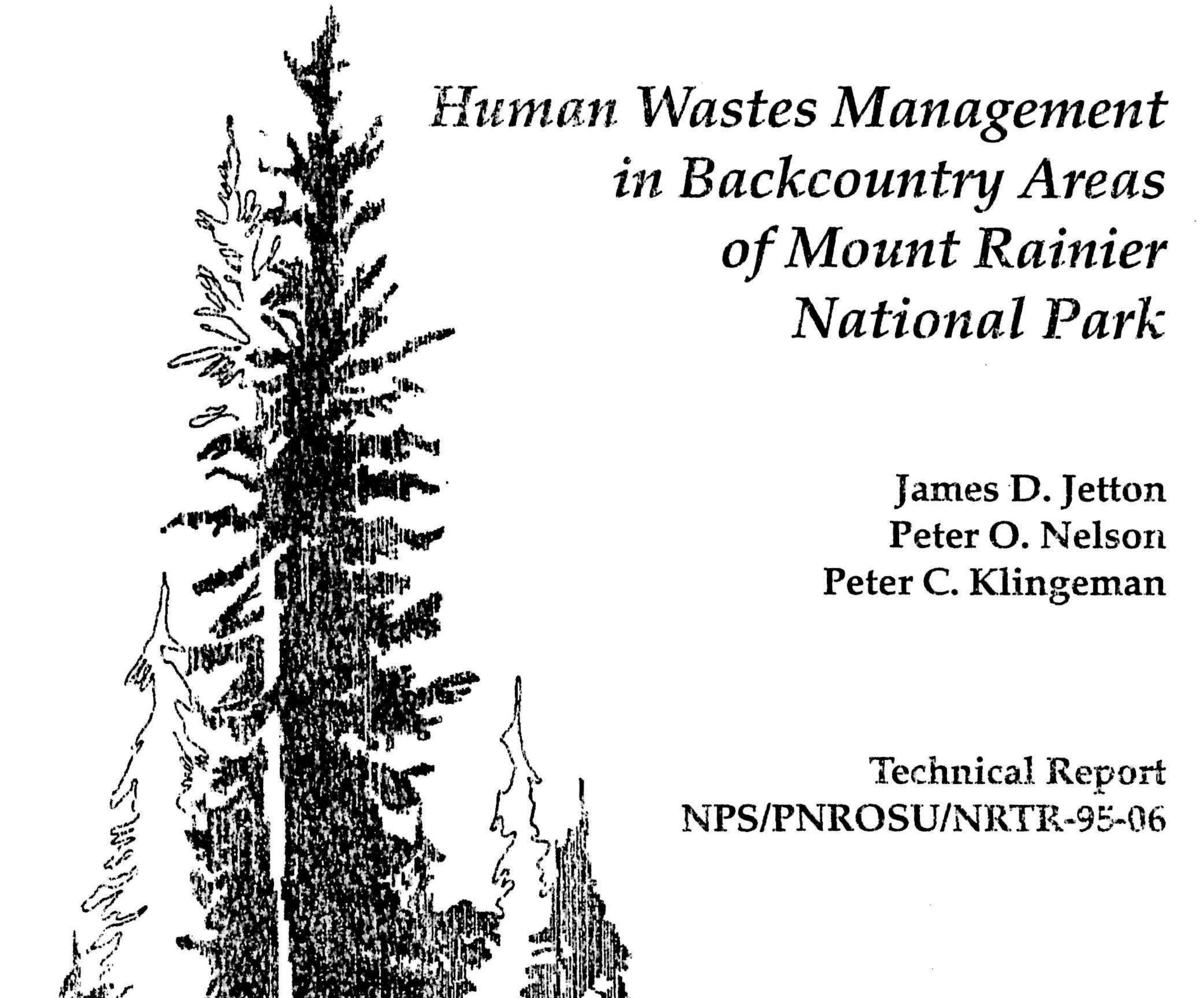
Human Wastes Management in Backcountry Areas of Mount Rainier National Park



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Technical Report
NPS/PNROSU/NRTR-95-06

United States Department of Interior - National Park Service -
Pacific Northwest Region

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ABSTRACT

Pit toilets are presently used at approximately 40 trailside camps and four backcountry cabins in backcountry areas of Mount Rainier National Park and at one roadside camp (Mowich Lake). Water quality impacts, such as nutrient addition and enteric organisms, from the pit toilets located near the park's lakes and streams have become a point of concern. Site visits were made to all 45 pit toilet sites and evaluations were made of pit conditions and the potentials for water quality degradation.

The processes involved in pit toilet function are characterized. These include hydrologic transport mechanisms, water quality impacts, and relationships of transport to pit toilet management. One purpose is to develop a better understanding of the interactions between human wastes in pit toilets and the conditions found in nearby soils, subsurface waters, and surface waters. Another purpose is to provide guidance in avoiding water quality problems that could result from pit toilets.

Soil water conditions have a critical influence over the siting and use of pit toilets. Saturated soils experience macropore flow that will allow nutrients and enteric organisms to spread quickly over large distances. Such spreading is not likely if soils are unsaturated, particularly when soil moisture values are below field capacity values that must be exceeded to allow gravitational drainage. Thus, the safest use of pit toilets is limited to unsaturated conditions with soil moisture below field capacity.

To illustrate the potential water quality problems for receiving waters, a calculation is made of the sensitivity of Crystal Lake to added nutrients from human wastes derived from a nearby trailside camp. The calculated waste loading from a pit toilet is converted to lake response in terms of steady-state phosphorus concentrations. Results show that such lakes are quite sensitive to added wastes from pit toilets.

Site inspections revealed that design and maintenance of pit toilets are important problems. Proper methods for designing, installing and maintaining pit toilets are critical in controlling human wastes and encouraging proper disposal of wastes by users. Procedures are outlined to improve the park's pit toilet management, including the use of standard parts for repairs.

Guidelines are developed for pit toilet siting and management in backcountry areas. These are applied to all trailside camps and backcountry cabins within Mount Rainier National Park. Alternative systems for the management and disposal of human wastes are reviewed and recommendations are made for use in the fragile environments of the park.

INTRODUCTION

STUDY AREA

Mount Rainier National Park is located in the Cascade Mountain Range in west-central Washington. Its proximity to Seattle, Tacoma, Olympia and other major population centers, as shown in Figure 1, results in a large number of park visitors each year. The park is accessible from several directions. Roads and trails have been developed to allow dispersed entry to various portions of the park.

Approximately 16,500 visitors used the wilderness and backcountry areas of the park, resulting in over 30,000 visitor-use-nights in 1990 (Samora, undated). Day use by hikers is estimated at about 1,000,000 per year (unpublished data). This places a large pressure on the fragile natural resources of the park over an extensive area. Disposal of human wastes is one of the most critical management problems. Figure 2 shows the park in greater detail, including the backcountry campsites and ranger stations (backcountry cabins). In areas such as these, where overnight camping involves the use of pit toilets, the potential for water quality degradation is a particularly serious concern.

BACKGROUND OF STUDY

One of the primary objectives for managing human waste disposal in the backcountry is to prevent and mitigate contamination of water resources. National park mandates and wilderness standards require protection of aquatic resources and public health. Current methods of human waste disposal are often inadequate to ensure that these mandates are met.

Pit toilets have been used in Mount Rainier National Park for many years to manage human wastes. They are presently used at approximately 40 backcountry trailside camps, four backcountry cabins (ranger stations), and one day-use facility accessible by road (Mowich Lake) (Jetton, 1993). The trailside camps are used by overnight campers. Use is limited to at most ten individual campsites per trailside camp by means of a park registration policy.

Park management has been concerned about how the pit toilet disposal system for human wastes is affecting water quality and the park's lake and stream ecology. In response to this concern, a report titled "Managing Backcountry Human Wastes and Water Quality" was prepared by Marshall and Nelson (1991) which described effects from human wastes such as increased algal growth in pristine lakes and contamination of surface waters by enteric organisms. Effects from the increased use of remote areas and subsequent human wastes disposal problems has been a concern in other studies (King and Mace, 1974; Ebert, 1985; Nichols et al., 1982).

