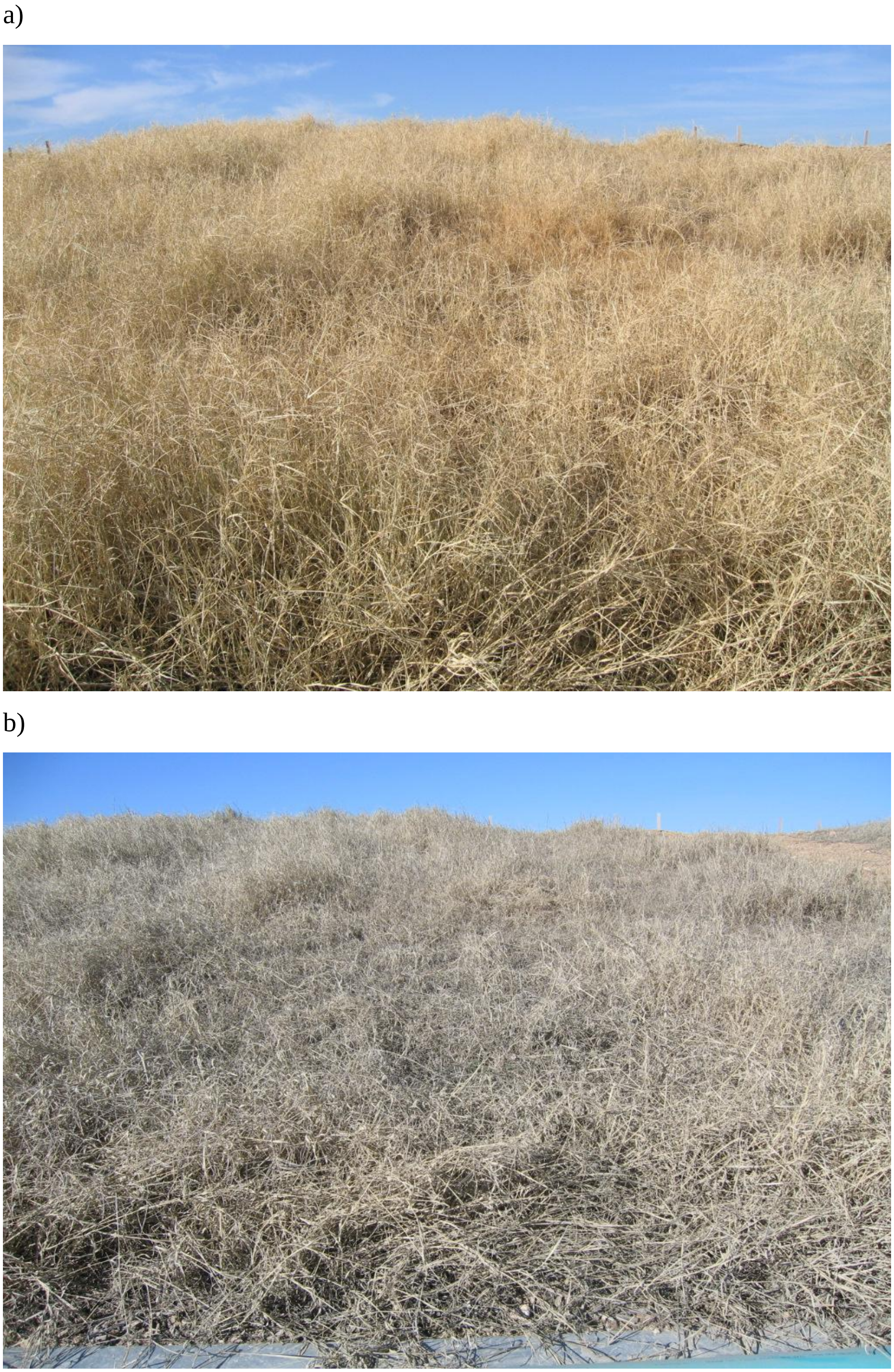

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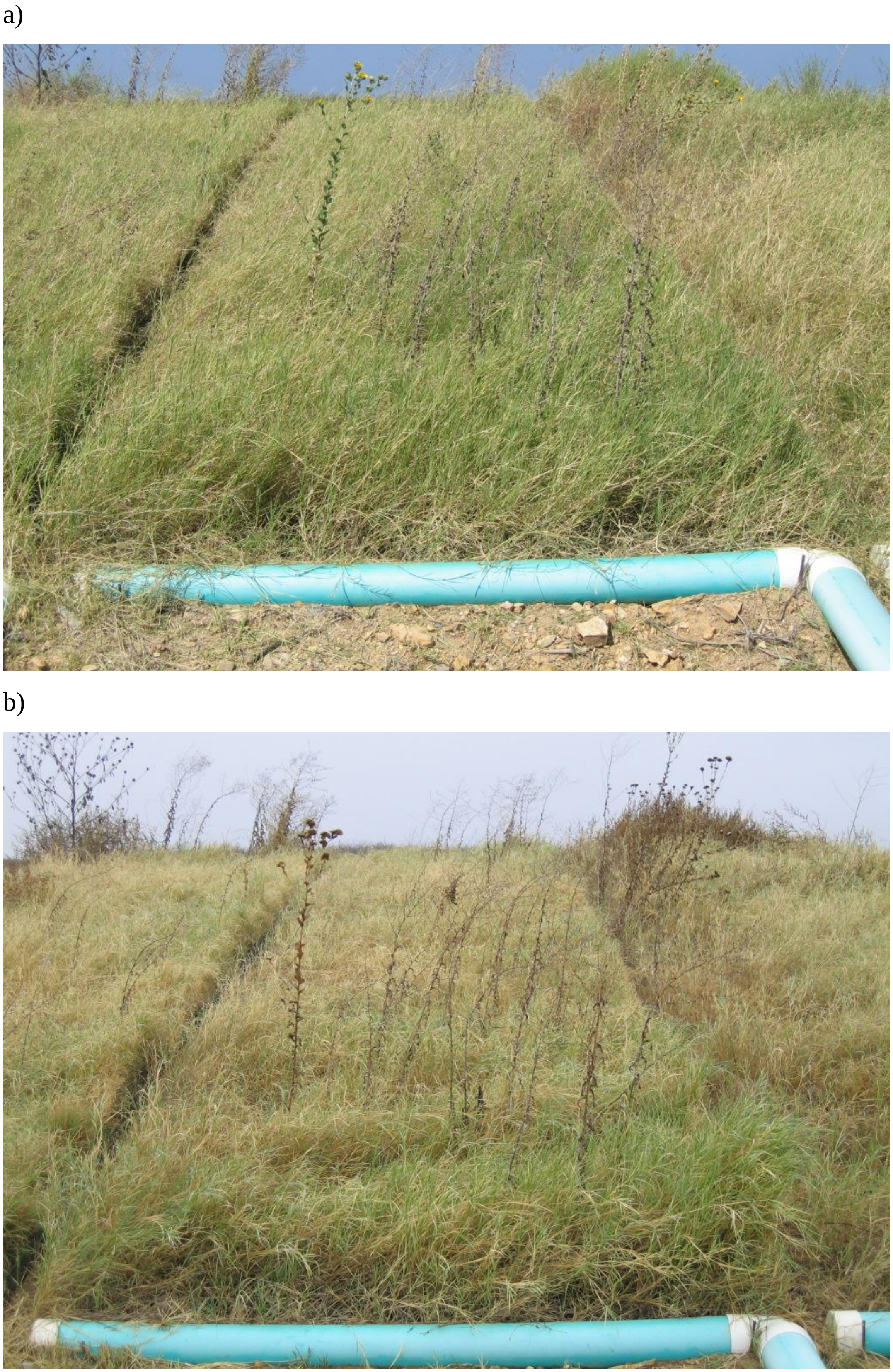
Figure A-39. Vegetative cover VP06 a) April 19, 2007 and b) June 18, 2007.



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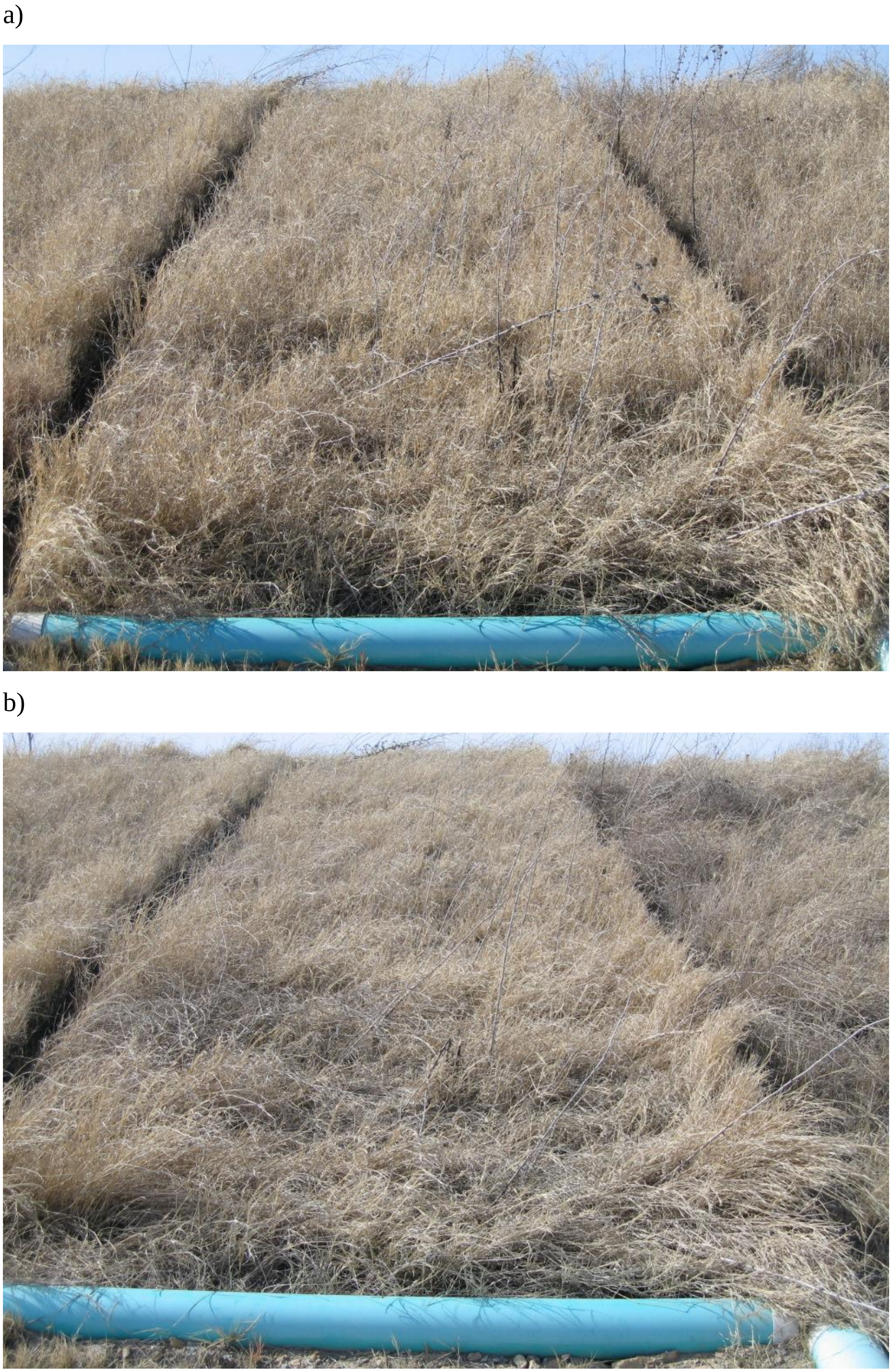

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Figure A-42. Vegetative cover VP06 April 17, 2008.

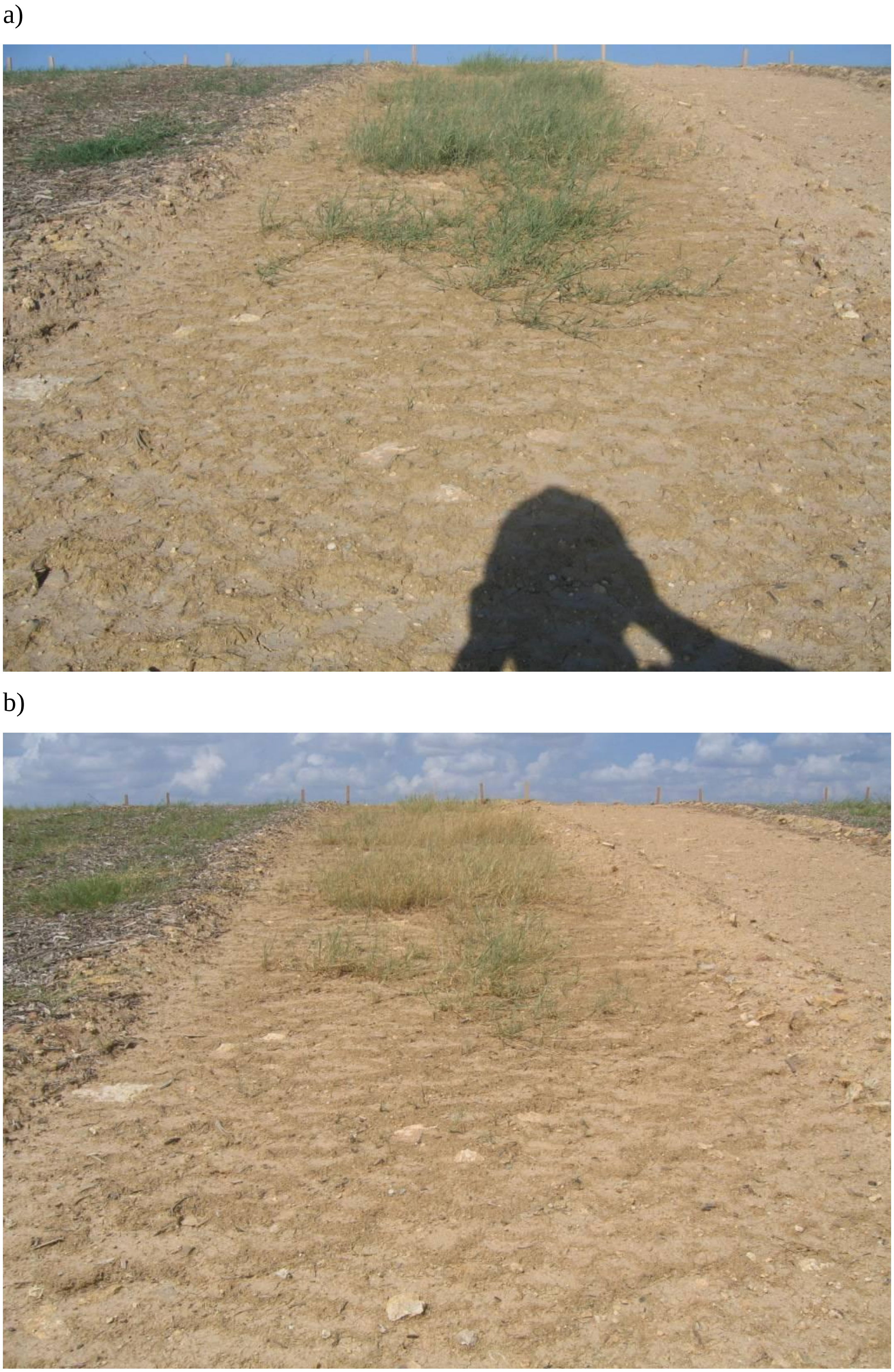


Figure A-43. Vegetative cover VP07 a) July 14, 2006 and b) August 14, 2006.

a)

b)

Figure A-44. Vegetative cover VP07 a) September 14, 2006 and b) October 10, 2006.