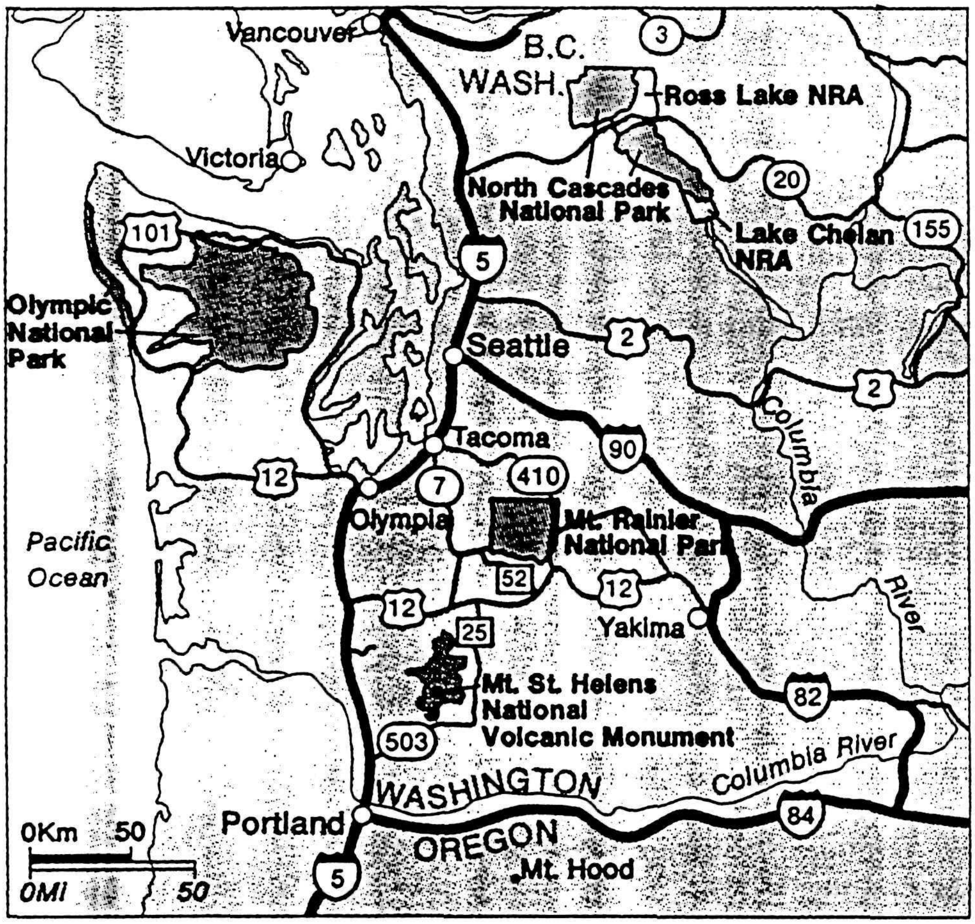

Figure 1. Mount Rainier National Park and Vicinity

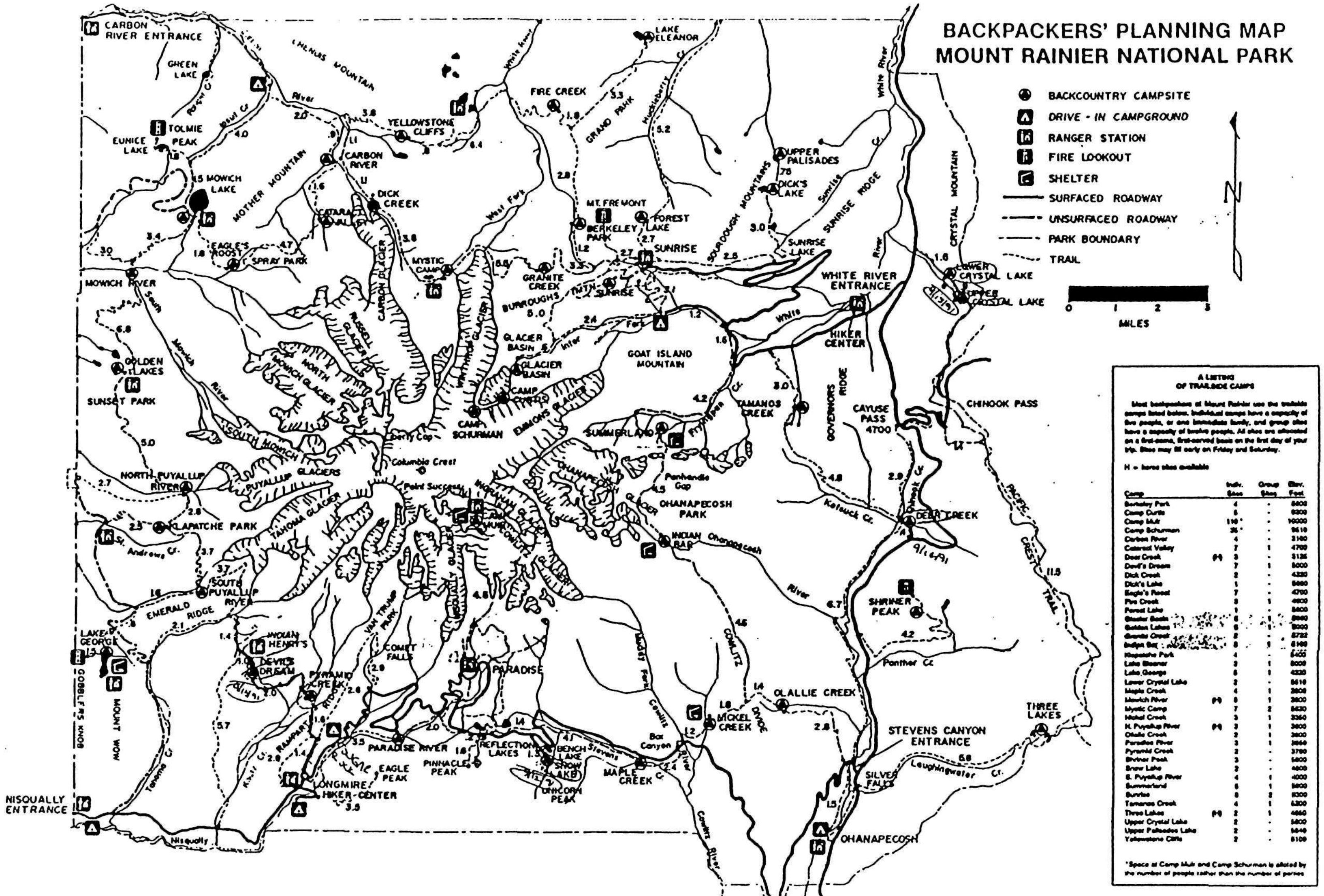

Figure 2. Mount Rainier National Park Backcountry Campsites and Ranger Stations

SCOPE OF STUDY AND PROJECT OBJECTIVES

Following Marshall and Nelson's study (1991), Mount Rainier National Park initiated the present study to develop and implement a workable system for managing human wastes in trailside camps.

The overall objectives of the study were to:

1. Review and assess the processes affecting transport of contaminants resulting from human waste disposal in backcountry pit toilets such as those found in the park;

2. Evaluate water quality impacts of human waste disposal in pit toilets for nearby water bodies;

3. Review alternative systems for disposal of human wastes in backcountry areas where water quality is easily impacted;

4. Perform site reviews of waste disposal systems at all backcountry trailside camps and cabins (ranger stations) in the park.

5. Develop criteria for the siting of and guidelines for the management of pit toilets in the subalpine and forest zones of the park;

6. Develop a priority list of pit sites to be removed or replaced based on the criteria developed; and

7. Review management alternatives for waste disposal systems where pit sites are not available due to water quality and ecological concerns.

Collectively, the detailed objectives guided the progress of the study and the development of conclusions and recommendations.

This report describes the processes which affect the movement of contaminants from human wastes disposed in pit toilets. Such processes are important in the placement of pit toilets. The relevant parameters describing soils, water transport mechanisms, and water quality impacts are discussed. The results are applied to pit toilet management at Mount Rainier National Park. In discussions of pit toilet management, elevation zones of the park are divided into alpine, subalpine, and lower forest zones, corresponding approximately to elevations above 6500 ft., between 5000-6500 ft., and below 5500 ft., respectively.

Pollutant transport mechanisms consider the transient nature of forest ground water and the unusual qualities of a hydrologic system which is shallow, on steep slopes, and has high hydraulic conductivities. The water quality impacts are nutrient pollution, enteric organism contamination, and pollution by hazardous materials deposited into pits.

Water quality protection is the highest concern of pit toilet management. However, proper maintenance can have a significant impact on pit toilet use and therefore is also considered in detail. A common problem with pit toilets is a lack of repairs. Often the most noticeable features of pit toilets are the numerous flies and obnoxious odors. Poor maintenance may lead to avoidance of pit toilet use and subsequent loss of management control over the disposal of human wastes. This increases the risk of water contamination and resulting adverse health effects. Most fly and odor problems can be eliminated with standard guidelines for repairs.

Specific practices that should be followed in pit toilet management are developed. Alternative systems of human wastes management are also described. Examples of such systems include ventilated pit toilets, composting toilets, and no-pit systems.

All the pit toilet sites within the park were visited and evaluated in terms of their potentials for water quality degradation. Each evaluation includes a description of the site's physical features, a map showing hydrologic pathways and proposed pit relocation sites, and recommendations of future actions. An album of site photos (identified as watch points in site maps) was previously submitted to Mt. Rainier National Park (Mt. Rainier National Park files).

WATER AND CONTAMINANT TRANSPORT FROM PIT TOILETS

A conceptual description is presented in this chapter of pertinent soil and subsurface water characteristics. Their influences on water and pollutant transport is stressed.

FOREST SOILS AND WATER CONDUCTIVITY

Soil structures in mountainous regions are spatially limited, unlike the more extensive soil structures encountered in valleys and floodplains at lower elevations. This is because of the irregular terrain, steep slopes, and the extensive presence of rock formations in mountainous areas. Soil structures in subalpine regions of Mt. Rainier are typically thin, occur on steep slopes, and possess high hydraulic conductivities. Forest zone soils are similar in overall content but are less spatially limited, occur on less-steep slopes, have greater depth, and possess more extensive forest duff and organic (A1) layers.

A general, simplified description of typical soils found near pit toilet sites in backcountry areas of Mount Rainier National Park is given in Table 1 (Franklin, 1966). Only hydrologically important terms are used in this description. This information is needed to understand the soil medium which contains the subsurface water and through which most contaminants are transported. Both Franklin (1966) and Hobson (1976) described the soils of Mount Rainier National Park. Forest-zone soils typically are overlain by organic matter and underlain by weathered, fractured or solid bedrock. Sand is the dominant soil type in all descriptions. Clay soils are very rarely found in either author's soil descriptions. The podzolic, or iron- and lime-leached, nature of the soils was recognized by Franklin (1966). Leached iron has formed impervious iron pans in deeper soil layers (Hobson, 1976). The deepest 15 cm of this example soil (at about 1 m depth) is 85 percent rock or gravel by volume; this may have prevented deeper exploration.

The flow of water through a permeable soil or rock formation occurs either as a porous media flow through the interconnected pores or as a macropore flow through larger openings. Flows tend to be highly variable and the rates are difficult to predict for forest soil environments.

The hydraulic conductivity (measure of ease with which water passes through soil or rock, equal to water velocity for unit hydraulic gradient [slope of water table measured in ft/ft or m/m]) of permeable soils made up primarily of sand and gravel, which is the dominant soil type at Mount Rainier, can be conservatively estimated as equal to that of fine sand. Domenico and Schwartz (1990) give an average hydraulic conductivity value of $2x10^{-5}$ m/sec or 140 ft/day for fine sand. They note that values for coarse sand can be as high as $6x10^{-3}$ m/sec or 1,700 ft/day. In contrast, hydraulic conductivities for clay and silt range from about $3.5x10^{-9}$ to $3.5x10^{-6}$ m/sec (0.0003 to 0.3 ft/day). Thus, water can move over rather large distances in short periods of time in the relatively coarse soils of Mt. Rainier National Park.

Macropore flow occurs through openings, larger than those between interstitial soil grains (micropores), that usually are highly irregular in location. Macropores are associated with rotting wood, charcoal, lapilli, roots, worm holes, and cracks in rocks. Such flows have higher effective hydraulic conductivities than those predicted from soil types (Jury et al., 1991) and thus may increase the distances of water movement in short time periods. Macropore flow is limited by the smallest pores encountered, such that some macropore pathways are more effective than others for conducting water through the soil matrix (bulk soil structure, including micropores and macropores). Saturated soil conditions apparently enhance macropore flow.

Table 1. Typical Forest-Zone Soil Profile in Mt. Rainier National Park (after Franklin, 1966)

Depth in cm	Description
Forest Duff (above soil surface)	
9-7	Matted needles, leaves, and twigs
7-0	Densely matted organic matter, abundant roots
Soil Surface	
0-2	grey, coarse sand
2-5	dark grey, coarse sand
5-15	dark brown, gravelly sandy loam, 26% lapilli, roots, rotting wood, and charcoal abundant
15-20	dark grey-brown, sandy loam, 16% lapilli, charcoal, roots, and rotting wood common
20-57	yellowish red and dark brown, coarse sand, 12.8% organic matter, roots occasional
57-90	dark grey, sandy clay loam, 8.7% organic matter
90-105+	dark yellowish brown, very rocky loamy sand, 85% rock and gravel, no roots

Macropore flow is a critical factor in pollutant transport. It enhances the mobility of chemicals (Jury et al., 1991, Singh et al., 1989) and greatly increases microorganism transport distances (Smith et al., 1985).

SUBSURFACE WATER

Subsurface water is usually divided into soil water and ground water (e.g., Hewlett and Nutter, 1969). The zones in which this water is found are usually divided into the zone of aeration and the zone of saturation (Todd, 1980). The zone of aeration is often further subdivided vertically into the soil-water zone, the intermediate vadose zone, and the capillary zone. The hydrologic processes in these zones differ, with important consequences for contaminant transport.

Soil water is water in the vadose (unsaturated) zone (the soil or root zone) above the water table. It is held there as soil moisture and is controlled by surface tension and gravitational forces. An intermediate zone occurs in many locations where the soil zone is not thick enough to be in direct contact with underlying ground water. This zone may be thin or quite thick, depending on the distance to the water table. Subsurface water drains downward through the intermediate zone toward the ground water zone under the action of gravity. The capillary zone, if it occurs, is a zone where water is drawn up a short distance above the water table due to capillary action caused by surface tension forces.

Ground water is water in the saturated-soil zone. Ground water flow involves water displacement in the direction of gravitational flow, or that of the piezometric surface. It is sometimes described as "plug flow" in which older water progresses down-gradient and is replaced by new water entering the system (Hewlett and Nutter, 1969). Ground water flow is an important transport mechanism for moving pollutants to nearby streams or lakes.

Aquifers are soil-rock formations that contain and transmit water. Aquifers are saturated zones and the water found there is called ground water. There are two main categories of aquifers -- unconfined and confined aquifers. Unconfined aquifers have an upper water surface known as the water table. The water table is the level of standing water seen in pits and wells. It is a three-dimensional surface extended over the saturated zone. Confined aquifers contain water under pressure due to overlying formations that have much smaller hydraulic conductivities. The level to which water in a confined aquifer would rise if free to do so (e.g., if a well were installed) is known as the piezometric level. It is analogous to the water table of an unconfined aquifer. In three dimensions, it is referred to as a piezometric surface.

The water table of an unconfined aquifer is the interface between the unsaturated and saturated zones. Ground water thus occurs beneath the water table of an unconfined aquifer as well as within confined aquifers. In either case, ground water saturates the pores and moves in response to gravity and differences in hydraulic energy (piezometric) levels. The slope of the water table or of the piezometric surface at any location denotes the direction and magnitude of the energy gradient.

The relative amount of moisture in the soil zone controls the ability of water to migrate. Saturation, at one extreme, is the condition where all pores are filled with water and the moisture content is 100 percent. Near the other limit, the soil may be so dry that wilting may occur for particular plants or, under more extreme conditions of drying, where the hygroscopic coefficient is reached. More typically, however, the moisture conditions vary over a range having its lower limit above the wilting condition and its upper limit at saturation. The field capacity is a moisture content of particular significance within this normal range of fluctuation. It represents the maximum amount of moisture that a particular soil can retain against gravitational drainage. If the soil moisture exceeds the field capacity, the excess soil moisture will drain to lower zones.

SUBSURFACE WATER FLOW

Subsurface flow begins with infiltration and percolation. The entry of water to the soil zone is called infiltration. This is the process by which water passes vertically downward through the soil surface. The movement of water downward through soil is called percolation. Percolation is the process of vertical movement of water within the soil matrix (including macropore flow).

Hewlett and Nutter (1969) identify several factors that affect infiltration. These also affect percolation. The factors include:

a. antecedent water content,
b. soil texture and structure (porosity and grain size),
c. biological activity and organic matter in the soil,
d. depth and type of surface mulches or vegetative cover,
e. surface soil wettability,
f. soil frost and ice,
g. quality of infiltrating water, and
h. entrapped air in underlying soils.

Forest soils are rarely homogeneous, except quite locally. Soil heterogeneities may occur due to many causes, including (a) the presence of roots and rocks, (b) pores of various sizes and irregular connections, (c) macropores running in various directions, and (d) low-permeability soil layers or lenses interspersed with higher-permeability soils. These heterogeneities have spreading effects on percolating water by obstructing flows or providing preferential flow paths. Thus, dispersion occurs and causes the lateral spreading of water during its downward movement. Consequently, water may move laterally into a pit toilet, even though direct vertical inflow is blocked. Seepage from a pit toilet may move vertically and/or laterally away, spreading as it moves.

EFFECTS OF STORMS AND SNOWMELT

Water that may reach pit toilets located at higher elevations is primarily caused by snowmelt. For sites at lower elevations, rainstorms are also likely to be important.

Snowmelt usually occurs slowly enough that forest soils can completely absorb the resulting liquid water through processes of infiltration and percolation. In rainfall events most of the precipitation also enters the ground by infiltration except locally where rock outcrops or other low-infiltration surfaces occur. Water that can not infiltrate will either move downhill as overland flow or, if the local terrain is flat, may pond until either lost by evaporation or infiltration. In the lower forest zone of Mt. Rainier National Park which generally covers elevations lower than 5000 ft., extensive overland flow is unlikely to occur because of the predominance of soils of high infiltration capacity. The result of importance to contaminant transport is that most of the precipitation reaching the ground in a forested area, whether as snow or rain, is likely to infiltrate into the soil and move as subsurface water. Thus, abundant ground water flow is available that has the potential to reach and be contaminated by an unsealed pit toilet.

Storm flow and base flow are terms that help distinguish the types of ground water movement that bring water to streams. The largest component of storm water flow reaching forest streams is thought to begin as subsurface flow (Hewlett and Nutter, 1969), either as interflow seeping above the water table or as base flow from below the water table. Large infiltration and percolation rates, large effective hydraulic conductivities, shallow transmitting zones, and easy lateral flow due to non-homogeneous conditions allow rapid ground water movement, thus allowing discharges in streams to quickly increase in response to rainfall events.

Base flow is the outflow to a stream from aquifers which are recharged by water percolating vertically through the soil mantle to the water table (Hewlett and Nutter, 1969). Base flow is sustained and seasonally augmented by infiltration and percolation of snowmelt and rain. Base flow in the Pacific Northwest is most significant to adding water to stream flow in the summer months. Pollutant transport at this time, when dilution from storm flow is minimal, make base flow a concern to pit toilet management.

Several factors can affect the significance of ground water transport of pollutants to nearby surface waters. These are:

a. duration, intensity and timing of storm events,
b. quantity and mobility of nutrients or pollutants,
c. size and sensitivity of the water body, and
d. background nutrient inputs.

LOCAL SUBSURFACE WATER FLOW PHENOMENA

Local subsurface water flow phenomena occur that can significantly influence ground water flow and pollutant transport. These result from such conditions as perched water tables, springs, and seeps. A perched water table is a local anomaly involving a small, artificially high water table due to an underlying layer of relatively impervious soil that holds percolating subsurface water above the surrounding water table (Linsley et al., 1949). The iron pan development of forest soils, which is characterized as common within the park by Hobson (1976), can result in perched water tables, such as those in the Golden Lakes area.

Springs and seeps are the results of an intersection of a water table and the soil surface (Linsley et al., 1949) and are evidence of a locally high water table. Because the terrain is so irregular within the park, many opportunities are provided for springs and seeps to occur.

ESTIMATING THE POSITION OF THE WATER TABLE

The position of the water table beneath the land surface can be roughly estimated to be a subdued image of the surface topography (Linsley and Franzini, 1979). Similarly, the water table elevation near a stream or lake can be roughly approximated by the elevation of the surface of that water body. Farther away from lakes or streams, shallow water tables may be indicated by vegetation that requires abundant moisture in order to flourish.

Surface morphological features that extend beneath the land surface, such as large rock outcrops, can obstruct ground water flow. These also influence the water table elevations and make their locations more difficult to estimate.

CONTAMINATION OF SUBSURFACE WATER BY PIT TOILETS

Trailside camps on Mt. Rainier range in elevation from 2700 to 6300 feet. Therefore, the sites vary from rain-dominated to snow-dominated regions. The availability of water for infiltration also varies for these two regions. In rain-dominated regions, water is supplied to the soil almost continuously throughout the winter but is diminished at most other times of year. In contrast, in snow-dominated regions precipitation is stored as snow until the spring melt, when it becomes readily available for infiltration (Beschta, 1991).

The forest soils of Mt. Rainier allow rainfall to infiltrate rapidly and then percolate locally to the water table (Beschta, 1991). One flow path which results in vertical transport of pollutants and contamination of subsurface water is illustrated in Figure 3. In this example, rain or snowmelt water infiltrates the surface, percolates to a less permeable layer, spreads laterally into the pit, wets the wastes, and continues to percolate downward out of the pit toward the water table, but now carrying along dissolved and colloidal contaminants from the pit.

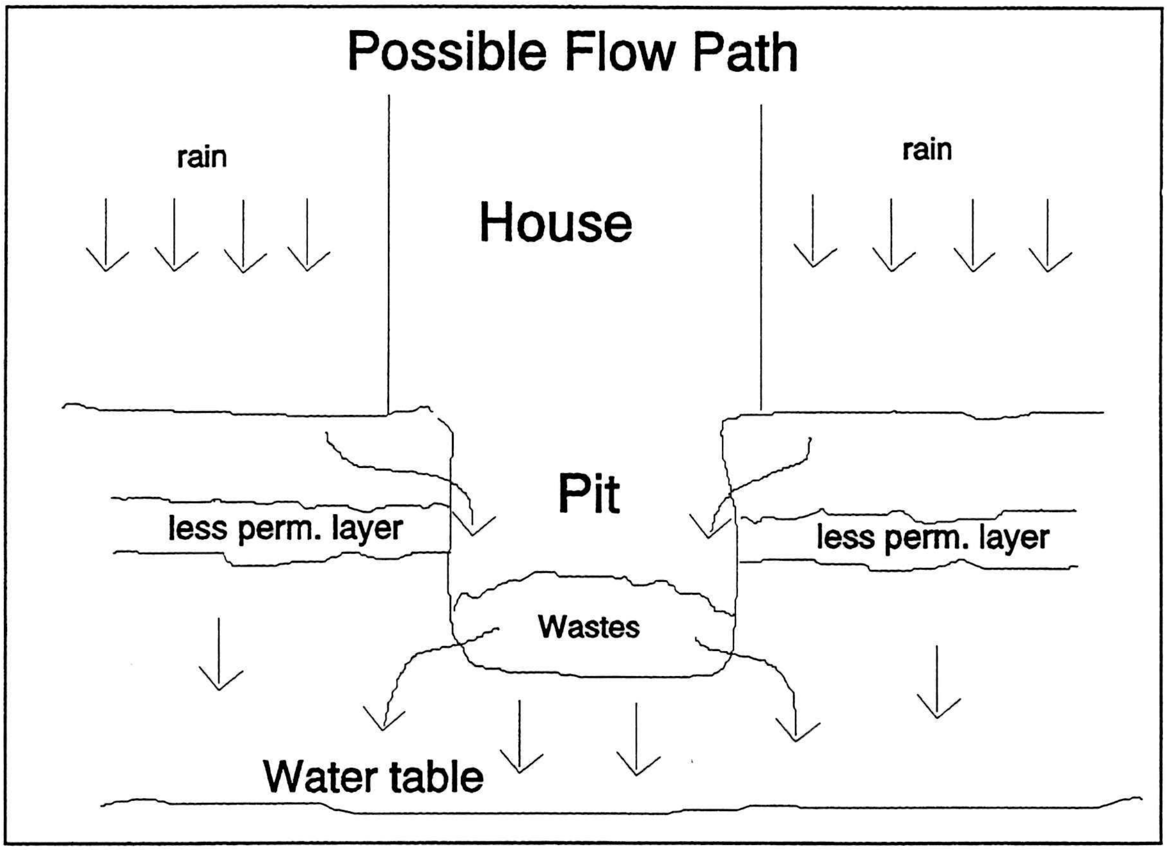

Figure 3. Example of Contamination of Percolating Water Due to Pit Toilet and Layered Soil in Vadose Zone (arrows indicate water movement).