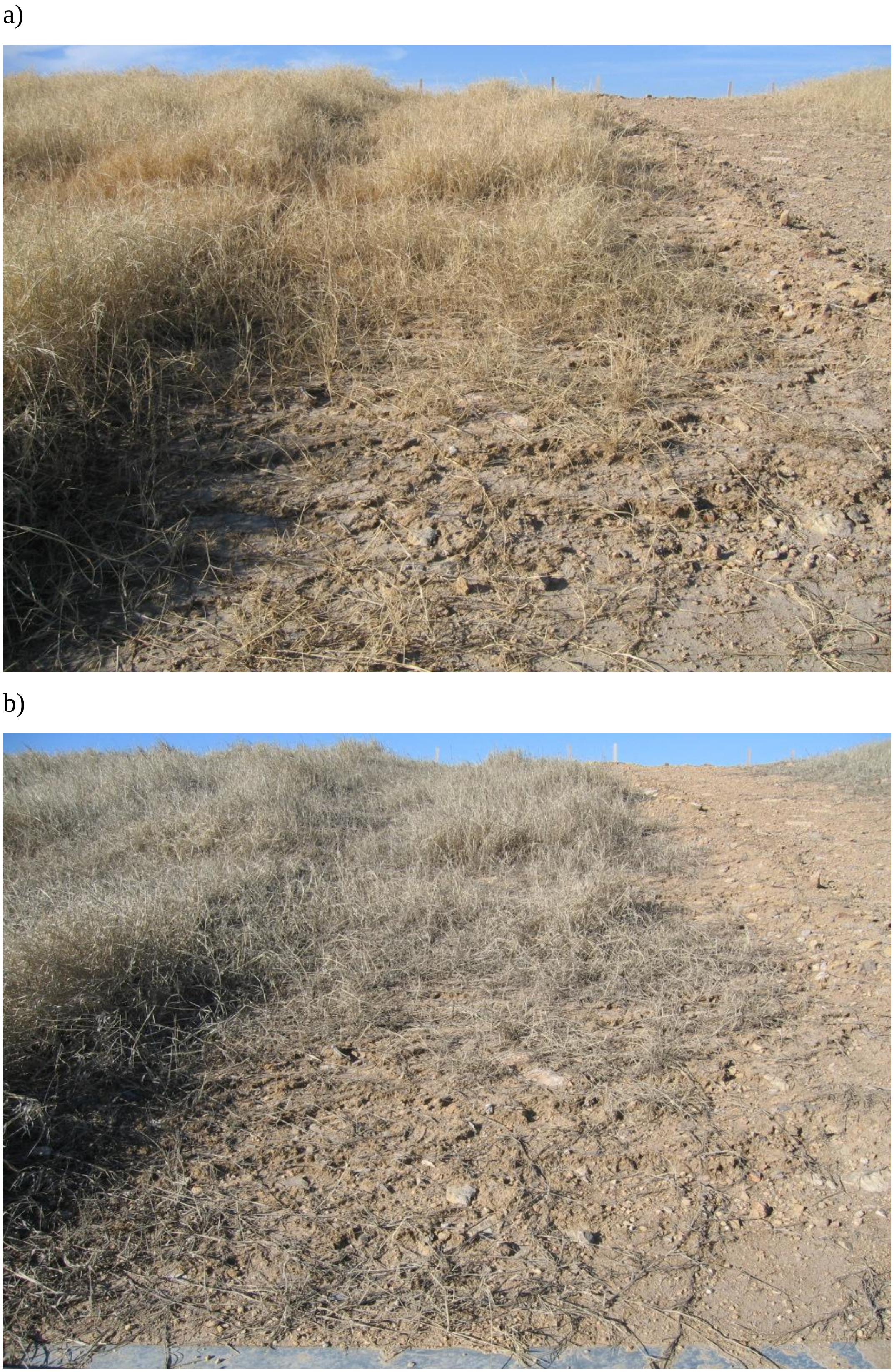
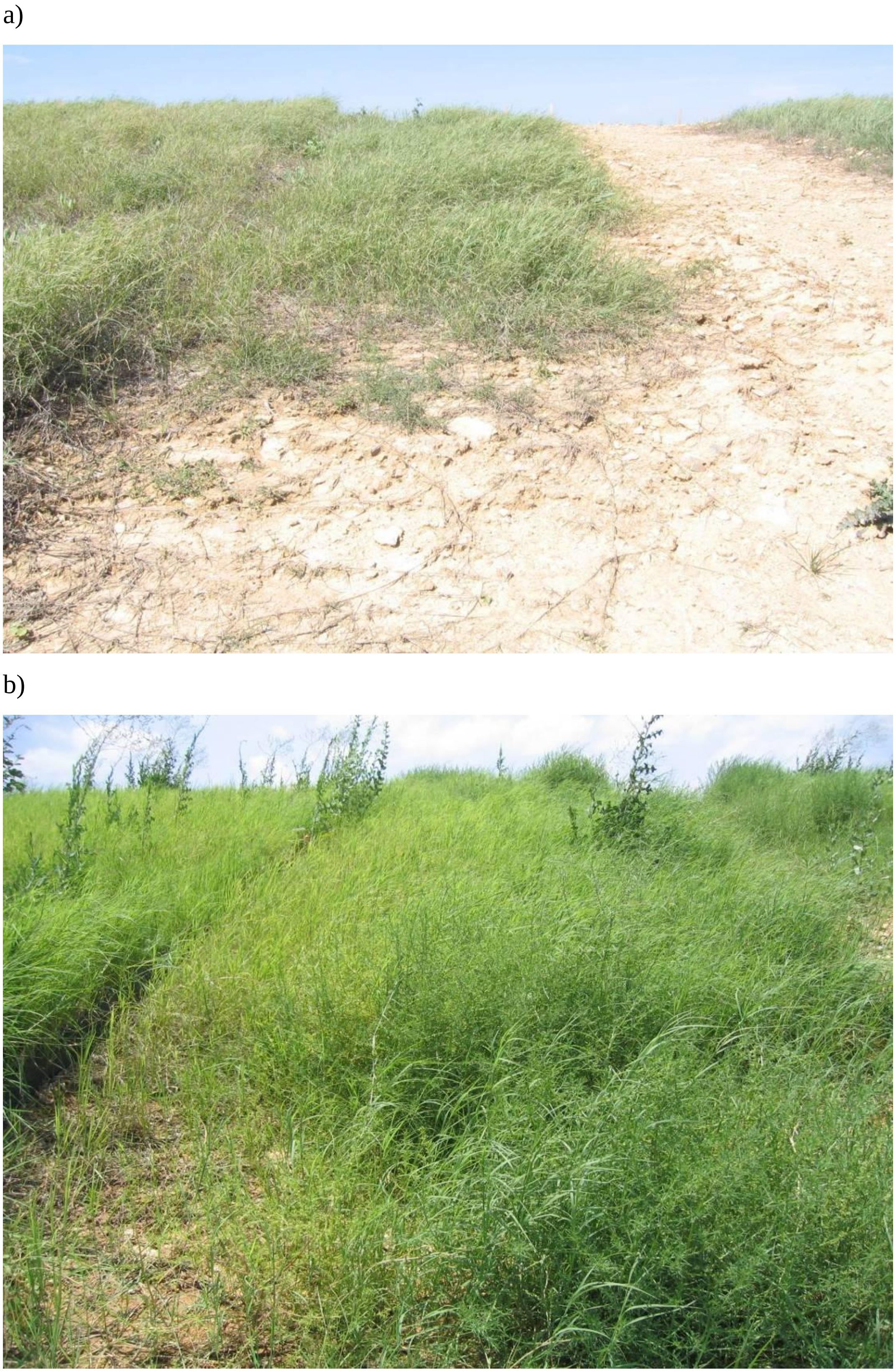


Figure A-45. Vegetative cover VP07 a) December 14, 2006 and b) February 21, 2007.



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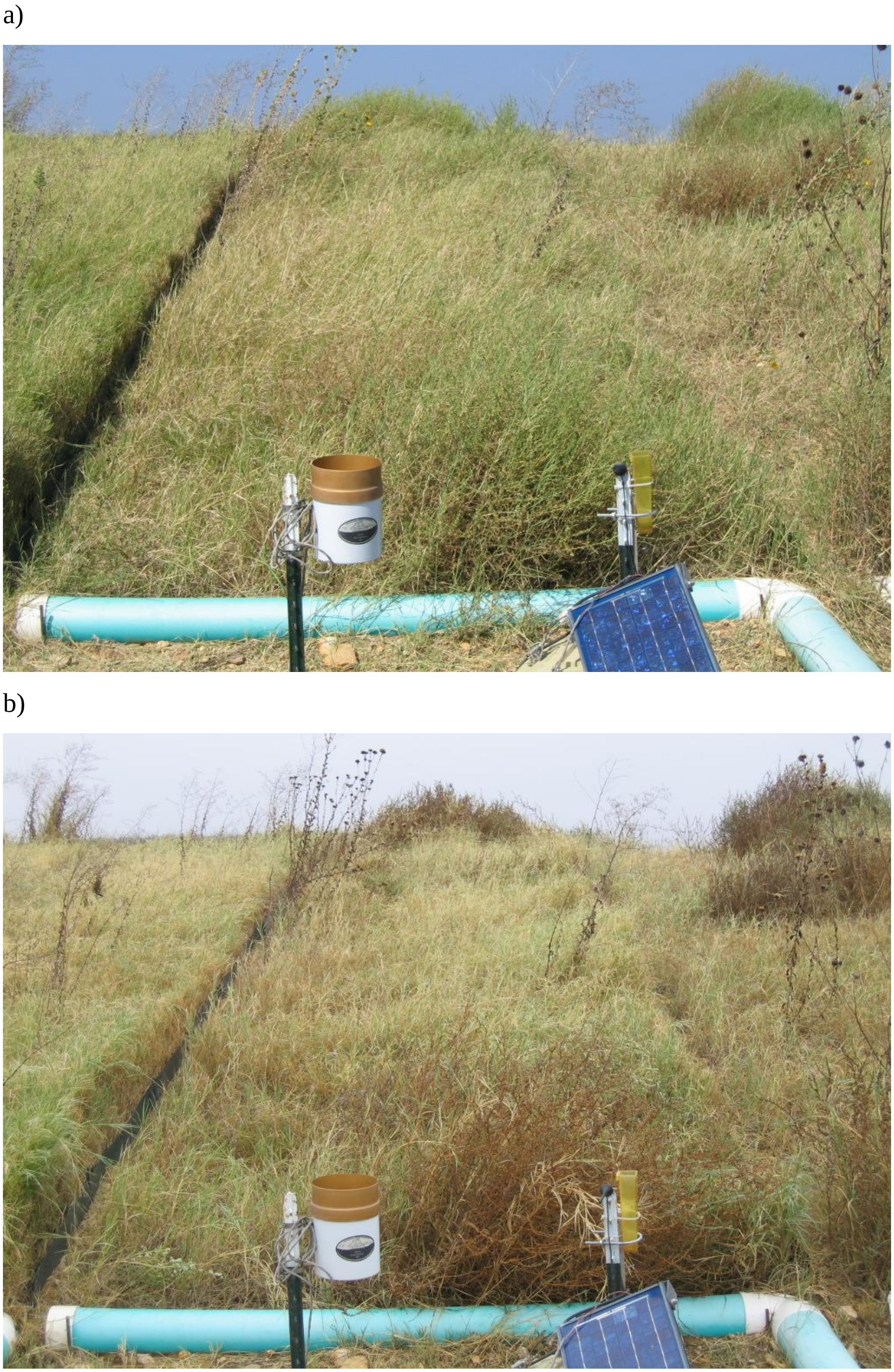

a)

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Figure A-47. Vegetative cover VP07 a) August 20, 2007 and b) October 16, 2007.