WATER QUALITY IMPACTS OF PIT WASTES ON NEARBY WATER BODIES

GENERAL CONCEPTS

Marshall and Nelson (1991) described several concepts useful in evaluating the water quality impacts of human wastes on lakes and streams in Mount Rainier National Park. Based on these concepts, the water quality impacts of human wastes in pit toilets can be divided into three categories:

a) nutrient pollution,
b) enteric organism contamination, and
c) improper disposal of hazardous materials.

Human fecal matter biodegrades and releases nutrients over time. Enteric organisms such as bacteria, viruses, and protozoa are also contained in feces. Nutrients and enteric organisms can migrate in groundwater from a pit toilet and impact nearby surface waters.

Biochemical oxygen demand (BOD) is a measure of the demand for oxygen during stabilization of organic matter by microorganisms and is used widely as a control parameter for effluent quality from wastewater treatment plants to control dissolved oxygen (DO) depletion in receiving waters (Henry and Heinke, 1989). Oxygen depletion caused by the BOD of wastes which potentially reach surface waters from pit toilets is not considered of primary importance to pit toilet management because of the low BOD concentrations involved. Most BOD is readily removed by microbial action in the pit and soil, and even under worst-case conditions assuming maximum pit toilet use (consistent with park management policies), no degradation and removal of BOD in the pit and soil, and low stream flow, dilution is sufficient to limit DO depletion to negligible amounts.

The process of waste degradation within a pit toilet is assumed to have two zones of decomposition, a surface layer where oxygen penetrates to enable aerobic decomposition and a deeper anaerobic zone which digests the wastes by fermentation reactions. The anaerobic digestion process solubilizes nutrients (nitrogen and phosphorus) that can potentially migrate into ground water and, consequently, can be a source of nutrients to nearby lakes and streams. The range of conditions encountered in the park due to the diversity of elevation and geographic location includes variable water availability, soil and water temperature, and waste loading rates (pit toilet use). This creates a wide range of possible degradation rates for wastes. For a worst-case estimate, nutrients released from pit toilets were assumed to be proportional to waste loading rate and to not depend on specific site conditions such as waste degradation rates that might mitigate nutrient loading rates.

Stream and lake biological processes can differ greatly from each other due to differences in hydrological regimes. Streams are generally less susceptible to eutrophication from nutrient inputs than lakes because they have more turbulence, may have greater limitations of sunlight penetration, and have shorter residence times (Marshall and Nelson, 1991). Furthermore, dilution makes streams with large flow rates less susceptible to impacts than those with small flow rates.

Nutrient recycling, retention time, and lake sensitivity are important concepts associated with waste degradation in lakes (Marshall and Nelson, 1991). Nutrient recycling is nutrient storage and release from sediments in a lake. Retention time characterizes how long water is retained in a lake. This is controlled by factors such as watershed area, rainfall amounts, and lake volume. Lake sensitivity varies with physical characteristics and provides an indication of relative sensitivity to nutrient loadings (Marshall and Nelson, 1991).

NUTRIENT POLLUTION

The primary nutrients of concern found in human wastes are nitrogen and phosphorus. Nitrogen occurs predominantly in two forms in roughly equal amounts in human wastes, ammonia-nitrogen (NH_3 and NH_4^+, 40%) and organic nitrogen (proteinaceous forms, 60%). During waste degradation, nitrogen is released in dissolved forms (ammonia and organic) and may also be oxidized to the very mobile nitrate ion (NO_3^-) under aerobic conditions (Metcalf and Eddy, 1979). Organic phosphorus forms are converted during the degradation process and released as orthophosphate (PO_4^{3-}). The amounts of nitrogen and phosphorus produced are estimated to be six and nine grams/person-day for organic and ammonia nitrogen, respectively, and four grams/person-day for phosphorus (Metcalf and Eddy, 1979).

Both nitrogen and phosphorus found in human wastes can contribute to algal growth in surface waters. Nitrate-nitrogen is considered highly mobile in ground waters (Domenico and Schwartz, 1990). In most soils phosphorus is less mobile because of its adsorption to soils (Marshall and Nelson, 1991). However, phosphorus has been shown to be more mobile in soils that have large contents of sand and organic matter (Mansell et al., 1977). Under unsaturated soil conditions, both vegetative assimilation and soil retardation can have a pivotal role in reducing contaminant transport. However, retardation of nutrient transport provided by soils is diminished greatly if macropore flow occurs (Smith et al., 1985). Macropore flow under saturated soil conditions greatly increases the rate of transport of phosphorus and nitrogen, making them much less available for assimilation or retardation.

Gilliom (1983) has developed a parameter labeled the sensitivity (S) of a lake which represents its susceptibility to nutrient addition. It is primarily a function of the physical characteristics of a lake (watershed area, mean depth, residence time) and can be expressed as a numerical value. Marshall and Nelson (1991) used Gilliom's approach to evaluate the sensitivity rating of 19 lakes in Mt. Rainier National Park. Table 2 is taken from Marshall and Nelson (1991) and shows the sensitivity values and rating criteria. About 50 percent of the 19 lakes were rated moderately to highly sensitive to nutrient additions and an additional 10 percent were extremely sensitive to nutrient additions. For example, (Upper) Crystal Lake has a sensitivity rating of high.

Using the lake evaluation process of Marshall and Nelson (1991), a calculation is used to illustrate phosphorus loadings and their effects on lake sensitivity for Crystal Lake (see Appendix

1). The background (natural) phosphorus loading to Crystal Lake is predicted to be about 3.2 kg/yr, while a maximum increase of 1 kg/yr phosphorus is predicted from human waste disposal in the pit toilet located in the watershed assuming no assimilation or retardation in the soil. This phosphorus increase of 31%, to 4.2 kg/year, results in an increase in lake phosphorus concentration of 2 micrograms/liter, from 6.2 to 8.2 micrograms/liter. Although algal production in Crystal Lake would remain low, the new lake phosphorus concentration is notably closer to the limit of 10 micrograms per liter (Gilliom, 1983) between a low- and moderate-productivity lake. This calculation illustrates the sensitivity of lakes with small drainage basins and low background phosphorus loadings to potential phosphorus inputs from pit toilets.

Table 2: Sensitivity Rating for Lakes in Mt. Rainier National Park. (From Marshall and Nelson, 1991)

Lake	Sensitivity Rating (S x 10)[#]	Sensitivity Criteria[@]	Sensitivity Ranking[%]
Allen*	17.1	High	4
Bench*	21.8	Extreme	2
Clover	5.3	Moderate	8
Crescent*	4.7	Moderate	10
Crystal	19.6	High	3
Eleanor	4.6	Moderate	11
Frozen*	30.6	Extreme	1
George	2.3	Low	15
Golden	3.3	Moderate	12
Green*	0.9	Low	18
James	1.2	Low	17
Louise*	1.7	Low	16
Mowich	0.9	Low	19
Mystic	9.3	Moderate	5
Reflection*	2.8	Low	13
Shadow	5.3	Moderate	9
Shriner*	8.2	Moderate	7
Snow	2.4	Low	14
Tipsoo*	9.2	Moderate	6

* Lake has no nearby pit latrine

S (Sensitivity) is a composite parameter proposed by Gilliom (1983) computed from a lake's mean depth, surface area, and hydraulic detention time (residence time). Sensitivity Rating is a scale based on values of S multiplied by 10 which is compared to Gilliom's Criteria.

@ Criteria proposed by Gilliom (1983) based on Sensitivity Rating

% Relative sensitivity of Mt. Rainier National Park lakes to nutrients

ENTERIC ORGANISMS

The water-transmitted organisms harmful to humans include bacteria, viruses, and protozoa (Marshall and Nelson, 1991). Total coliforms were found to be more numerous in lakes with adjacent campsites than in lakes without nearby campsites (King and Mace, 1974). Transport distances were measured by Johnson and Urie (1976) by injecting raw wastes into a sandy soil; the wastes were detected 15 feet down gradient directly after injection. In saturated hill-slope soils of western Oregon, horizontal transport was measured to cover a distance of 50 feet in one hour (Rahe et al., 1978). Soil moisture controls the bacteria transport rates and distances. Saturated conditions significantly increased the distances traveled (Marshall and Nelson, 1991).

INAPPROPRIATE DISPOSAL OF HAZARDOUS MATERIALS; MISCELLANEOUS POLLUTION

There is potential for campers to improperly dispose of hazardous materials in pit toilets. This may be done when containers are considered to be empty; it may also be done to lighten hiking packs. Examples of such material include excess cooking fuel and empty fuel containers. Fuel seepage to a pristine lake could be harmful or even devastating to the ecology of the lake and surrounding area.

A wide variety of miscellaneous trash is disposed of in pit toilets. Non-biodegradable trash, while not presenting a direct water quality concern, can add significantly to the volume of wastes in a pit. This can increase the seepage head in the pit, causing a greater rate of outflow for contaminants. This also decreases the life span of a pit location.

SUMMARY OF MOUNT RAINIER BACKCOUNTRY PIT TOILET SITE REVIEWS

A primary objective of this study was to examine the backcountry pit toilets of Mt. Rainier National Park in terms of their potential for water quality degradation. A total of 44 backcountry (trailside camp and cabin/ranger station) pit toilets and one roadside pit toilet (Mowich Lake) where examined. Summaries of the individual site reviews are given in Appendix 3, together with an explanatory key.

The evaluation of pit toilet sites and the development of management guidelines were carried out simultaneously for logistical reasons and to meet needs of park staff. This resulted in some variations in the evaluations as new information was obtained. Therefore, the format of individual site reviews shifted over time as experience was gained with park needs. The timing of the site surveys, which were conducted during mostly drought conditions, affected site observations, and thus findings noted for each camp (Appendix 3) may not have been typical. Some of the reviews and resulting management recommendations should thus be considered to be preliminary. Final decisions should be made by park rangers and maintenance personnel who understand the pit toilet guidelines and who can apply their understanding to each pit site when making final decisions as to pit placement.

Pit toilets in alpine areas were not surveyed as part of this study. These include toilets at Camps Muir, Schurman, and Curtis. Other toilets not surveyed due to time constraints are St. Andrews Backcountry Cabin, Paradise walk-in camp, and Tolmie and Fremont fire lookouts.

RECOMMENDATIONS FOR PIT TOILET SITING ACTIONS AND REPAIRS

Table 3 lists the pit toilet sites reviewed. The table also gives the types of water bodies that could be impacted, recommended siting actions, recommended repairs, and term definitions. Figures 4 and 5 summarize recommended siting actions and repairs, respectively. The terms used in Figures 4 and 5 are defined in Table 3.

Recommended siting actions for Mt. Rainier pit toilets (Table 3 and Figure 4) are based on the individual site reviews as detailed in Appendix 3 and include 44 total sites (proposed site at Kotsup Creek not included). Of the 9 sites requiring relocation, 6 were in need of relocation due to potential water quality impacts while 3 required relocation only because pits were overloaded (full). At Forest Lake Camp, no pit toilet exists and the extensive use of cat-holes for waste disposal is a serious potential threat to water quality in Forest Lake. Of the 8 low priority sites, 7 require relocation due to potential water quality impacts that may result from long-term use. Of the total of 15 backcountry camps (excluding other sites) with potential water quality impacts (bold typeface in Table 3), four are near lakes that have sensitivity ratings of moderate (Table 2), while none was near lakes with high or extreme sensitivity. All 6 of the special action sites have water quality concerns and require alternative waste disposal systems. Pit siting guidelines are described in the following section on Guidelines for Siting Pit Toilets and for Pit Toilet Management.

Of the repairs recommended at the 44 active pit toilet sites (Figure 5), approximately two-thirds require no or only minor repairs, while about one-third require major repairs. Maintenance and recommended repairs are discussed relative to pit toilet types in the following section on Guidelines for Siting Pit Toilets and for Pit Toilet Management.

Table 3. Summary of Mt. Rainier Pit Toilet Conditions

Camp Name	Impacted Water Body	Siting Action Needed	Repairs
Berkeley Park	stream	no action	major
Carbon River	river	no action	minor
Cataract Valley	wetland	**resite**	minor
Deer Creek	river	no action	major
Devil's Dream	stream	no action	none
Dick Creek	stream	no action	minor
Dick's Lake	lake	**resite**	minor
Eagle's Roost	no water	resite, pit full	major
Fire Creek	stream	no action	minor
Forest Lake	lake	**site pit**	minor
Glacier Basin	lake	**resite**	major
Golden Lakes	lake	**special**	minor
Granite Creek	stream	**resite, pit full**	minor
Indian Bar #1	river	no action	major
Indian Bar #2	river	resite, pit full	minor
Klapatche Park	lake	resite	minor
Kotsup Creek (proposed)	stream	n/a	n/a
Lake Eleanor	lake	**resite**	major
Lake George	no water	no action	none
Lower Crystal Lake	stream	no action	none
Maple Creek	river	no action	major
Mowich River North	river	no action	minor
Mowich River Middle	river	no action	minor
Mowich River South	river	no action	major
Mystic Camp	stream	**resite, pit full**	major
Nickel Creek	stream	**study**	minor
N. Puyallup River	river	no action	none
Ollalie Creek	stream	**study**	none
Paradise River	river	study	minor
Pyramid Creek	river	no action	none
Shriner Peak	no water	no action	major
Snow lake	lake,river	**resite**	none
S. Puyallup River	river	no action	none
Summerland	no water	resite, pit full	major
Sunrise	lake	**special**	minor
Tamanos Creek	no water	no action	minor

Table 3, continued. Summary of Mt. Rainier Pit Toilet Conditions

Camp Name	Impacted Water Body	Siting Action Needed	Repairs Needed
Three Lakes	lake	**resite**	major
Upper Crystal Lake	lake	**resite**	major
Upper Palisades Lake	lake	**resite,pit full**	minor
Yellowstone Cliffs	stream	**resite**	none
Others:			
Indian Henry's Ranger Cabin	lake	**special**	none
Lake James Ranger Cabin	stream	no action	none
Mowich Lake Ranger Cabin	lake	special	none
Mowich Lake Campground	lake	**special**	minor
Mystic Lake Ranger Cabin	lake,stream	**special**	major

Terms used in Table 3 and Figures 3 and 4:

Impacted Water Body

- lake: lake or pond
- stream: small stream up to small river
- river: large river
- wetland: saturated soil, typical wetland vegetation present
- no water: no nearby surface waters

Siting Action Needed

- re-site: relocate pit as soon as possible due to potential water quality impacts or pit overloading (full)
- no action: no relocation of pit needed based on lack of water quality concerns
- special: potential water quality impacts and lack of suitable pit relocation sites requires special consideration (alternative waste disposal systems)
- study: further study required, since unclear whether surface waters are potentially affected by current pit location
- Notation: **Bold typeface** indicates potential water quality problems from current pit toilet location

Needed Repairs

- none: no repairs needed
- minor: small easily accomplished repairs (e.g., holes into the pit)
- major: many small to large repairs or a replacement part needed

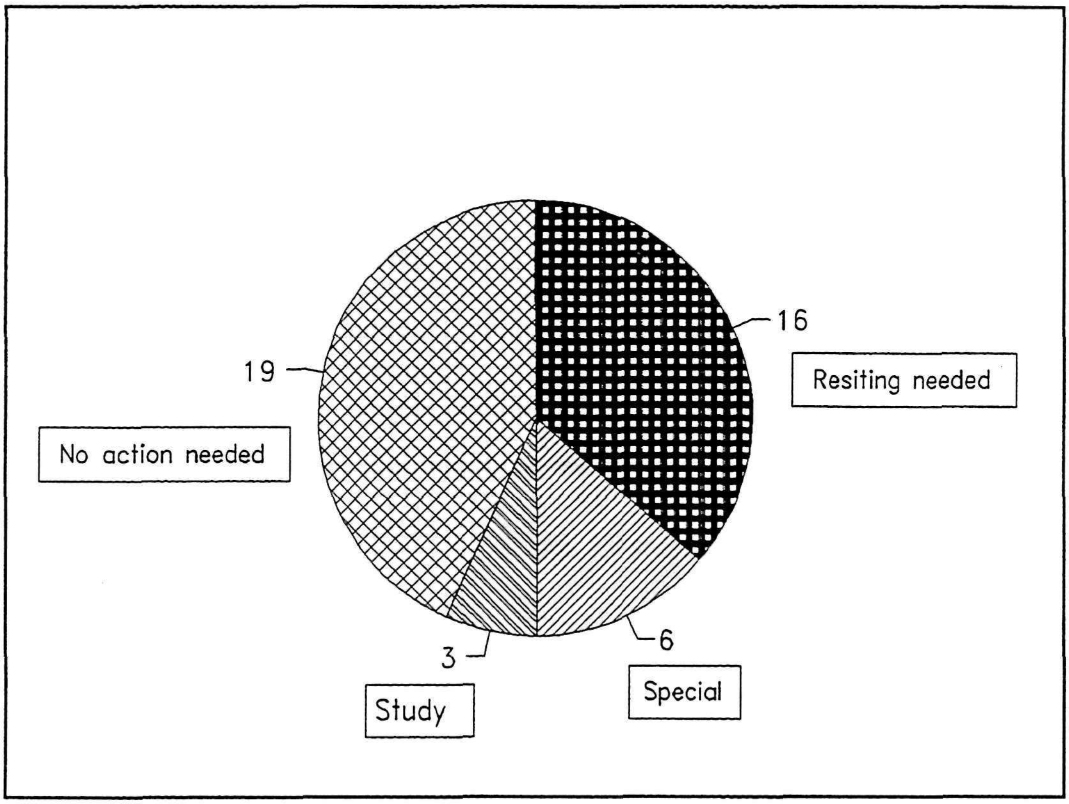

Figure 4. Summary of Recommended Siting Actions
for Mt. Rainier Pit Toilets

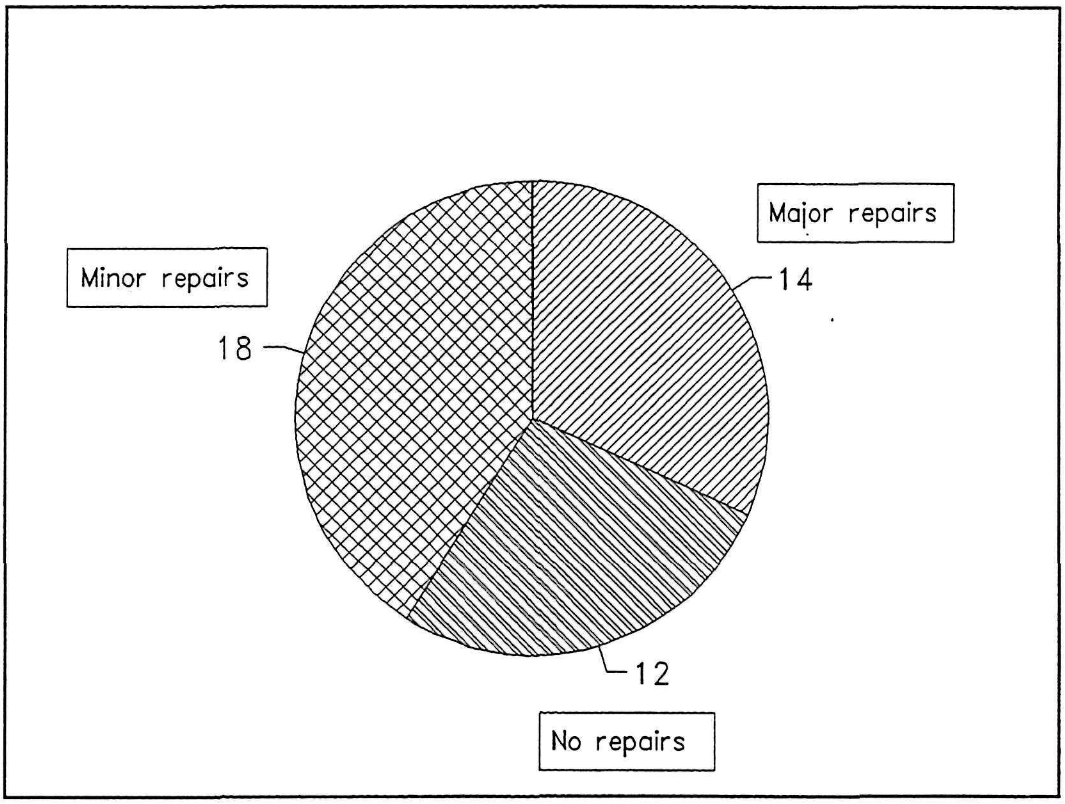

Figure 5. Summary of Recommended Repairs for Mt. Rainier Pit Toilets

GUIDELINES FOR SITING PIT TOILETS AND FOR PIT TOILET MANAGEMENT

Producing guidelines for human wastes management in backcountry areas of Mount Rainier National Park is a primary goal of this study. The pit toilets are the main focus of this effort. However, other systems for human waste management are also examined.

Guidelines were specifically developed in this study for use by park service personnel for pit toilet siting and maintenance. These are based on knowledge of surface and subsurface hydrology, contaminant transport mechanisms, and probable impacts of contaminant transport on water quality, as summarized in previous sections of this report.

EMPHASIS OF GUIDELINES

A framework for the development of guidelines is suggested in the wording of The Wilderness Act. This act mandates that wilderness areas:

> ". . . are managed so as to preserve . . . natural conditions," and "generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable."