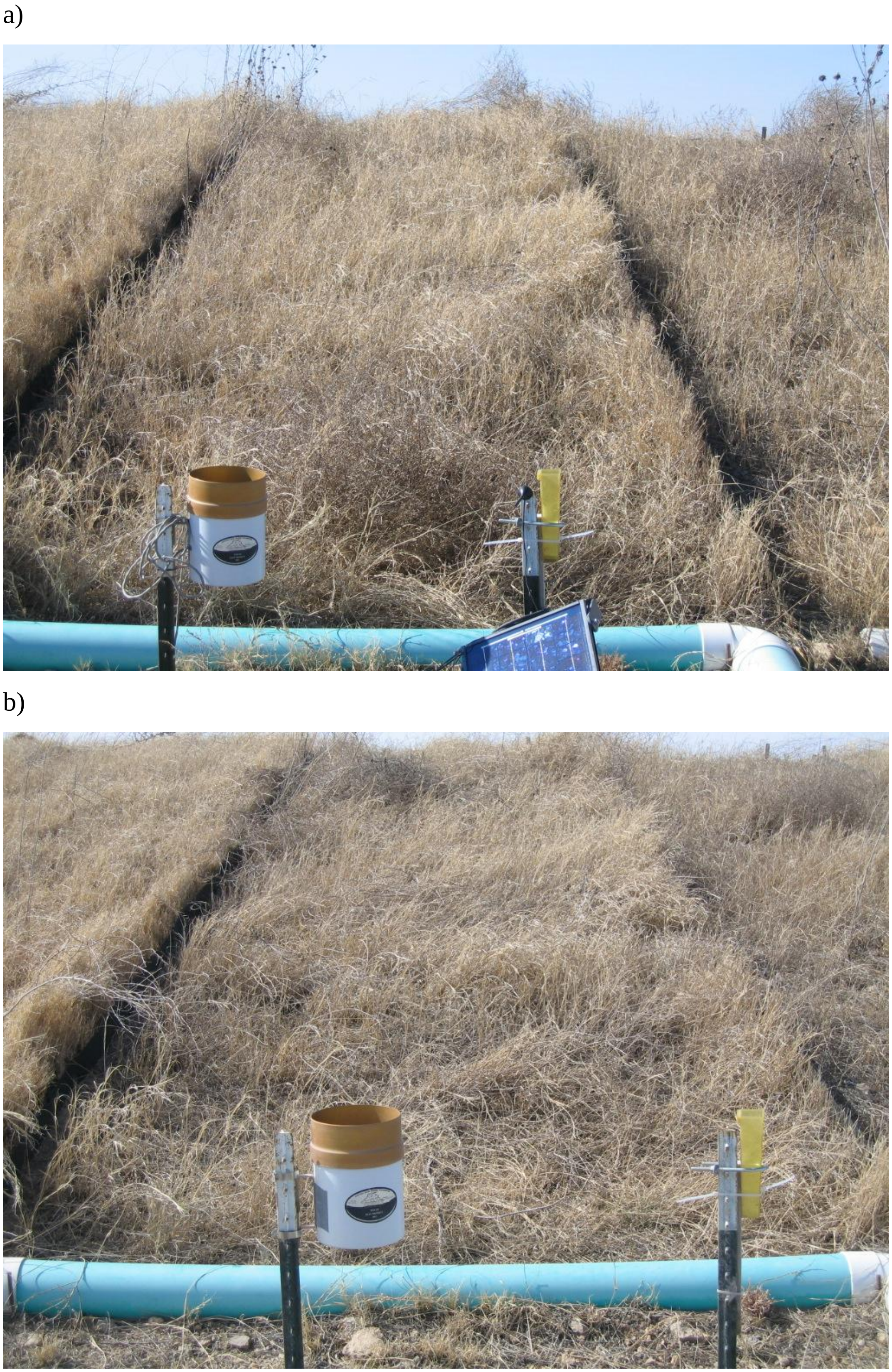

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Figure A-49. Vegetative cover VP07 April 17, 2008.

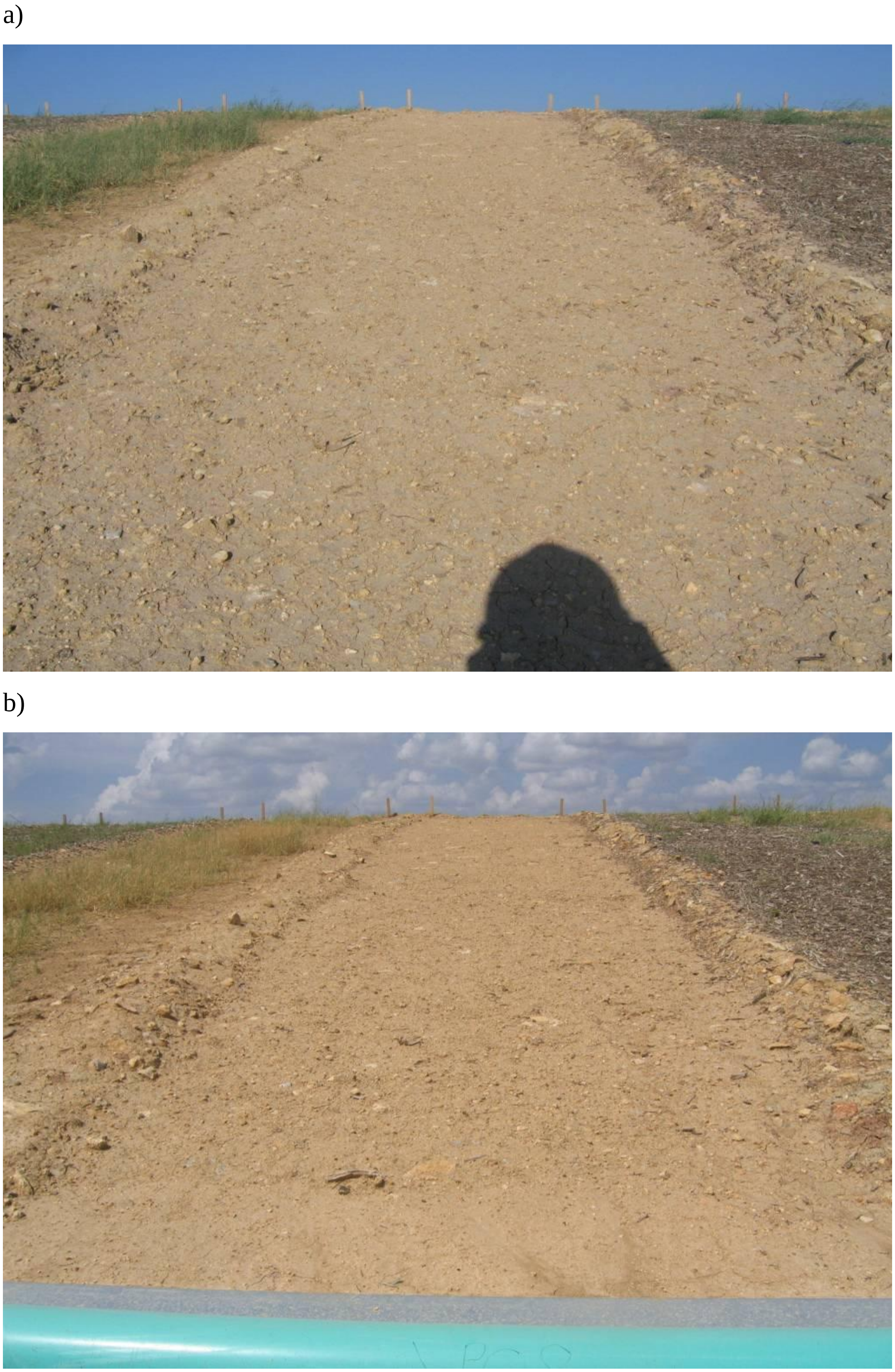


Figure A-50. Vegetative cover VP08 a) July 14, 2006 and b) August 14, 2006.

a)

b)

Figure A-51. Vegetative cover VP08 a) September 14, 2006 and b) October 10, 2006.

Figure A-52. Vegetative cover VP08 a) December 14, 2006 and b) February 21, 2007.

a)

b)

Figure A-53. Vegetative cover VP08 a) April 19, 2007 and b) June 18, 2007.

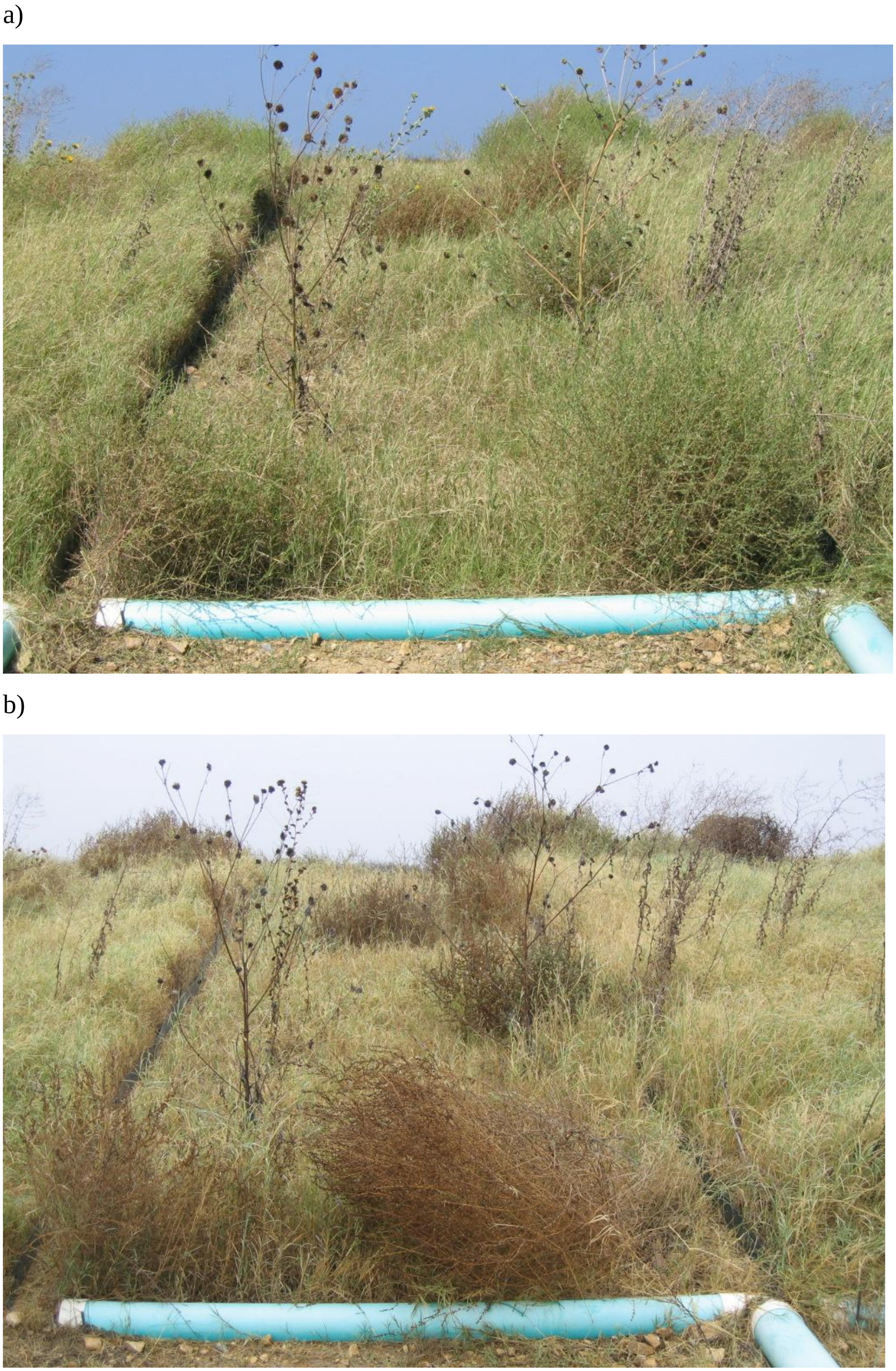


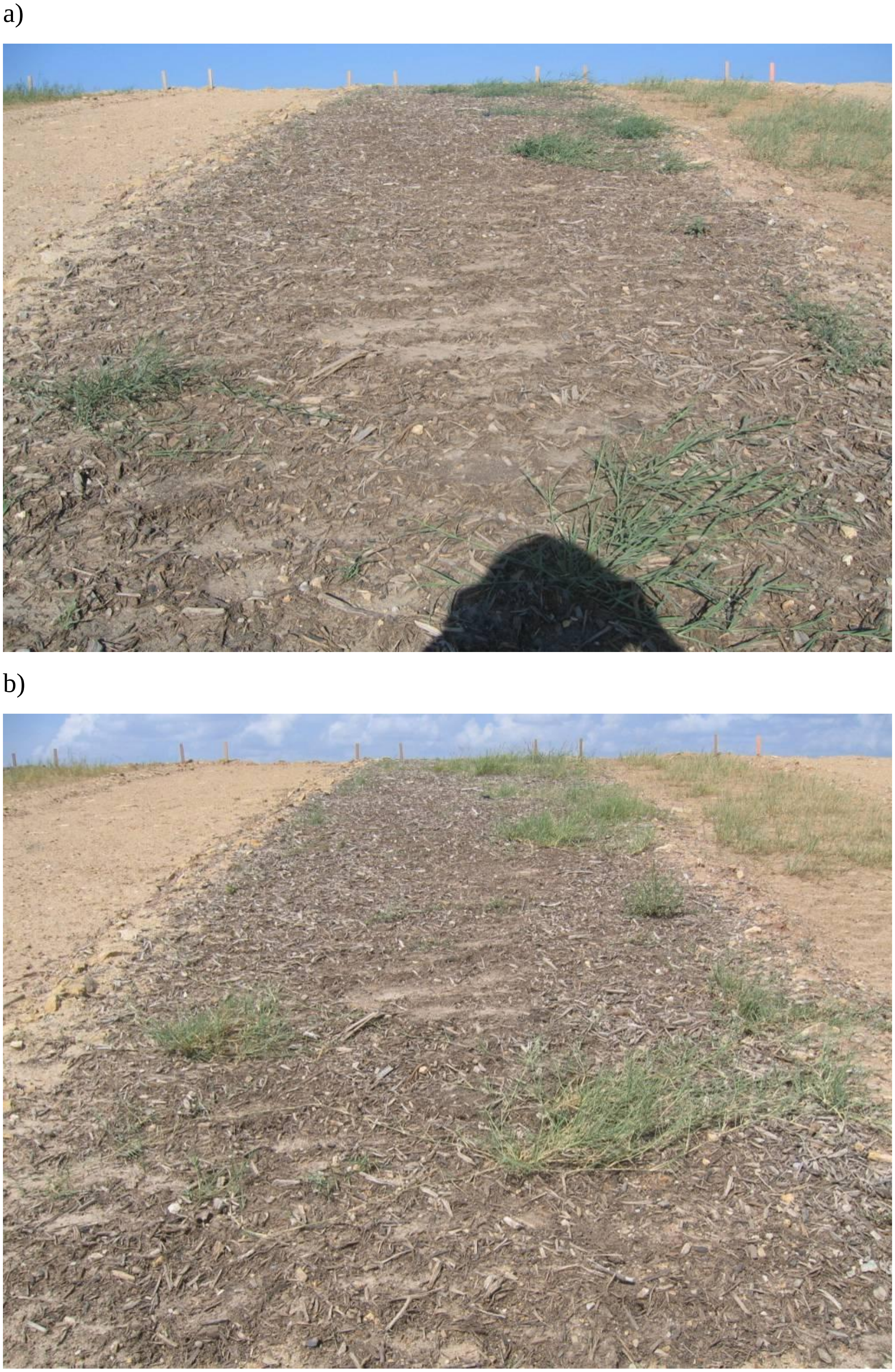
Figure A-54. Vegetative cover VP08 a) August 20, 2007 and b) October 16, 2007.

a)

b)

Figure A-55. Vegetative cover VP08 a) January 3, 2008 and b) February 14, 2008.