Interpreting this statement in terms of managing human wastes in backcountry areas dictates that all reasonable means should be employed in developing management guidelines to minimize detectable water quality and ecological impacts in streams and lakes of Mt. Rainier National Park. It is recognized that both unanticipated and long-term cumulative impacts could occur due to uncertainties in identifying site conditions and the difficulty of assessing long-term and indirect effects. By minimizing direct impacts, it is hoped that potential long-term cumulative impacts are substantially avoided. To reduce risks from uncertainty to a negligible level would require prohibition of pit toilet use at many present sites in the park. The resulting uncontrolled disposal of human wastes could only be averted by closure of such areas to human access. It should be recognized that a natural background level of nutrients contributed by wastes from wildlife exists and that human waste impacts should be evaluated in this context.

IMPORTANCE OF LOCAL KNOWLEDGE AND DATA BASE

A toilet management system must consider the expertise of backcountry rangers or maintenance personnel because they will be responsible for its implementation. These personnel, with access to files of annual site review forms (see Appendix

2) maintained for each pit toilet site, are probably the most familiar with sites and their variations in conditions and therefore should be best able to make the needed site evaluations.

A toilet management system must also consider the practicality of data collection. Critical parameters that are not easily measured are often evaluated with surrogate information. For example, the extent of soil saturation and the soil moisture levels in unsaturated soils are critical to pollutant transport predictions. Lacking direct measurements, information on water table depths can be estimated using indicators of near-surface saturation such as wet-site vegetation or by making appraisals based on surface topography. This results in management guidelines that are not fully experimentally-determined and/or data-driven.

DEVELOPMENT OF CRITERIA AND GUIDELINES

Marshall and Nelson (1991) recommended that an ideally designed pit should be four to five feet above the water table. This places the pit in the zone dominated by soil water. It also provides a vertical margin for seasonal water table fluctuation. At Mt. Rainier National Park , the shallow soil depths (see Table 1 and discussion above) in most cases will prevent pit construction with this margin of safety above the water table. Where possible, shallow, wider pits should be used preferably over deeper, narrow pits.

A protective distance of 150 feet between a pit and the nearest surface water was recommended by Ebert (1985) and reaffirmed by Marshall and Nelson (1991). This distance was proposed to give adequate screening (Nichols et al., 1982) of enteric organisms and to allow sufficient soil mass to provide ample sites for phosphorus adsorption. For unsaturated soils, this distance is adequate to prevent enteric organism pollution. Saturated soils, however, have been reported to have higher transport distances (Rahe et al., 1978; Marshall and Nelson, 1991). Phosphorus was also shown by Mansell et al. (1977) to be more mobile in soils similar to those often found on Mt. Rainier than in soils with higher clay content. Therefore, unsaturated conditions must be maintained to reduce enteric organism or phosphorus transport (Marshall and Nelson, 1991).

The 150 foot distance should be measured along the suspected path of ground water flow from the pit to the nearest surface water. Surface topography (relief features) and intervening geomorphological features (landforms, such as rock outcroppings) must be considered in estimating the groundwater flow path. Locations with possible short-circuiting through fractured rock (fracture-flow) and with extreme slopes should be avoided.

Predicting the water table elevation is difficult without direct measurement. The location can be estimated by the surface topography. Water tables can be assumed to be farthest below the surface on higher segments of a slope, because of drainage from high ground to low ground. Perched water tables and seasonal water availability variations add to the complexity of predictions. Field notes of site observations during wet conditions (early summer during snowmelt, after storm events) will aid understanding of specific site conditions.

Ideally, contaminated soils at pit toilets should never become saturated or subject to flooding (Ebert, 1985). Unsaturated conditions are difficult to assure throughout the year; however, the requirement of infrequent flooding within a pit is feasible. Flooding resulting from snow melt or severe summer storm events is difficult to anticipate, but chronically flooded pits are indicative of a high water table. Soils with induration (consolidation) and mottling present such as those with iron cementation horizons are indicative of poor internal drainage. A dense herbaceous cover and the presence of certain types of vegetation indicate chronic wetness and a saturated soil and should be avoided. *Devils club* (groundcover shrub vegetation) and *Alaska cedar* are associated with the wettest soils. Other shrubs that may be associated with wet soils include *alpine rhododendron* and *huckleberry*, while other trees that may be associated with wet soils include *vine maple, silver fir, western hemlock, red cedar*, and *Douglas fir* (Hobson, 1976). The trash condition in a pit can also indicate recent flooding because wastes sort into heavier organic components, which generally sink, and trash components, which float. Therefore, a visible surface layer of trash can be evidence of recent flooding.

Lakes are susceptible to pit-toilet pollution from nutrients, enteric organisms, and inappropriately disposed hazardous materials. The Upper Crystal Lake Camp phosphorus calculation showed that the potential for nutrient impact on a lake could be important. Enteric organisms from pit toilets can also impact lakes if saturated soil conditions facilitate their transport. The impact from improperly disposed hazardous materials is difficult to predict and has a devastating potential. The lakes of Mt. Rainier National Park are unique natural resources that are particularly sensitive to nutrient and other contamination because of their pristine condition. Removing pit toilets from the drainage basins of lakes and ponds can give a high level of protection by preventing direct ground water transport of pollutants to these waters. Pit toilets near large, less sensitive lakes should be reviewed individually to determine specific impacts from site-specific loadings. In general, potential nutrient loadings from human wastes at present use levels at Mt. Rainier National Park are small or insignificant relative to background sources (land drainage and precipitation) (Nelson and Marshall, 1991).

The location of a pit toilet should not be such as to endanger the water quality and ecology of a stream. Streams that potentially serve as drinking water sources for backcountry users may merit an additional level of protection. Enteric organisms can travel several hundred meters under saturated conditions in porous soils (Nichols et al., 1982). Complete assurance of unsaturated conditions is difficult, thus making it important to provide other safeguards for backcountry users. Where feasible, the recommendation is made to provide an additional margin of safety against surface water contamination from enteric organisms by providing a 100-foot down-gradient distance between projected entry points for contaminated ground water from pit toilets and potential water use locations (trail crossings and adjacent campsites).

Abandoned or closed pit toilets can be a continuing source of pollution because of long-term degradation of the wastes. Sikora et al. (1980) reported that after four years about sixty to eighty percent of the nitrogen from sewage trenches had leached into the surrounding soil. Thus, continued pollution of waters from abandoned pit toilets can be difficult to predict. Future research may provide insight into degradation rates of human wastes and continuing nutrient loading rates in backcountry environments.

Four abandoned pit toilets located in the lower forest zone were excavated as part of this study. The wastes in three of these were visually and texturally indistinguishable from rich fine soils. The site at Golden Lakes was located in a wetland and material in the pit was only partially decomposed as strong odors remained. A large assortment of miscellaneous trash was found in each pit. Records did not indicate the closure dates for these pits, but an estimation of three years of non-use was made from interviews with rangers. Pit waste degradation rate is a function of temperature, moisture content, and soil conditions. Human wastes in pit toilets have been reported to persist in partially degraded state for more than ten years in some locations, with pathogenic bacteria and viruses surviving up to 5 years (Reneau et al., 1989).

If backcountry users avoid pit toilets due to inconvenience or lack of maintenance, wastes can become unmanaged and a potential threat to human health and water quality. Pit toilets should be located sufficiently close to campsites to be conveniently used, but not so close as to make users uncomfortable. This is especially true for unhoused pit toilets (Wallowas), where sufficient screening must be provided by vegetation or topography.

PIT TOILET SITING GUIDELINES

The following guidelines are proposed for siting pit toilets in backcountry areas of Mt. Rainier National Park. The guidelines are listed in approximate order of importance for protecting the water quality and ecology of lakes and streams in the park from human waste disposal in pit toilets. It should be noted that in other backcountry settings, other criteria might be important or the order of importance may vary.

1. *Distance to surface waters.* Pit toilets should be located more than 150 feet from surface waters. Generally, this distance is measured along the suspected groundwater flow path considering local topographical and geological features. The intent of this recommended minimum distance is to provide a margin of safety in terms of soil assimilative capacity and attenuation of contaminants. Areas with suspected groundwater flow through porous or fractured rock should be avoided.

2. *Soil type and vegetation.* Pit toilets should be located where soil permeability is fair to good (silty to sandy loam) but not excessive (coarse sandy to gravelly/cobbly). Greater density of vegetation (shrubs and trees) intervening in direction of suspected groundwater flow aids in nutrient retardation. Pit toilets should not be located where saturated soil conditions or repeated flooding are known or suspected to occur. Wet site vegetation, springs, seeps, and surface ponding are indicators of shallow groundwater conditions. Soil profiles with evidence of induration (consolidation) and mottling are indicative of poor internal drainage.

3. *Sensitive lakes.* Pit toilets should not be located in the watersheds of sensitive lakes or ponds. In watersheds of less sensitive lakes, estimated nutrient loadings from human waste disposal should be reviewed individually to assess the possible location of pit toilets near these lakes. Alternative disposal systems (e.g. compost-and-carry toilets) should be considered where adverse water quality impacts from pit toilets cannot be avoided.

4. *Drinking water source.* Pit toilets should be located such that the projected subsurface flow path from the pit toilet enters a stream or surface water more than 100 feet down-gradient from suspected drinking water source locations (trail crossings and adjacent campsites) of backcountry users.

5. *Former pits.* Pit toilets should not be relocated in former pit sites as a priority choice due to the generally very slow degradation rates of buried wastes in mountainous (subalpine and forest) regions.

6. *Convenience and screening.* Pit toilets should be conveniently located to encourage use by campers. Adequate privacy screening should be provided for unhoused pit toilets (Wallowas), preferably by natural vegetative cover or topographical relief.

PIT TOILET MAINTENANCE GUIDELINES

For a pit toilet to work properly it must have regular maintenance. Emphasis is placed on the development of uniform structures and related repairs. A distinction is made between the house and the pit when describing recommended maintenance procedures. It is recognized that unhoused pit toilets (Wallowas) are the accepted standard design in backcountry (wilderness) areas.

Wastes in the pit attract insects, especially flies, that are a nuisance and health concern. Preventative measures must be taken to keep insects out of the pit and house. Fly screens should be in good condition. All holes in screens should be repaired with new screen material; deteriorating or old screens should be replaced. Flies and other insects are able to enter through small holes, so care should be given to their complete covering.

The house itself should be well sealed. Gaps in siding and at corners should be sealed to prevent fly entry. Doors should close securely without gaps that enable entry by flies and rodents. Proper ventilation should be ensured to reduce odor and heat build-up in a well-sealed structure.

Seat covers on pit toilets should provide a seal against fly and rodent entry and to control odors, and they should be left down when the toilet is not in use. The seat cover is especially important on unhoused toilets (Wallowas) because it is the only defense against entry of insects, animals, and precipitation.

It is important to prevent direct fly entry into the pit. All holes in the house floor and toilet seat structure should be thoroughly sealed. Holes around the outside base of the house that provide direct entry into the pit should also be sealed. One base sealing method is depicted in Figure 6 using a plastic skirt that is covered with soil to prevent ultraviolet exposure (sunlight) and photodegradation. The plastic skirt should be replaced whenever the seal is breached by normal wear, maintenance activities, or animal burrowing. Construction of a solid, level base aids greatly in preserving the integrity of the house and pit.