Figure A-56. Vegetative cover VP08 April 17, 2008.



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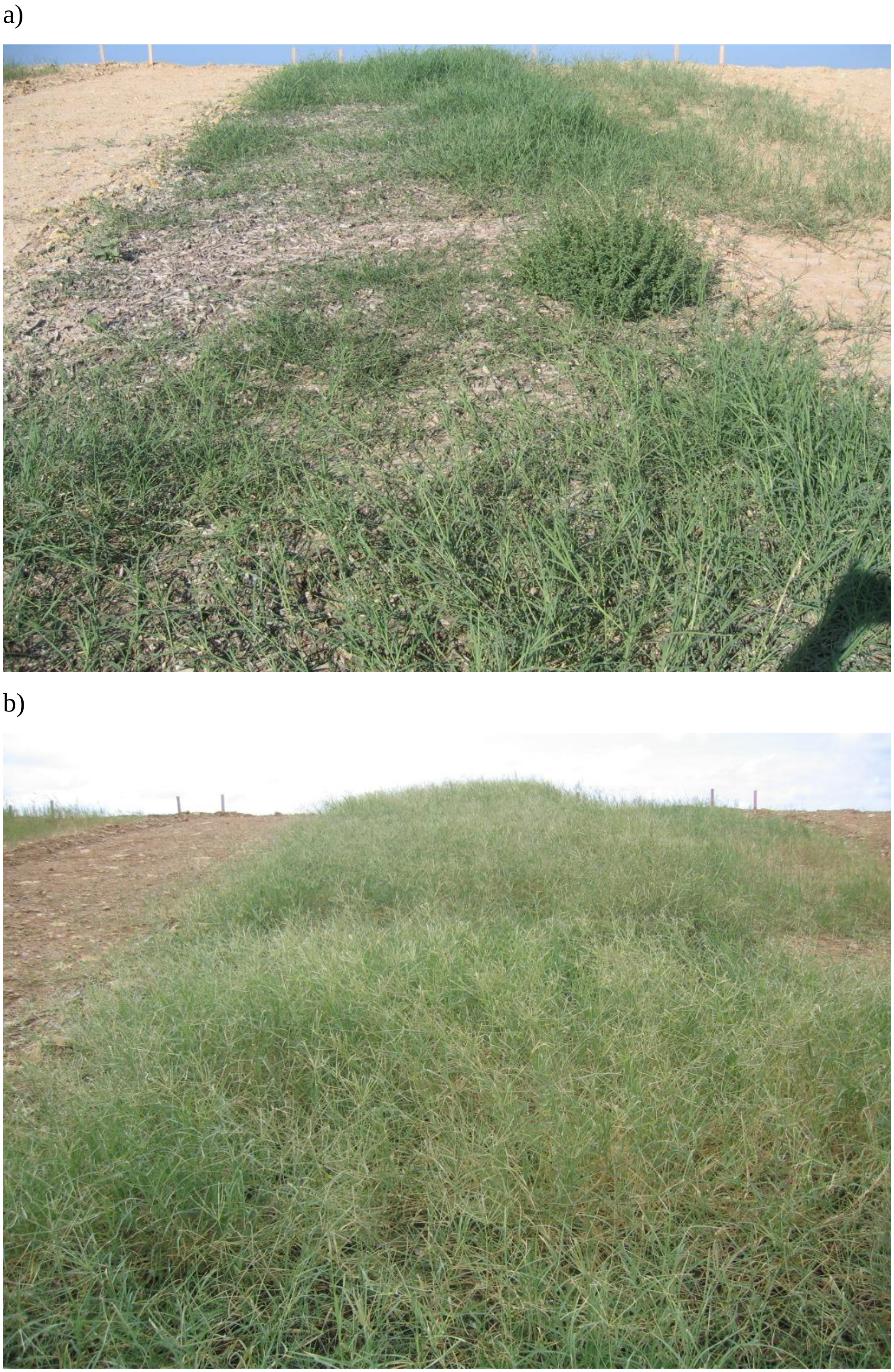

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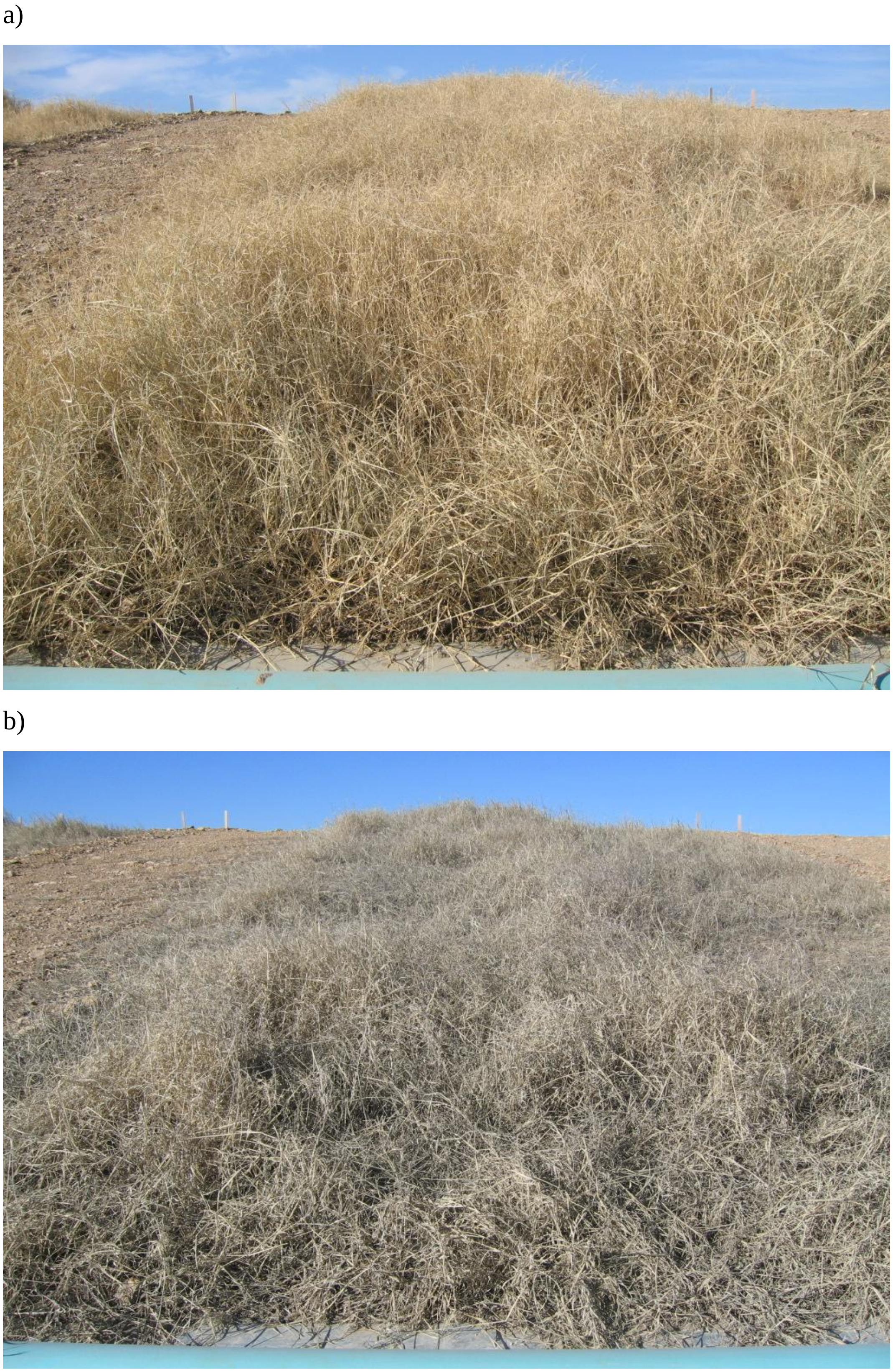

Figure A-59. Vegetative cover VP09 a) December 14, 2006 and b) February 21, 2007.

Figure A-60. Vegetative cover VP09 a) April 19, 2007 and b) June 18, 2007.

Figure A-61. Vegetative cover VP09 a) August 20, 2007 and b) October 16, 2007.

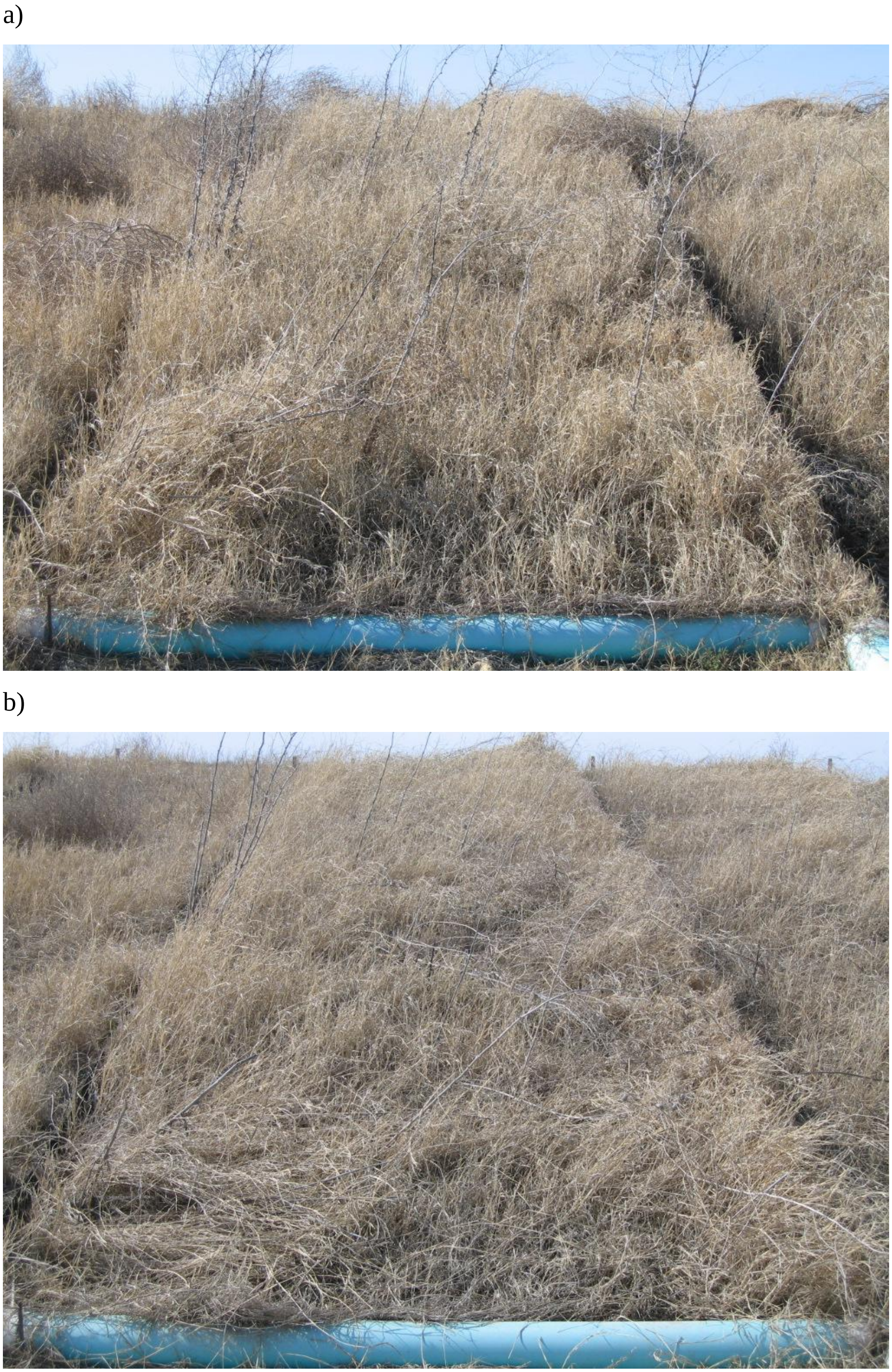

Figure A-62. Vegetative cover VP09 a) January 3, 2008 and b) February 14, 2008.

Figure A-63. Vegetative cover VP09 April 17, 2008.

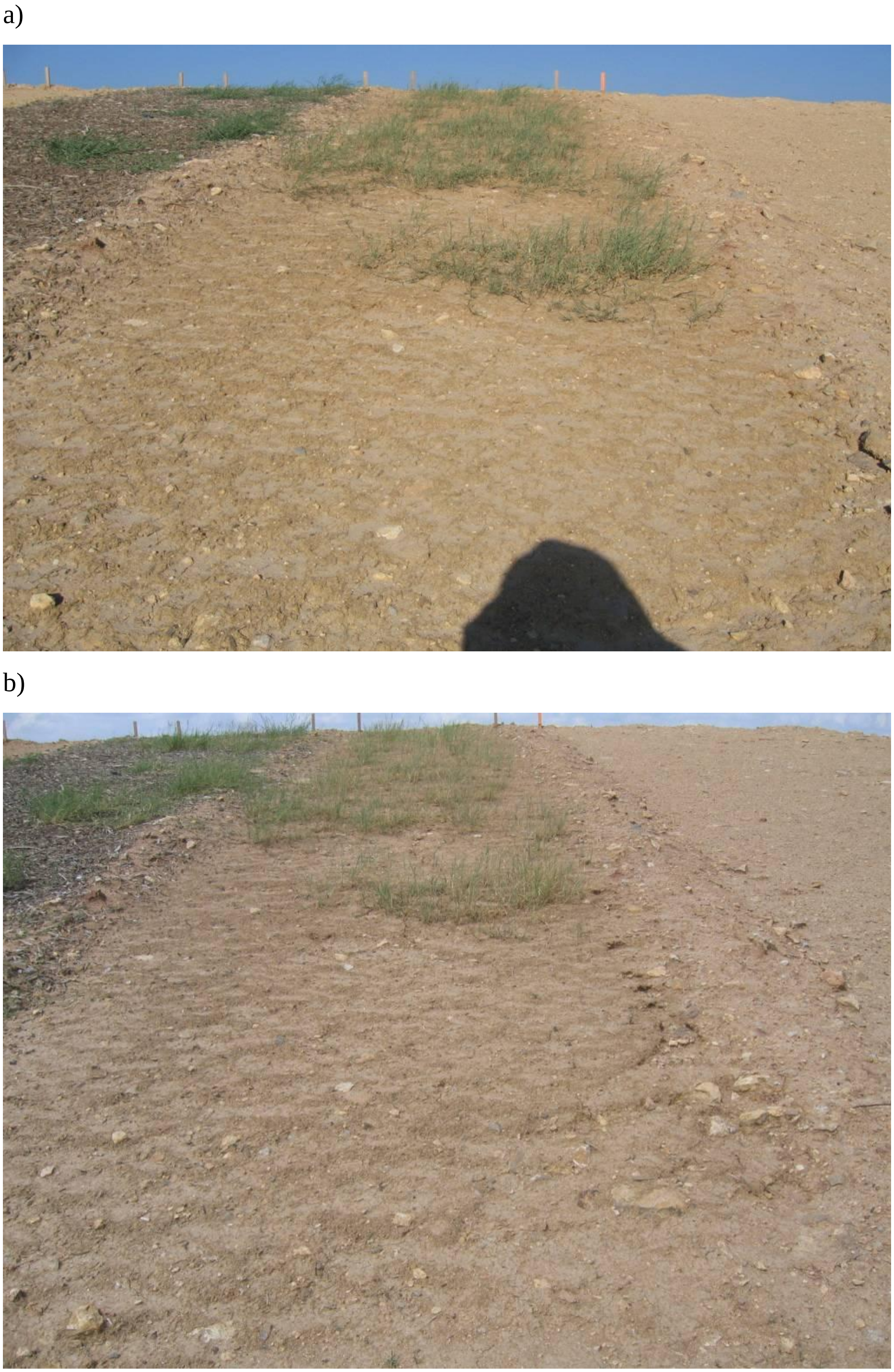

Figure A-64. Vegetative cover VP10 a) July 14, 2006 and b) August 14, 2006.

a)

b)

Figure A-65. Vegetative cover VP10 a) September 14, 2006 and b) October 10, 2006.

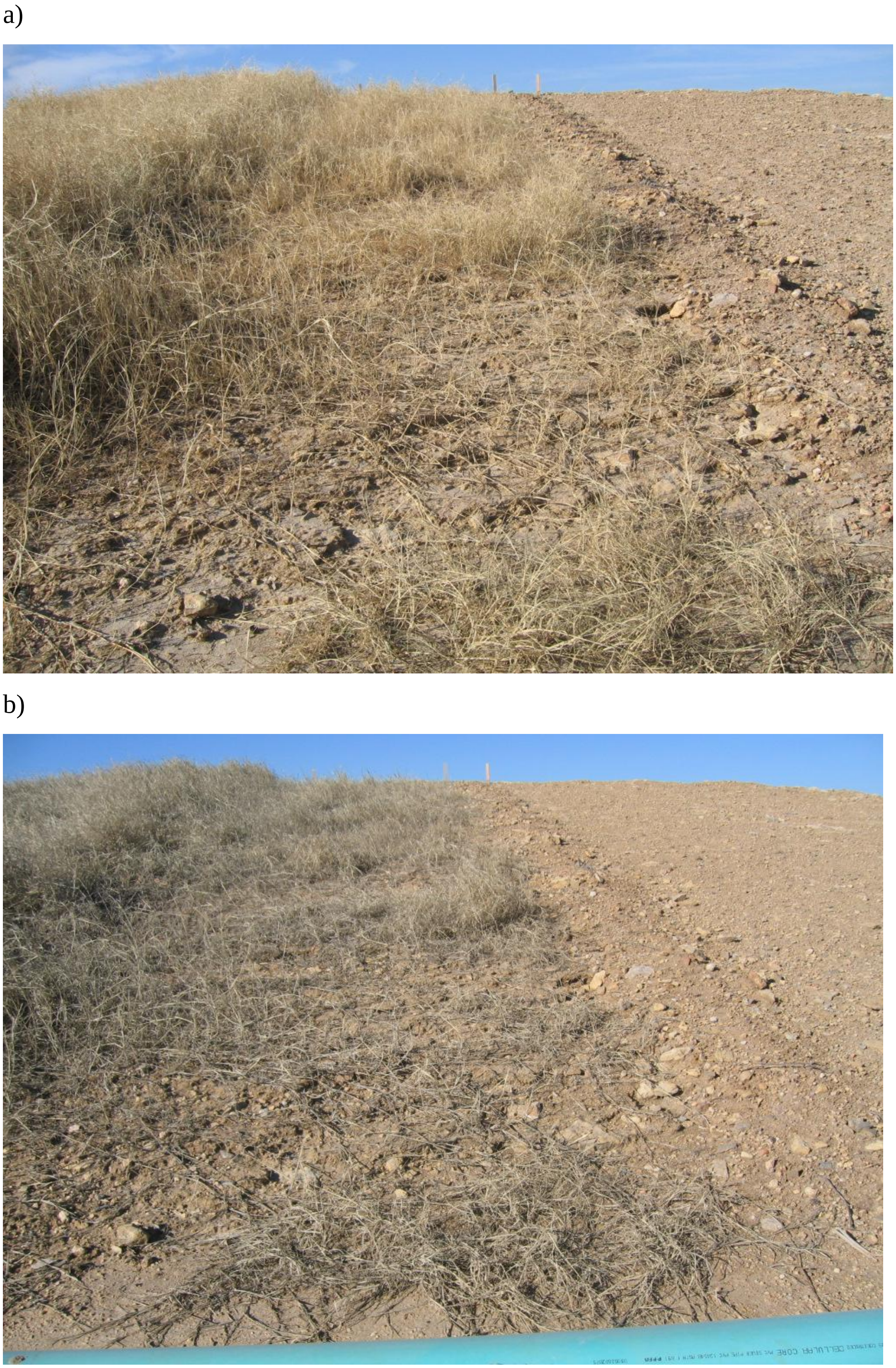

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Figure A-67. Vegetative cover VP10 a) April 19, 2007 and b) June 18, 2007

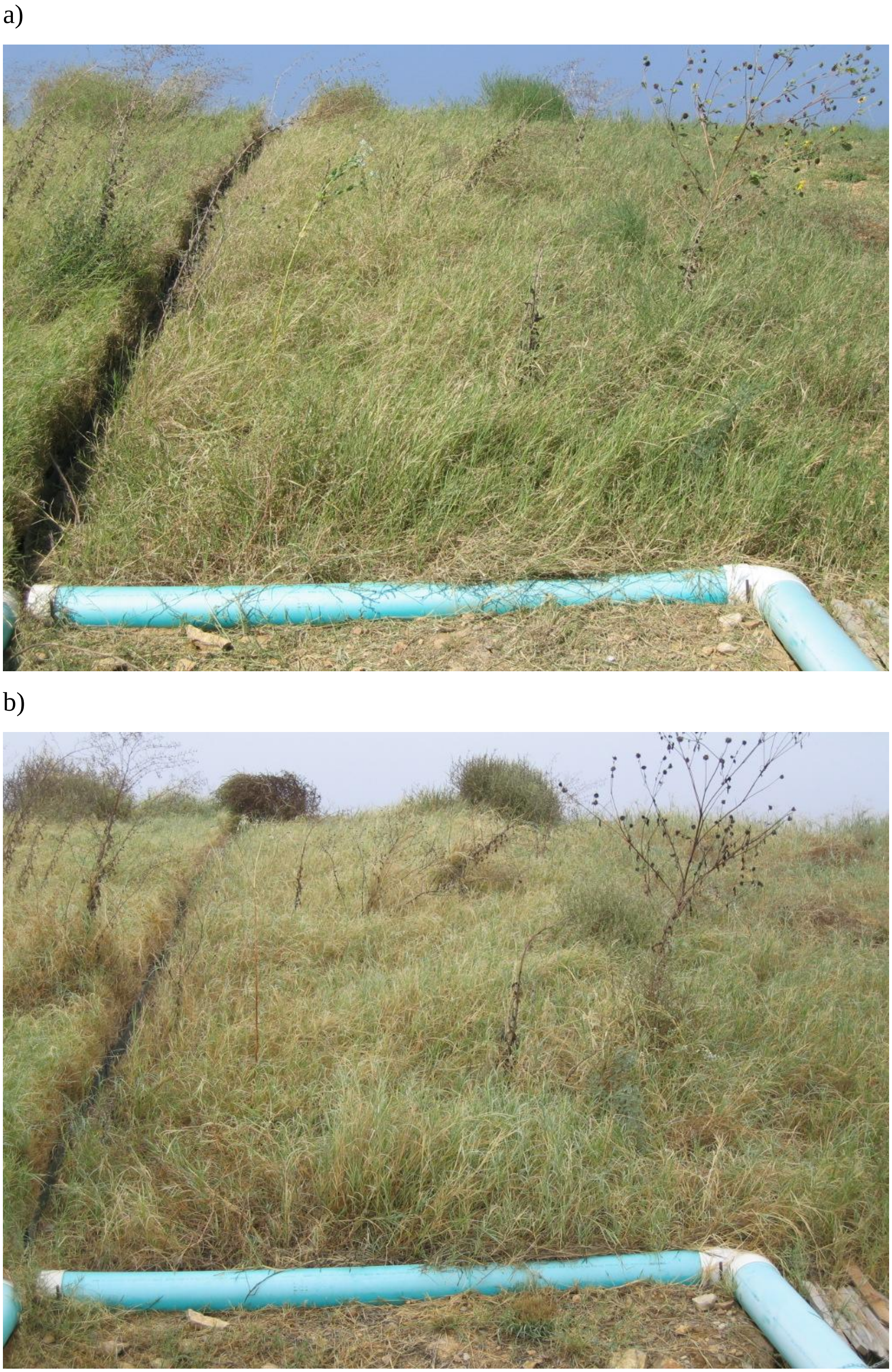

Figure A-68. Vegetative cover VP10 a) August 20, 2007 and b) October 16, 2007.

Figure A-69. Vegetative cover VP10 a) January 3, 2008 and b) February 14, 2008.

Figure A-70. Vegetative cover VP10 April 17, 2008.

Figure A-71. Composite view of test plots VP01, VP02, VP03, VP04, and VP05 (partial view) taken December 14, 2006.

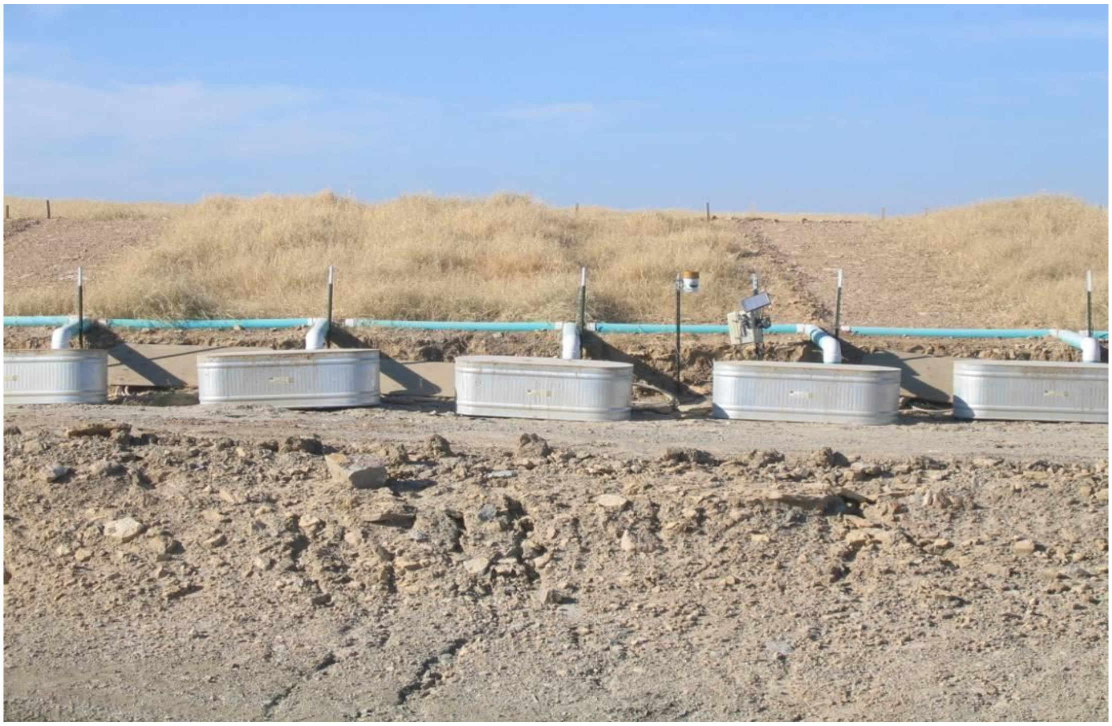

Figure A-72. Composite view of test plots VP04 (partial view), VP05, VP06, VP07, VP08, and VP09 (partial view) taken December 14, 2006.