Surface water runoff should be diverted away from the pit to prevent direct entry. Water should not be allowed to pond near the pit (10-20 ft. radius) where it can slowly percolate into the pit. A new site should be located when the wastes are within about six inches of the soil surface. The closed pit should be capped with soil to the maximum depth feasible (minimum 0.5-1 ft.) and mounded to prevent formation of a depression where water can pond. Wastes will continue to degrade and consolidate in the pit for up to several years after pit closure.

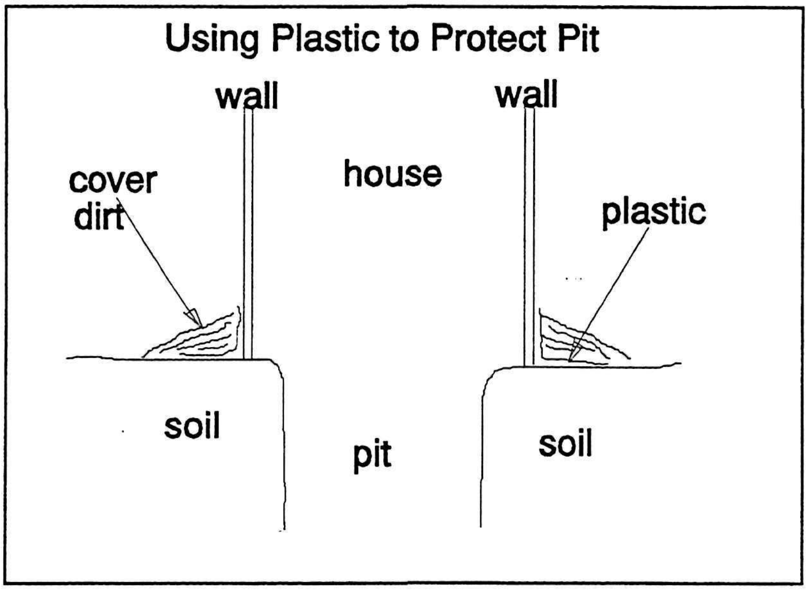

Figure 6. Proposed Toilet Pit Sealing Method

Comments on Pit Toilet Types and Recommended Repairs

Lack of pit toilet repairs is a problem at Mount Rainier National Park. There are five types of pit toilet structures in the park. They include:

1. *Unhoused toilets with small bases.* Upper and Lower Crystal Lakes pit toilets are examples. They are approximately 2' by 3' by 2' with a seat hole cut out of wood (no separate seat) and a seat cover. They are light but do not have a large enough base to be stable and are easily upset by overly large pits relative to base size or by animal holes that destabilize the base.

2. *Unhoused toilets with large bases.* The Snow Lake pit toilet is this type. They have roughly a 4' by 4' base with an aluminum seat and plastic seat cover and are stable and pleasant structures to use. The Snow Lake pit has a plastic seat that is currently (1992) not in working order.

3. *Housed toilets with poor ventilation.* Deer Creek Camp pit toilet is an example of this type. Gases from the pit rise into the structure and are trapped, making it unpleasant to use even if the seat covers are left down between uses. Housed pits are preferred in areas where use is high or cover is not available, but are typically so unsatisfactory to users that there is often ample evidence of non-use. These toilets should be eliminated or modified.

4. *Housed toilets with fair ventilation.* Lake George has a pair of this type of house. These are large, well-constructed structures which rely on vents around the roof eaves to provide ventilation through the house. If the vents are screened, this type of house functions well. The gases must pass through the house to vent to the atmosphere, but they do not tend to build up excessively unless heavily loaded with human waste. If the door does not close well, flies are attracted into the house -- making it less functional. Doors should either be equipped with springs or hung such that the doors swing shut automatically.

5. *Housed toilets with vent pipe.* Golden Lakes had this kind of house before a composting toilet system was implemented. The vent pipe allows the pit gases to escape to the atmosphere without passing through the house. The vent pipe is designed to warm in the sun and produce a natural convective draft within the pipe which draws out the pit gases. For this to work best, the vent needs to be on the sunny side of the house. The top of the vent must have a fly screen to trap any flies hatched in the pit that try to escape out through the vent pipe. Even if the house is not placed in the sun, a vent still provides some relief to odor and fly problems. Vented pit toilets have been used successfully in developing countries for years.

The variety of pit toilet structures in use makes it more difficult to specify standardized repair procedures. Each structural type requires its own specified repair measures. There are many common measures that can be taken. Frequently broken parts, such as seats, hinges, springs, and screens could be stocked, together with installation instructions. Standard parts and repair procedures can greatly improve the quality of the repairs made and therefore the functioning of the pit toilets. High-quality parts, such as solid wood seats and seat covers, should be the standard for all sites in the park.

MONITORING REQUIREMENTS

Many factors that affect the siting of pit toilets vary throughout the year. Therefore, good monitoring is required. Hydrological data should be gathered for each site throughout each year when sites are accessible. In particular, temporary flooding and surface runoff should be noted on regular reports for trailside camps. General pit and structure conditions, including depth to wastes, worn parts, and odor or fly problems, should be noted. Use of standard survey forms will facilitate monitoring. One recommended format is given in Appendix 2. Such use can produce both better communication of maintenance requirements and better site specific data.

ALTERNATIVE SYSTEMS FOR DISPOSAL OF HUMAN WASTES WHERE PIT TOILET SITES ARE UNAVAILABLE

Pit toilets are not the only disposal options available for human wastes in backcountry areas. Others options include cat holes, carry out bags, composting toilets, carry/compost toilets, ventilated pit toilets, mounded pit toilets, and peat-lined pit toilets.

CAT HOLES

An alternative to the use of pit toilets for human waste disposal is a no-pit system in which backcountry users make small "cat holes" or one-sit holes for waste burial (Meyer, 1989). Each user enters the surrounding forest and digs a small hole for personal one-time use. The advantage of this system is its low cost and the wide dispersal of wastes, taking advantage of the assimilatory capacity of the soil and natural vegetation. There are many disadvantages to the no-pit system. Backcountry user knowledge of pollution control is relied upon to insure proper placement of wastes so as to cause no water or health impacts. Areas encircling permanent camps become trampled and degraded as campers search out sites. This system is recommended for cross-country travel but not for trail camps or high-use areas.

An example of the no-pit waste disposal system relying on individual cat-holes is that at Forest Lake camp site. Extensive degradation of the surrounding area from overuse for waste disposal was observed. Potential water quality and human health impacts could result.

CARRY-DISPOSAL SYSTEM

Climbers and hikers using alpine zones at Mt. Rainier National Park are directed to manage their solid wastes in plastic bags ("blue-bag system") that are carried out and disposed in designated pick-up locations. This carry-disposal system is necessary in high elevations because low temperatures prevent significant degradation of solid wastes and also because of high trail and camp use. Human health is a primary concern from fecal contamination of snow and water. This system has the advantage of permanently removing the solid wastes from the alpine environment to a managed disposal system. Liquid wastes such as urine cannot be easily handled by a bagging system and are managed at alpine camps but not along trails.

The carry-disposal system of solid wastes management using plastic bags would be much more difficult to manage and enforce at lower elevations than for alpine zones and is also less necessary. Subalpine and forest zones have a widely distributed network of trails and camps where wastes are widely dispersed and where soils and vegetation are sufficiently developed to assimilate low quantities of wastes. Management of human wastes for prevention of nutrient and microbial contamination in surface waters is the primary concern in subalpine and forest zones.

VENTILATED TOILETS

Vent pipes may be added to housed pit toilets to vent gases directly from the pit to the outside atmosphere. Advantages of vent pipes are the reduction of odors which leads to less avoidance of use, and control of flies if vent pipes are screened at the top. It is recommended that all housed pit toilets be equipped with vent pipes, including the retrofitting of existing housed pit toilets.

COMPOST AND CARRY-COMPOST SYSTEMS

Composting systems are recommended for toilet locations where the water quality of surface waters (lakes, ponds, streams) cannot be protected by proper pit siting or where saturated soil conditions prevail (bogs, wetlands, springs, seeps, and ephemerally-inundated areas). The difference between composting and carry/composting systems is that the composting systems are one integrated unit for collection and waste composting, whereas carry-composting systems require transporting the wastes from toilets where they are collected to a separate composting bin where wastes are more easily managed.

The advantage of composting systems is that they capture the solid wastes and prevent direct groundwater pollution. They are very efficient at reducing the volumes of solid organic wastes by composting (aerobic decomposition) and often can function for many years without exceeding waste storage capacity.

The disadvantages of composting systems are their high maintenance requirements and their limited ability to handle liquid wastes. Maintenance entails; (a) weekly or twice weekly carrying of wastes to a compost bin, depending on use (for carry-compost systems) (b) addition of a carbon source (straw, peat, leaves) to aid in decomposition, and (c) stirring of the wastes to maintain aerobic conditions. Liquid wastes cannot be directly handled in the compost collection toilet system since oversaturation of the solid wastes inhibits oxygen transfer and aerobic decomposition, leading to anaerobic conditions and odor generation. Liquid waste contains nutrients (primarily ammonia-nitrogen from urea in urine) that should be managed separately.

An example of the carry-compost system is Golden Lakes campsite and ranger station (cabin). The collection container usually contains liquid wastes mixed with the solid wastes, causing an ammonia odor problem. One waste management problem at Golden Lakes is the ambiguous signage -- one urges campers not to leave the trail and the other urges campers to leave the trail to urinate.

To manage liquid human wastes, two possible alternatives are to use individual off-trail disposal, as at Golden Lakes, or to install a parallel system that would collect liquid wastes for separate disposal. Liquid disposal systems could be well suited for backcountry cabins and low-use camps. The intent of a separate liquid collection system is to contain liquid wastes for transport to a safe distance from surface waters in an area suitable for disposal onto the soil (use same criteria as for siting pit toilets). Individual off-trail disposal of liquid wastes should be accompanied by clearly written hiker/backpacker information and perhaps signs that provide guidelines.

MOUNDED-PIT TOILETS

Mounded pit toilets are used in areas where there is insufficient soil depth to provide the needed pit depth, volume, or distance to groundwater. Rocks and soil are used to create a mound encircling the pit. The toilet is constructed on top of and into this mound, allowing the pit to be deeper than it otherwise could have been. This procedure can add up to one-two feet to pit depth. In areas with moderately high ground water tables, mounding helps to prevent the pit from penetrating to the saturated zone. Landscaping may be required to maintain a more natural appearance. Pit closure is accomplished in a manner similar to that of conventional pits in which soil and rocks are infilled and mounded over the pit to allow for settling as wastes are degraded. Re-siting of pits in the same area will require construction of a new mound. Thus, mounded-pit systems may not be suitable for high-use areas if frequent re-siting is required.

PEAT-LINED PIT TOILETS

Peat liners for pit toilets have been recommended as a modification for the standard pit toilets (Nichols et al., 1982). Peat liners are installed at the time of pit construction. The liners help prevent the transport of phosphorus and bacteria to nearby waters. These liners kill bacteria by decreasing pH from the organic acids in the peat. Peat also adsorbs phosphorus decreasing its mobility. Liners thus provide additional protection against these potential pollutants but do not fully protect nearby waters. Use of peat-lined systems might be made where a higher degree of uncertainty exists in terms of soil structure and development for assimilation of nutrients and bacteria.