Figure A-73. Composite view of test plots VP07 (partial view), VP08, VP09, and VP10 taken December 14, 2006.

Figure A-74. Composite view of test plots VP01, VP02, VP03, VP04, and VP05 (partial view) taken April 19, 2007.

Figure A-75. Composite view of test plots VP04 (partial view), VP05, VP06, VP07, VP08, and VP09 (partial view) taken April 19, 2007.

Figure A-76. Composite view of test plots VP06 (partial view), VP07, VP08, VP09, and VP10 taken April 19, 2007

Figure A-77. Composite view of test plots VP01, VP02, VP03, and VP04 taken January 3, 2008.

Figure A-78. Composite view of test plots VP04 (partial view), VP05, VP06, VP07, VP08, and VP09 (partial view) taken January 3, 2008.

Figure A-79. Composite view of test plots VP08, VP09, and VP10 taken January 3, 2008.

Figure A-80. Composite view of test plots VP01, VP02, VP03, VP04, and VP05 (partial view) taken April 17, 2008.

Figure A-81. Composite view of test plots VP04 (partial view), VP05, VP06, VP07, VP08, and VP09 (partial view) taken April 17, 2008.

Figure A-82. Composite view of test plots VP06 (partial view), VP07, VP08, VP09, and VP10 taken April 17, 2008.

Appendix B: Observed Runoff Volumes and Concentrations

Table B-1. Runoff volumes and concentrations for June 17, 2006 event one.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.36	VP01 Low OM		No					
	VP02 High OM	5	No	1720	8.51	55.7	1.74	5.57
	VP03 Hydromulch		No					
	VP04 Untreated	23	No	20000	0.464	21.5	0.536	6.59
	VP05 Low OM		No					
	VP06 High OM		No					
	VP07 Hydromulch	11	No	8640	0.513	8.13	1.86	5.57
	VP08 Untreated	20	No	23600	0.474	25.1	0.173	7.96
	VP09 Low OM		No					
	VP10 Hydromulch		No					

Table B-2. Runoff volumes and concentrations for June 17, 2006 event two.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
1.23	VP01 Low OM	71	No	3380	4.25	26.9	1.49	7.14
	VP02 High OM	95	No	5740	0.203	60.9	2.40	18.2
	VP03 Hydromulch	132	No	21100	0.410	20.2	3.82	13.1
	VP04 Untreated	148	Possible	20800	0.761	36.1	0.731	12.7
	VP05 Low OM	78	No	5970	4.55	31.8	1.72	9.23
	VP06 High OM	93	No	6170	0.108	30.6	1.95	7.68
	VP07 Hydromulch	132	No	14400	0.383	17.9	2.30	10.2
	VP08 Untreated	155	No	35500	0.403	27.1	0.280	8.61
	VP09 Low OM	81	No	13400	2.33	28.0	1.30	8.86
	VP10 Hydromulch	107	No	20000	0.260	17.8	1.09	8.29

Table B-3. Runoff volumes and concentrations for June 23, 2006. Event sampled only for TSS.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.28	VP01 Low OM		No					
	VP02 High OM		No					
	VP03 Hydromulch		No					
	VP04 Untreated	13	No	7660				
	VP05 Low OM		No					
	VP06 High OM		No					
	VP07 Hydromulch		No					
	VP08 Untreated	12	No	3150				
	VP09 Low OM		No					
	VP10 Hydromulch		No					

Table B-4. Runoff volumes and concentrations for June 24, 2006.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.40	VP01 Low OM		No					
	VP02 High OM	4	No	3460	0.761	18.7	1.71	4.73
	VP03 Hydromulch	36	No	2600	0.602	10.2	1.54	6.55
	VP04 Untreated	56	No	37800	0.562	28.1	0.403	8.44
	VP05 Low OM		No					
	VP06 High OM		No					
	VP07 Hydromulch	40	No	6480	0.700	8.63	1.03	5.22
	VP08 Untreated	51	No	55700	0.548	26.7	0.177	8.76
	VP09 Low OM	5	No	8320	1.10	15.2	0.858	3.99
	VP10 Hydromulch	36	No	8780	0.573	8.34	0.713	5.15

Table B-5. Runoff volumes and concentrations for July 4, 2006.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
1.11	VP01 Low OM	66	No	2530	0.060	25.9	2.52	7.32
	VP02 High OM	66	No	4600	0.138	50.8	5.87	16.2
	VP03 Hydromulch	127	No	14800	0.090	18.4	1.85	10.6
	VP04 Untreated	158	No	46200	0.292	47.1	0.430	14.8
	VP05 Low OM	70	No	3320	0.062	25.6	3.05	9.25
	VP06 High OM	57	No	2020	0.093	33.2	4.59	9.14
	VP07 Hydromulch	130	No	6900	0.110	13.7	1.08	7.86
	VP08 Untreated	160	No	61800	0.286	55.4	0.161	14.8
	VP09 Low OM	59	No	5070	0.052	24.6	2.42	8.73
	VP10 Hydromulch	149	No	13400	0.125	14.8	0.838	7.94

Table B-6. Runoff volumes and concentrations for August 12, 2006. Event sampled only for TSS.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.11	VP01 Low OM		No					
	VP02 High OM		No					
	VP03 Hydromulch		No					
	VP04 Untreated	2	No	37800				
	VP05 Low OM		No					
	VP06 High OM		No					
	VP07 Hydromulch		No					
	VP08 Untreated	4	No	21100				
	VP09 Low OM		No					
	VP10 Hydromulch		No					

Table B-7. Runoff volumes and concentrations for August 14, 2006.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.45	VP01 Low OM	9	No	6150	< 0.04 [a]	18.6	0.886	6.26
	VP02 High OM	8	No	4950	0.079	23.2	1.91	8.26
	VP03 Hydromulch	48	No	22100	0.043	19.8	1.00	11.4
	VP04 Untreated	56	No	57700	0.221	49.3	0.531	16.9
	VP05 Low OM	13	No	7550	< 0.04 [a]	19.3	1.04	7.68
	VP06 High OM	7	No	5250	< 0.04 [a]	21.1	1.58	7.84
	VP07 Hydromulch	49	No	21500	0.048	17.1	0.49	8.89
	VP08 Untreated	61	No	54100	0.252	37.5	0.181	13.0
	VP09 Low OM	15	No	9250	< 0.04 [a]	23.1	1.06	8.91
	VP10 Hydromulch	53	No	20100	< 0.04 [a]	17.3	0.574	9.17

[a] Measured values less than the NO_2- N+NO_3-N reporting limit of 0.04 mg/L.

Table B-8. Runoff volumes and concentrations for August 27, 2006.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
1.25	VP01 Low OM	39	No	2050	0.056	11.7	0.988	4.36
	VP02 High OM	24	No	3100	0.281	17.7	2.50	5.29
	VP03 Hydromulch	135	No	11300	0.139	15.3	0.896	9.22
	VP04 Untreated	151	No	35000	0.230	24.2	0.289	11.5
	VP05 Low OM	35	No	2150	0.046	10.5	0.952	4.07
	VP06 High OM	13	No	1300	0.422	14.1	1.86	4.46
	VP07 Hydromulch	134	No	9200	0.053	10.7	0.584	6.41
	VP08 Untreated	157	No	78500	0.252	38.7	0.107	12.2
	VP09 Low OM	47	No	3100	0.087	14.1	0.982	4.84
	VP10 Hydromulch	150	No	10400	0.098	13.4	0.448	6.91

Table B-9. Runoff volumes for September 3, 2006. No water quality sample collected.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
2.68	VP01 Low OM	151	Yes					
	VP02 High OM	151	Yes					
	VP03 Hydromulch	150	Yes					
	VP04 Untreated	158	Yes					
	VP05 Low OM	130	No					
	VP06 High OM	122	No					
	VP07 Hydromulch	159	Yes					
	VP08 Untreated	157	Yes					
	VP09 Low OM	151	Possibly					
	VP10 Hydromulch	158	Yes					

Table B-10. Runoff volumes and concentrations for September 17, 2006.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
1.92	VP01 Low OM	150	Yes	952	0.105	4.52	1.61	2.60
	VP02 High OM	149	Yes	836	0.096	10.8	4.12	5.85
	VP03 Hydromulch	151	Yes	17600	0.054	14.8	0.384	8.06
	VP04 Untreated	157	Yes	68100	0.087	21.1	0.170	8.29
	VP05 Low OM	149	Yes	1232	0.066	5.27	1.43	2.99
	VP06 High OM	150	Yes	780	0.062	9.08	3.38	4.99
	VP07 Hydromulch	158	Yes	18100	0.053	11.8	0.271	6.40
	VP08 Untreated	157	Yes	92800	0.083	26.1	0.088	9.74
	VP09 Low OM	149	Yes	2310	0.096	6.06	1.38	3.37
	VP10 Hydromulch	160	Yes	23400	0.058	9.56	0.218	4.84

Table B-11. Runoff volumes and concentrations for October 10, 2006. No water quality sample collected.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.45	VP01 Low OM		No					
	VP02 High OM		No					
	VP03 Hydromulch	27	No					
	VP04 Untreated	97	No					
	VP05 Low OM		No					
	VP06 High OM		No					
	VP07 Hydromulch	24	No					
	VP08 Untreated	102	No					
	VP09 Low OM		No					
	VP10 Hydromulch	25	No					

Table B-12. Runoff volumes and concentrations for October 15, 2006.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
2.51	VP01 Low OM	150	Yes	242	< 0.04 [a]	1.57	2.41	3.39
	VP02 High OM	149	Yes	192	0.044	4.72	6.04	7.36
	VP03 Hydromulch	151	Yes	8500	< 0.04 [a]	6.70	0.298	5.36
	VP04 Untreated	157	Yes	19000	0.051	5.90	0.114	5.22
	VP05 Low OM	149	Yes	2620	< 0.04 [a]	1.19	2.36	3.48
	VP06 High OM	150	Yes	102	< 0.04 [a]	4.29	5.07	5.86
	VP07 Hydromulch	158	Yes	7000	<0.04 [a]	7.43	0.195	4.41
	VP08 Untreated	157	Yes	24100	0.045	8.30	0.050	5.23
	VP09 Low OM	149	Yes	416	0.050	2.07	2.41	2.78
	VP10 Hydromulch	160	Yes	9020	< 0.04 [a]	4.59	0.186	3.62

[a] Measured values less than the NO_2-N+NO_3-N reporting limit of 0.04 mg/L.

Table B-13. Runoff volumes for October 24, 2006. No water quality sample collected.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.26	VP01 Low OM		No					
	VP02 High OM		No					
	VP03 Hydromulch	9	No					
	VP04 Untreated	7	No					
	VP05 Low OM		No					
	VP06 High OM		No					
	VP07 Hydromulch	7	No					
	VP08 Untreated	6	No					
	VP09 Low OM		No					
	VP10 Hydromulch	7	No					

Table B-14. Runoff volumes and concentrations for November 5, 2006.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
2.56	VP01 Low OM	150	Yes	300	0.122	5.01	2.53	3.08
	VP02 High OM	151	Yes	304	0.126	9.16	6.06	7.01
	VP03 Hydromulch	151	Yes	17900	0.165	16.1	0.288	7.89
	VP04 Untreated	160	Yes	25500	0.179	20.0	0.100	7.29
	VP05 Low OM	150	Yes	284	0.121	4.15	2.63	3.43
	VP06 High OM	150	Yes	174	0.111	5.76	4.75	5.95
	VP07 Hydromulch	158	Yes	16300	0.160	11.9	0.195	6.91
	VP08 Untreated	156	Yes	42400	0.173	25.0	0.038	8.81
	VP09 Low OM	150	Yes	366	0.464	4.81	2.75	4.00
	VP10 Hydromulch	159	Yes	16200	0.178	14.1	0.162	6.06

Table B-15. Runoff volumes and concentrations for January 3, 2007.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.70	VP01 Low OM	8	No	157	0.099	4.13	2.68	3.38
	VP02 High OM	16	No	121	0.131	5.41	5.22	6.29
	VP03 Hydromulch	86	No	1050	0.158	3.26	0.245	1.44
	VP04 Untreated	72	No	1960	0.100	4.06	0.140	1.80
	VP05 Low OM	5	No	238	0.212	3.15	1.14	1.55
	VP06 High OM	4	No	216	0.122	2.01	1.49	2.15
	VP07 Hydromulch	81	No	1110	0.134	1.23	0.188	0.90
	VP08 Untreated	74	No	1680	0.100	3.15	0.049	1.63
	VP09 Low OM	16	No	93	0.222	4.43	3.03	3.70
	VP10 Hydromulch	79	No	560	0.245	1.59	0.142	1.12

Table B-16. Runoff volumes and concentrations for March 11, 2007.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.59	VP01 Low OM	1.9	No	708	0.970	3.33	< 0.005 [a]	0.87
	VP02 High OM	1.5	No	868	1.83	5.56	0.228	1.46
	VP03 Hydromulch	20	No	1120	0.248	4.03	0.523	1.56
	VP04 Untreated	19	No	2160	0.319	4.69	0.155	1.57
	VP05 Low OM	1.6	No	770	0.809	2.09	0.030	0.84
	VP06 High OM	2.5	No	766	0.615	6.67	0.183	1.19
	VP07 Hydromulch	21	No	1360	0.287	4.36	0.209	1.50
	VP08 Untreated	23	No	2220	0.196	4.51	0.099	1.52
	VP09 Low OM	1.5	No	702	0.935	4.00	0.009	1.25
	VP10 Hydromulch	17	No	910	0.315	3.09	0.446	1.21

[a] Measured value is less than the PO_4-P reporting limit of 0.005 mg/L.

Table B-17. Runoff volumes and concentrations for April 30, 2007.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.97	VP01 Low OM	4	No	396	0.310	2.71	0.442	1.09
	VP02 High OM	3	No	324	0.449	4.80	1.57	2.33
	VP03 Hydromulch	75	No	4340	0.254	4.59	0.135	2.56
	VP04 Untreated	74	No	8520	0.257	6.45	0.036	2.80
	VP05 Low OM	12	No	1600	0.299	4.33	0.557	1.75
	VP06 High OM	4	No	320	0.323	2.85	0.778	1.31
	VP07 Hydromulch	71	No	3020	0.243	3.27	0.076	1.59
	VP08 Untreated	91	No	8000	0.293	6.26	0.017	2.57
	VP09 Low OM	5	No	368	0.313	4.30	0.623	1.16
	VP10 Hydromulch	55	No	2640	0.215	5.00	0.061	1.78

Table B-18. Runoff volumes and concentrations for June 1, 2007.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.76	VP01 Low OM	1.6	No	211	0.480	2.08	0.246	0.63
	VP02 High OM	1.9	No	242	0.847	1.99	0.736	1.12
	VP03 Hydromulch	67	No	1800	0.327	3.38	0.197	1.62
	VP04 Untreated	74	No	7350	0.433	7.49	0.044	3.12
	VP05 Low OM	3.5	No	352	0.428	2.35	0.356	0.97
	VP06 High OM	2.1	No	193	0.364	1.23	0.386	0.73
	VP07 Hydromulch	61	No	980	0.349	3.27	0.133	1.42
	VP08 Untreated	78	No	9650	0.481	8.54	0.032	3.27
	VP09 Low OM	1.6	No	161	0.445	2.46	0.527	0.90
	VP10 Hydromulch	50	No	1140	0.361	3.04	0.090	1.13

Table B-19. Runoff volumes and concentrations for October 22, 2007.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.65	VP01 Low OM	1.6	No	150	0.577	6.54	1.64	1.90
	VP02 High OM	1.5	No	215	1.24	4.46	2.44	2.83
	VP03 Hydromulch	1.8	No	173	2.06	3.70	0.214	0.47
	VP04 Untreated	17	No	135	0.360	14.8	0.460	0.82
	VP05 Low OM	1.7	No	152	0.710	3.82	0.813	1.04
	VP06 High OM	1.9	No	248	0.916	2.30	0.819	1.14
	VP07 Hydromulch	3.1	No	178	1.31	3.41	0.291	0.53
	VP08 Untreated	9	No	116	0.395	2.87	0.109	0.31
	VP09 Low OM	2.1	No	193	2.61	55.4	7.12	8.72
	VP10 Hydromulch	1.1	No	351	2.64	63.0	2.16	3.59

Table B-20. Runoff volumes and concentrations for November 24, 2007.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
1.78	VP01 Low OM	7	No	199	0.608	6.36	1.54	2.12
	VP02 High OM	9	No	185	0.800	29.0	2.57	3.30
	VP03 Hydromulch	76	No	62	0.214	1.15	0.268	0.50
	VP04 Untreated	154	No	144	0.092	0.90	0.095	0.42
	VP05 Low OM	10	No	125	1.86	4.37	0.729	1.08
	VP06 High OM	8	No	28	1.02	5.34	1.26	1.82
	VP07 Hydromulch	44	No	57	0.420	1.59	0.267	0.51
	VP08 Untreated	115	No	105	0.101	1.01	0.045	0.35
	VP09 Low OM	10	No	86	0.975	8.20	2.14	2.68
	VP10 Hydromulch	16[a]	No	90	0.575	2.78	0.342	0.60

[a] Possible berm breach to outside of plot (breach did not affect nearby plot VP09).

Table B-21. Runoff volumes and concentrations for February 18, 2008.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
1.10	VP01 Low OM	7	No	492	1.44	9.56	1.15	2.32
	VP02 High OM	16	No	404	1.68	4.79	2.80	3.97
	VP03 Hydromulch	87	No	672	0.469	3.78	0.273	1.16
	VP04 Untreated	126	No	1900	0.255	4.31	0.115	1.80
	VP05 Low OM	12	No	608	2.78	5.75	1.14	2.16
	VP06 High OM	13	No	576	1.88	7.46	2.22	2.55
	VP07 Hydromulch	92	No	452	0.511	3.69	0.313	1.02
	VP08 Untreated	125	No	972	3.20	113	1.30	5.68
	VP09 Low OM	9	No	708	0.382	5.76	0.117	1.14
	VP10 Hydromulch	70	No	690	0.423	7.52	0.257	1.78

Table B-22. Runoff volumes and concentrations for March 16, 2008.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
1.37	VP01 Low OM	6	No	132	0.208	3.41	1.24	1.67
	VP02 High OM	19	No	106	0.291	3.96	3.46	3.88
	VP03 Hydromulch	133	No	155	0.101	2.05	0.152	0.36
	VP04 Untreated	142	No	536	0.121	1.97	0.048	0.60
	VP05 Low OM	13	No	282	0.389	2.62	1.47	1.92
	VP06 High OM	8	No	140	0.432	3.75	2.28	2.76
	VP07 Hydromulch	107	No	82	0.113	2.26	0.187	0.37
	VP08 Untreated	145	No	184	0.140	1.59	0.022	0.30
	VP09 Low OM	7	No	137	0.493	4.33	1.62	2.46
	VP10 Hydromulch	104	No	232	0.073	3.33	0.166	0.54

Table B-23. Runoff volumes and concentrations for April 9, 2008.

Rainfall (inches)	Plot	Volume (gallons)	Overflow	TSS (mg/L)	Dissolved NO_2-N + NO_3-N (mg/L)	TKN (mg/L)	Dissolved PO_4-P (mg/L)	Total-P (mg/L)
0.87	VP01 Low OM	12	No	109	0.855	5.38	1.20	1.75
	VP02 High OM	24	No	113	0.620	5.05	2.91	3.53
	VP03 Hydromulch	146	No	200	0.280	2.49	0.080	0.47
	VP04 Untreated	157	No	950	0.265	2.90	0.032	1.00
	VP05 Low OM	12	No	202	1.39	3.48	1.10	1.66
	VP06 High OM	14	No	143	0.977	5.36	2.54	3.22
	VP07 Hydromulch	120	No	114	0.213	2.31	0.093	0.41
	VP08 Untreated	158	No	220	0.274	2.33	0.018	0.44
	VP09 Low OM	10	No	135	1.77	8.22	1.36	2.54
	VP10 Hydromulch	101	No	404	0.188	3.13	0.054	0.71

Appendix C – Monthly and Bimonthly Narrative Observations

The following are narrative observations recorded monthly from July 14, 2006 through October 13, 2006, and then bimonthly thereafter, due to the attainment of 70 percent vegetative cover on the compost plots. Pictorial observations are presented in Appendix A. Of note, due to technical difficulties, pictorial observations associated with the October 13, 2006 written observations were taken on October 10, 2006 in association with a small storm event that had volume measured but was not sampled.

July 14, 2006 - Monthly Narrative Observations

All compost test plots have a good distribution of vegetation from top to bottom of each plot. Vegetation is greener and appears to be healthier than vegetation growing on the hydromulch plots. All compost plots continue to have new emergence of vegetation. Test plots VP01, VP06, and VP09 (all low or high OM compost plots) have some runner development in areas where vegetation is more mature. Due to the uniformity of the plots, water runoff occurs in sheet form. No rill development has occurred on any compost plots with the exception of VP09 (a “wash” area resulting from focused supplemental watering was noted near the center of that plot). For all compost test plots, the compost blend is still present and no areas of bare ground were observed.

The hydromulch plots have more vegetative coverage than the rest of the test plots with the exception of VP03 (10 percent coverage; see July 14, 2006 - Table 4-4). Vegetative coverage is limited to the upper two-thirds of each plot. Vegetation is more mature and runner development is more advanced in the hydromulch plots than the compost test plots. Vegetation in the hydromulch plots is not as green and lush as vegetation growing in the compost plots and is beginning to “grey” in color due to stress from extreme drought conditions. Also, leaves are thinning due to drought conditions. Hydromulch fibers are still present in each plot. However, bare ground is visible in all plots, especially in the lower half of each plot. Erosion is occurring in sheet form with a very small amount of rill development in each hydromulch plot.

Of the untreated plots, VP04 has a very small amount of vegetation emerging at the bottom of the plot near the metal approach. VP08 has no vegetation. Erosion is predominately in sheet form with some very small rill development in the untreated plots.

August 14, 2006 – Monthly Narrative Observations

From installation of the test plots to present date, drought conditions have been the dominate weather pattern. Of note, extreme temperatures (several days >100°F) have prevailed since the previous observation. Less than 0.70 inches of precipitation (two very small rainfall events) has fallen on the test plots since July 14, 2006. Supplemental watering has been sufficient only to sustain the existing vegetation. However, high temperatures over the previous 7 to 10 days have resulted in significant signs of vegetative stress in all plots, especially the hydromulch plots.

Runner development was observed in all compost plots. Vegetative stress was evident in all plots as leaves were beginning to turn from grey to brown. However, vegetation in the compost plots is still greener and healthier when compared to the hydromulch plots. Of note, vegetation in the high OM compost treatments (VP02 and VP06) was slightly greener than vegetation in the low OM plots. No new emergence of vegetation or rill development was observed. Also, no bare ground was visible

All three hydromulch test plots have been adversely affected by the extreme temperatures and drought significantly more so than the compost plots. Of the hydromulch plots, VP03 and VP07 appear to be suffering more so than VP10. Vegetation on all plots is mostly brown with shades of grey/green color. Vegetative growth appears to have halted with no new emergence. Vegetative coverage is still limited to the upper two-thirds of each plot. Hydromulch fibers are still present in each plot, but diminishing. Bare ground is visible in all plots, especially in the lower half of each plot. Erosion continues to be in sheet form with no rill development.

On the untreated plots, the vegetation in plot VP04 emerging at the bottom of the plot near the metal approach has grown slightly, but coverage is still less than one percent of the total plot. VP08 has no vegetation. Erosion continues to be in sheet form with some very small rill development, especially in VP08.

September 14, 2006 – Monthly Narrative Observations

Cooler temperatures (< 100°F) and significant rainfall (3.93 inches) have occurred over the past few weeks. These weather conditions have allowed for a significant increase in vegetative coverage in all compost plots (Table 4-4). Some increase in vegetative coverage was noted for the hydromulch plots as well.

Vegetative health for the compost plots is significantly better than previous visits as evident in the deep green vegetative color and large leaf development. Vegetation in the compost plots is greener and healthier than that of the hydromulch plots. Runner development has significantly improved since the last visit and is spreading to nearby plots. No distinctions can be made between the low and high organic matter compost plots with the exception of percent vegetative coverage (low OM slightly higher; Table 4-4). Erosion continues to be in sheet form with no rill development. The compost blend is still present in all plots and no bare spots were observed.

While vegetation in the hydromulch plots has rebounded due to recent favorable weather conditions, the effects have been less significant than those experienced in the compost plots. Vegetation is greener than the previous visit, but still has a slight tint of grey color. Growth is apparent with some runner and leaf advancement in all hydromulch plots. However, when compared to the compost plots, runners and leaves are thinner and less abundant in the hydromuch plots. All hydromulch plots are experiencing vegetation encroachment from nearby compost plots, especially VP10. Hydromulch fibers are still present in each plot, but continue to recede. Bare ground is visible in all plots, especially in the lower half of each plot. Minimal rill development was observed in each hydromulch plot as erosion is mainly in sheet form.

No significant vegetative changes have occurred at the untreated plots since the previous visit. Very slight rill development was observed at VP08. Sheet erosion continues to dominate both untreated plots.

October 13, 2006 – Monthly Narrative Observations

Additional rainfall has permitted vegetation in the compost plots to continue to grow and spread considerably. Total rainfall amounts, since the September observations, were noted to be 2.37 inches. These timely rainfall events have also yielded increases of vegetative coverage in the hydromulch plots (Table 4-4). However, most of this increase in coverage in the hydromulch plots is attributed to runner encroachment from nearby compost plots.

The vegetative health of the compost plots is good, but signs of stress (brown spots on leaves) are evident in all compost plots. Compared to the hydromulch plots, vegetation in the compost plots continues to be greener and healthier. Significant development of vegetative runners was apparent. Also, the runners from the compost plots continue to spread to nearby plots. VP05 has a small bare spot near the bottom of the plot. Dense vegetative coverage prohibits visual inspection of the ground beneath. The project requirement of the compost plots attaining 70 percent coverage was met in October 2006, thus, leading to bimonthly vegetative monitoring thereafter.

Vegetation on the hydromulch plots is green and growing, but less vigorously than on the compost plots. Of note, VP07 is somewhat browner than the other hydromulch plots. Vegetative encroachment from nearby compost plots continues to occur in all hydromulch plots, especially in VP10. Hydromulch fibers are still present in each hydromulch plot, but continue to dwindle. Erosion continues to occur predominately in sheet form with very slight development of existing rills observed in VP07 and VP10.

The untreated plots are experiencing runner encroachment from nearby compost plots. No new emergence was observed. Without runner encroachment from VP09, VP08 would be bare. Sheet erosion continues to dominate both plots with minimal rill development was observed in VP08.

December 14, 2006 – Bimonthly Narrative Observations

A significant amount of precipitation (5.93 inches) has occurred since the October 13, 2006 observations. Vegetation in the compost plots has continued to grow and spread (Table 4-4). Vegetative coverage increases, mainly from runner encroachment, were observed in the hydromulch plots as well.

Vegetation is now dormant with complete coverage in all compost plots. Compared to the hydromulch plots, vegetation in the compost plots is denser and taller. Vegetation has continued to spread from the compost plots to adjoining plots. No visual distinctions could be made in the amounts of vegetative cover between the low and high organic matter compost treatments. Dense vegetative growth prohibited visual inspection of erosion; however, “spot checks”, performed by moving the vegetation aside by hand, revealed no apparent soil erosion in any compost plot. In fact, the compost treatment was observed to be in place and no bare ground was visible.

Vegetation in the hydromulch plots is also dormant. While a slight increase in vegetative coverage was noted, the majority of the coverage increase is due to encroachment from nearby compost plots. Hydromulch fibers continue to recede and exist only in scattered patches. A significant amount of visible erosion has occurred since the previous observations were performed. Erosion continues to be in sheet form with scouring occurring below each scattered hydromulch patch (see photograph below taken 12/14/06) with some slightly advanced rill development in VP07 and VP10.

The untreated plots have encountered a slight increase in coverage due to vegetative encroachment from nearby compost plots. Of note, newly emerged vegetation (possibly weeds) was observed in both plots, but noted to be scarce. Both plots have experienced significant erosion since the previous observations. Existing rill development has advanced slightly in VP08. Sheet erosion continues to dominate both untreated plots.

Close-up View of Scouring Occurring near the Bottom of VP07

February 21, 2007 – Bimonthly Narrative Observations

Rainfall totaling 4.01 inches has occurred at the test plots since the December 14, 2006 observations were conducted. Vegetation in all plots is dormant. No change was observed at the compost plots since the December 2006 observations.

No vegetative changes were noted for the hydromulch test plots. Erosion continues to be in sheet form with a slight increase in scouring occurring in VP07 and VP10 since the last visit.

No vegetative change for the untreated plots has occurred since the previous observations were conducted. Rill development has advanced slightly in VP08. Erosion continues to occur predominately in sheet form.

April 19, 2007 – Bimonthly Narrative Observations

The test plots have continued to experience abundant rainfall as 6.01 inches of precipitation has fallen on the plots since the previous visit (February 21, 2007). Vegetation in all plots has emerged from dormancy and is growing. Also, in an effort to control vegetative encroachment between the test plots, metal edging was installed between each plot on April 19, 2007.

All compost plots have 100 percent coverage of old vegetation. Coverage of new, growing vegetation is almost 100 percent for all compost test plots, except for test plots VP05 and VP06 (99 percent and 95 percent respectively). No soil erosion is visible. Spot-checking, performed by pulling the vegetation back, shows that the compost blend is still intact.

Vegetation in the hydromulch plots was observed to be growing. Significant scouring and some rill development have occurred since the prior visit, especially in test plots VP03 and VP07. Erosion continues to occur predominately in sheet form. Some hydromulch fibers are visible, but sparse.

VP04 has growing vegetation at the bottom of the plot near the metal approach along with vegetative encroachment from VP05. Vegetative encroachment from VP09 is still occurring on VP08, but coverage is only about one percent. Erosion continues to be in sheet form with slight rill development in both plots, especially VP04.

June 18, 2007

Substantial rainfall, totaling 15.9 inches, has occurred since the April 19, 2007 observations were conducted. Vegetation in all plots is growing with significant coverage increases in the hydromulch and untreated plots (Table 4-4). Rabbit droppings were observed in both the compost and hydromulch test plots. Periodic grass trimming along the metal edging between the plots was implemented in June 2007 to further assist with control of runner encroachment.

Coverage of new, growing vegetation is almost 100 percent on all compost test plots. VP05 and VP06 have a few bare spots. A few weeds were observed in all compost plots. Because of the dense vegetation, visual observation of soil erosion was difficult. Spot checks revealed that erosion continues to occur in sheet form with no rill development. The compost treatment is still present as random spot checks were conducted in all compost plots by digging (by hand) through the compost-blend until the soil beneath was visible.

A notable increase in vegetative coverage was observed in all hydromulch plots since the previous bimonthly observations. A few weeds were observed in all hydromulch plots. Increased vegetative cover made erosion observations difficult; however, spot checks revealed erosion is still predominantly in sheet form with scouring occurring only below the remaining hydromulch fibers. No major advancement of the few existing rills was noted. Some hydromulch fibers are visible, but sparse.

A notable increase in vegetative coverage was observed in both bare plots since the previous observations were performed. Sheet erosion continues to dominate both plots.

August 20, 2007

Rainfall has been abundant since the June 18, 2007 visit as 7.44 inches was recorded at the test plots. Vegetation in all plots is growing with notable coverage increases in the untreated plots (Table 4-4). Vegetative stress (brown leaves) is apparent in all plots due to recent high temperatures (a few days >100 °F). Periodic grass trimming along the metal edging continues to occur in an effort to control runner encroachment between plots.

All compost plots have complete vegetative coverage. Compost plot vegetation was noted to be denser than the hydromulch and untreated plots. A few weeds were observed in all compost plots; however, fewer tumbleweeds (if any) were observed in the compost plots than the hydromulch or untreated plots. Visual observation of soil erosion was not possible due to the dense vegetation in the compost plots. Spot checks revealed erosion is occurring in sheet form with no rill development. Random checks conducted in each compost plot revealed the compost-blend to be intact with a notable increase in vegetative root growth.

Vegetative coverage for all hydromulch plots is now 100 percent. In comparison to the compost plots, the hydromulch plots have more weeds (especially tumbleweed). Similar to the compost plots; visual observation of soil erosion was not possible. Spot checks performed in each hydromulch plot revealed some soil erosion in sheet form with scouring occurring below the remaining hydromulch fibers. The hydromulch fibers continue to erode.

A significant increase in vegetative coverage, due to abundant rainfall, was observed in both untreated plots (especially VP08). However, vegetation density was observed to be notably less than the compost or hydromulch plots. Erosion continues to occur in sheet form with no rill development.

October 16, 2007

A total of 4.25 inches of rainfall was measured at the plots since the August 20, 2007 visit. Most of the rainfall occurred in the first half of September 2007. Vegetation in all plots is growing. However, an increase in vegetative stress (brown/yellow leaves), due to recent dry conditions, was observed in all plots. The untreated plots continue to experience noteworthy coverage increases (Table 4-4). Grass trimming along the metal edging continues to occur in an effort to control runner encroachment between the plots. Of note, wildlife presence was apparent as several of the collection tanks contained mice, and a few contained frogs. One collection tank had a small snake in it. All wildlife was removed from the tanks.

All compost plots have complete vegetative coverage. Vegetation continues to be denser in the compost plots than the hydromulch or untreated plots. While a few weeds exist in each compost plot, all compost plots were observed to be less impacted by weeds than the hydromulch or bare plots. Visual observation of soil erosion was not possible due to the dense vegetative cover. Spot checks revealed no rill development, so erosion is occurring as sheet form. Random checks also revealed the compost treatment to be intact and an increase in vegetative root growth. Of note, mice nests were discovered in plot VP06.

Vegetative coverage for all hydromulch plots is complete and denser than the previous visit. However, the vegetation in the hydromulch plots remains less dense with more weeds when compared to the compost plots. Dense vegetation prohibited visual observation of soil erosion for all hydromulch plots. Spot checks revealed for signs of erosion indicated some scouring below the remaining hydromulch fibers.

Vegetative coverage for both untreated plots is at or near 100 percent. The vegetation in VP08 is denser than VP04. However, vegetative density continues to be considerably less than the compost or hydromulch plots. No rill development was observed. Erosion continues to occur in sheet form.

Due to logistical constraints, no bimonthly observations were recorded in December 2007, but instead bimonthly observations were recorded on January 3, 2008.

January 3, 2008

A total of 3.18 inches of rainfall has occurred at the plots since the October 16, 2007 visit. Vegetation in all plots is dormant. Vegetative coverage did not change from the previous visit (Table 4-4). Evidence of wildlife continues to be observed. Several of the collection tanks contained mice, which were removed. Mice nests, as in October 2007, were observed in test plot VP06.

All compost plots have complete vegetative coverage. Dense vegetation prevails for all compost plots. The compost-blend is still intact and vegetative root development is denser and more advanced than the previous visit. Dense vegetation prevented visual observation of soil erosion. Spot checks revealed erosion continues to occur in sheet form with no rill development.

No vegetative changes have occurred on the hydromulch plots since the previous visit. Of the hydromulch plots, VP07 and VP10 are denser in vegetative cover than VP03. Thick vegetative cover prohibited visual observation of soil erosion for all hydromulch plots. Spot checks revealed that soil erosion is primarily in sheet form with some scouring occurring only below the remaining hydromulch fibers, especially VP03.

Little change from the previous visit was noted for the untreated plots. VP04 is approaching 100 percent coverage, while VP08 has obtained complete coverage (Table 4-4). Vegetative density continues to be less than the compost or hydromulch plots. No rill development was observed. Erosion continues to occur in sheet form. More rocks were visible than the previous visit.

February 14, 2008

Only 0.26 inches of rainfall has occurred at the plots since the January 3, 2008 visit. The vegetation in all test plots is still dormant. No change in vegetative coverage or soil erosion was observed in any test plot. Evidence of wildlife was indicated. Dead mice were found in several of the tanks and removed. Mice nest were observed within several plots associated with the compost and hydromulch treatments.

April 17, 2008

Abundant rainfall totaling 7.59 inches has occurred at the plots since the February 14, 2008 visit. New vegetation is emerging in all test plots. No change in vegetative coverage from the previous visit was noted for all test plots. Evidence of wildlife was abundant in the compost and hydromulch plots.

New vegetation is visible in all compost plots. The compost plots continue to have denser vegetation than the hydromulch or untreated plots. The compost-blend remains intact. Observation of soil erosion was prevented by dense vegetation. Spot checks revealed erosion continues to occur in sheet form with no rill development. Of note, extensive mouse tunnels in the compost-blend were observed throughout all compost plots. Mice and nests were observed in each compost plot.

All hydromulch plots have complete vegetation coverage with new vegetation emerging. VP10 continues to have the denser vegetative cover than the other hydromulch plots. While the hydromulch plots are denser in vegetative cover than the untreated plots, they remain less dense than the compost plots. Erosion observations were not possible due to the dense vegetative cover. Spot checks revealed erosion continues to occur in sheet form. A few mice nests were observed in each hydromulch plot.

The only untreated plot to not have complete vegetative coverage is VP04 (95 percent). The vegetation in VP08 continues to be denser than VP04. Regarding overall vegetation density, the untreated plots remain the least dense compared to the compost or hydromulch plots. No rill development was observed. Erosion continues to occur in sheet form. More rocks were visible than the previous visit.

Appendix C: Statistical Details

Low OM Treatment

```
> ## LOW OM
> ##
> summary(LowOM.mr)

Call:
lm(formula = Runoff_in ~ Rainfall_in + DayNo + FMI_iph, data = LowOM)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.104853 -0.045426  0.008064  0.046616  0.127846 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -6.686e-02  1.721e-02  -3.886 0.000295 ***
Rainfall_in  2.147e-01  1.699e-02  12.642  < 2e-16 ***
DayNo       -3.632e-04  3.532e-05 -10.284 4.91e-14 ***
FMI_iph      6.101e-02  1.147e-02   5.321 2.32e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.05732 on 51 degrees of freedom
  (3 observations deleted due to missingness)
Multiple R-Squared: 0.8324,     Adjusted R-squared: 0.8226 
F-statistic: 84.45 on 3 and 51 DF,  p-value: < 2.2e-16 

> confint(LowOM.mr)
                    2.5 %        97.5 %
(Intercept) -0.1014070576 -0.0323162617
Rainfall_in  0.1806422189  0.2488493110
DayNo       -0.0004341278 -0.0002923203
FMI_iph      0.0379915938  0.0840349103
```

High OM Treatment

```
> ## HIGH OM
> ##
> summary(HighOM.mr)

Call:
lm(formula = Runoff_in ~ Rainfall_in + DayNo + FMI_iph, data = HighOM)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.181055 -0.060206  0.004692  0.055102  0.146047 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -8.018e-02  2.832e-02  -2.832 0.007833 ** 
Rainfall_in  2.067e-01  2.593e-02   7.971 3.40e-09 ***
DayNo       -3.270e-04  5.733e-05  -5.703 2.32e-06 ***
FMI_iph      7.385e-02  1.887e-02   3.913 0.000431 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.07747 on 33 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-Squared: 0.7534,     Adjusted R-squared: 0.731 
F-statistic: 33.61 on 3 and 33 DF,  p-value: 3.802e-10 

> confint(HighOM.mr)
                    2.5 %        97.5 %
(Intercept) -0.1377829257 -0.0225676507
Rainfall_in  0.1539387386  0.2594521490
DayNo       -0.0004436054 -0.0002103076
FMI_iph      0.0354504273  0.1122516124
```

HYDROMULCH TREATMENT

```
> ##  HYDROMULCH
> ##
> summary(Hydromulch.mr)

Call:
lm(formula = Runoff_in ~ Rainfall_in + DayNo + FMI_iph, data =
Hydromulch)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.37667 -0.07529 -0.00159  0.05883  0.27600 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -1.111e-01  4.000e-02  -2.777  0.00771 ** 
Rainfall_in  3.411e-01  4.855e-02   7.027 5.44e-09 ***
DayNo       -1.650e-04  8.603e-05  -1.918  0.06087 .  
FMI_iph      1.893e-01  2.663e-02   7.108 4.07e-09 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.1303 on 50 degrees of freedom
  (3 observations deleted due to missingness)
Multiple R-Squared: 0.7478,     Adjusted R-squared: 0.7327 
F-statistic: 49.43 on 3 and 50 DF,  p-value: 5.492e-15 

> confint(Hydromulch.mr)
                    2.5 %        97.5 %
(Intercept) -0.1914168208 -3.072006e-02
Rainfall_in  0.2436371928  4.386617e-01
DayNo       -0.0003377807  7.818159e-06
FMI_iph      0.1358089934  2.427993e-01
```

UNTREATED TREATMENT

```
> ## UNTREATED
> ##
> summary(Untreated.mr)

Call:
lm(formula = Runoff_in ~ Rainfall_in + DayNo + FMI_iph, data =
Untreated)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.16554 -0.07663  0.03759  0.06489  0.13353 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -1.542e-01  3.355e-02  -4.595 6.41e-05 ***
Rainfall_in  5.002e-01  4.072e-02  12.286 1.18e-13 ***
DayNo       -9.170e-05  7.215e-05  -1.271    0.213    
FMI_iph      1.872e-01  2.234e-02   8.380 1.42e-09 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.0892 on 32 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-Squared: 0.9169,     Adjusted R-squared: 0.9091 
F-statistic: 117.7 on 3 and 32 DF,  p-value: < 2.2e-16 

> confint(Untreated.mr)
                    2.5 %        97.5 %
(Intercept) -0.2225158974 -8.583826e-02
Rainfall_in  0.4173065827  5.831810e-01
DayNo       -0.0002386679  5.527469e-05
FMI_iph      0.1416854249  2.326840e-01
> 
```