SUMMARY AND CONCLUSIONS

SUMMARY

The management practices presented have shown that pit toilet use in the backcountry camps of Mount Rainier National Park can be an effective form of human waste management. Water quality and ecological impacts can be a concern for pit toilets located in lake drainage basins or in areas continually subjected to saturated soil conditions.

The pit toilet strategies outlined for control of surface water quality and human health impacts rely on limited data and uncertain theoretical processes. Surrogate restrictions are used when influential parameters cannot be ascertained because of difficulty in experimentation or uncertainty in the information defining a process.

Uncertainty exists in the control of water quality effects from human waste disposal in pit toilets. Despite this uncertainty, pit toilets for human waste disposal are still preferred for their mechanical simplicity, relative ease of maintenance, and effectiveness for control of environmental and health impacts from human wastes. Composting toilets and other alternatives to pit toilets should be considered for use in locations where pit toilets potentially pose a water quality problem. Insufficient operational experience and a lack of data on performance of composting toilets and other alternatives currently exists at Mt. Rainier National Park to provide guidance for their implementation. Recent studies at other national parks (e.g., North Cascades) may help fill this information gap.

The standard pit toilet design for wilderness areas at Mt. Rainier National Park is the unhoused Wallowa structure. A stable, well-sealed base is required to lessen opportunity for fly and rodent entry or for erosion-caused breach in the base seal and runoff or snowmelt entry. A simple base-sealing method was proposed. The seat and stool structure should also be well-sealed, waterproof, and durable.

Design of housed pit toilet structures should include proper venting and a stable, sealed base. For optimum odor and fly control, the vent pipe should be located outside the structure and where solar exposure is maximized (usually the south side) to aid natural draft. Current pit toilet structures should be modified to conform to this recommended design.

Poorly maintained pit toilets are indirectly a potential hazard to water quality and human health by encouraging non-use of the facility. Many of the pit toilets visited for review were in need of maintenance and basic repairs. Establishment of standard designs with common repair parts and procedures could simplify maintenance practices and greatly improve the functioning of pit toilets as a system of human wastes disposal in the park. A standard pit toilet site review form has been proposed (Appendix 2).

CONCLUSIONS

The following conclusions were reached based on this study.

1. In saturated soil conditions, travel distances are increased and travel times are reduced for the nutrients and microorganisms found in human wastes compared to those for unsaturated soil conditions. Because of this possibility, pit toilets should not be sited in locations subject to persistent flooding or soil saturation.

2. Surface water quality impacts that could result from inappropriate location or inadequate design of pit toilets for human wastes disposal include nutrient enrichment, contamination by enteric organisms, and pollution from inappropriately disposed hazardous materials. None of these impacts has been specifically documented for Mt. Rainier National Park.

3. Guidelines for siting pit toilets should consider soil water conditions, ground water flow directions, soil types, local topography, the proximity, type, and use of potentially-impacted surface waters, human wastes loading rates, and proximity to users.

4. Composting toilets or other suitable alternatives to pit toilets should be considered where site location and conditions are such that potential water quality impacts cannot be mitigated using the siting guidelines.

5. Thirty percent of the pit toilet sites visited for review in Mount Rainier National Park require relocation of pits because of potential surface water quality impacts or because the pit has reached its capacity. Twenty percent need to be eliminated or replaced with alternative waste disposal systems because of water quality concerns. Greater than fifty percent of the pit toilets appear to be properly sited, functioning adequately, and are not potentially impacting surface water quality.

6. Maintenance or modifications are required on approximately seventy percent of the pit toilet structures visited for review in Mount Rainier National Park to optimize their function and use.

SUGGESTIONS FOR FUTURE WORK

Better understanding of degradation processes of human wastes in the pit toilet environment, the physical and chemical forms of degradation products, and the process of clogging the soil matrix are areas where future research could refine management practices.

The ecological impacts of the relatively small inputs of pollutants into sensitive, pristine streams and lakes is also an area where multi-disciplinary research could refine the assessments used in developing management techniques.

Ground water flow along preferential flow paths and its role in pollutant transport is an area of ongoing research (Jury et al., 1991). The influence of storm events in creating saturated soil conditions that greatly increase pollutant transport distances by allowing macropore flow to dominate are an area where field experiments can greatly increase present understanding of the processes involved. Continuous measurements of precipitation intensities, water table depths, and water qualities at several points down-gradient for a few selected sites can provide a empirical backing to the processes now hypothesized. Sites chosen for more in-depth study should be representative of conditions in various zones of the park. Potential sites include those at Deer Creek (forest zone) and Upper Crystal Lake (subalpine zone). Representative west-side sites should also be considered.

Amassing a data base of site hydrological characteristics such as location and type of seasonal waters and frequency of saturated conditions can make more complete site evaluations possible. This task can be accomplished as part of the regular reporting on pit toilet conditions that has already been recommended.

Compaction of soils and therefore increased surface runoff and erosion was noted at many trailside camps. In addition to contributing to nutrient addition (Marshall and Nelson, 1991), eroded soils can create turbidity problems, increase siltation, and degrade aesthetics. Preventative management techniques to control erosion should be implemented and studies undertaken to document effectiveness.

An education program directed at backcountry users is needed to provide information on improper methods for disposal of cooking fuel, wash water, and trash, in addition to human wastes.

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APPENDIX 1

EXAMPLE CALCULATION OF LAKE SENSITIVITY TO PHOSPHORUS

Example Calculation of Crystal Lake Sensitivity to Phosphorus Loading (Marshall and Nelson, 1991).

Calculate background P (phosphorus) levels:

P input from rain = 5 $kg/km^2/year$

P input from forest = 22 $kg/km^2/year$

lake surface area = 0.032 km^2

lake drainage area = 0.132 km^2

background P = (5 * 0.032) + (22 * 0.132) = 3.2 kg/year

Calculate P input by humans:

130 person use days (from backcountry use statistics)

assume 120 person use days from day and unregistered users

total use = 130 + 120 = 250 person use days/year

P production = 0.004 kg/person/day

Human P = (250 * 0.004) = 1 kg/year

Determine the response in steady state P levels in the lake:

S (lake sensitivity factor for Crystal Lake) = 1958 $year/km^3$

P_{ss} (P concentration at steady state) = (1 + 3.2) * 1958 * 10^{-3} $(ug/L)/(kg/km^3)$ = <u>8.2 micrograms/liter</u>

Effect of human waste input:

(1/3.2) * 100 = <u>31% increase P loading to lake</u>, or about 2 ug P/L in the lake.

APPENDIX 2

SITE AND PIT TOILET REVIEW FORM

Site and Pit Toilet Review Form

SiteName ______________________________

Date ______________ Reported by ______________________________

Condition of Facility	Yes	No	N/A	Action taken
House:				
holes through house into pit	y	n	n/a	________
seat in good working condition	y	n	n/a	________
seat cover in working condition	y	n	n/a	________
door spring working	y	n	n/a	________
door closing properly	y	n	n/a	________
screens in good order	y	n	n/a	________
Pit:				
holes around base into pit	y	n	n/a	________
trash in pit	y	n	n/a	________
water standing in pit	y	n	n/a	________
Flies around toilet	y	n	n/a	________
Surface water entering pit	y	n	n/a	________
Evidence of animal activities	y	n	n/a	________

Parts needed:

____

____

____

____

____

Site Observations:

Nearby seasonal streams or springs (include type, direction, distance, size):

____

____

____

____

____

Nearby wet site vegetation (include direction, distance, type):

____

____

____

____

____

Other observations or concerns:

____

____

____

____

APPENDIX 3

INDIVIDUAL SITE REVIEWS

Site Review Key

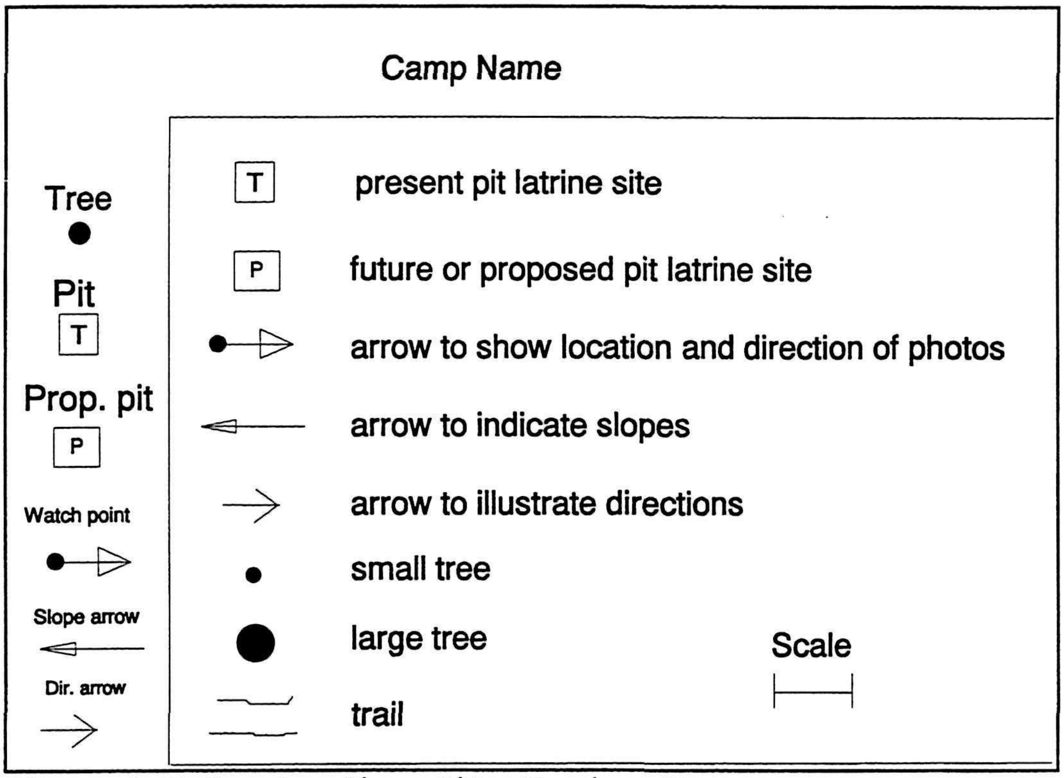

Figure 1 Understanding Site Review Maps

Site map locations can be recognized by using the symbols for trees and paths. All distances shown are approximate. Not all trees are shown on all maps. Site photographs are included in a photo album which was previously submitted to Mt. Rainier National Park (Mt. Rainier National Park files). Not all watch points shown on the maps are available in the photo album.

Recommendations for pit siting and use at each site are presented in the text and a short summary of the actions recommended is given below the text.

Recommendations for specific repairs that were needed at the time of review are given in the text. The categories used to define the magnitude of these repairs in the summary section of the report are given in the text below Table 3 in the report.

Berkeley Park

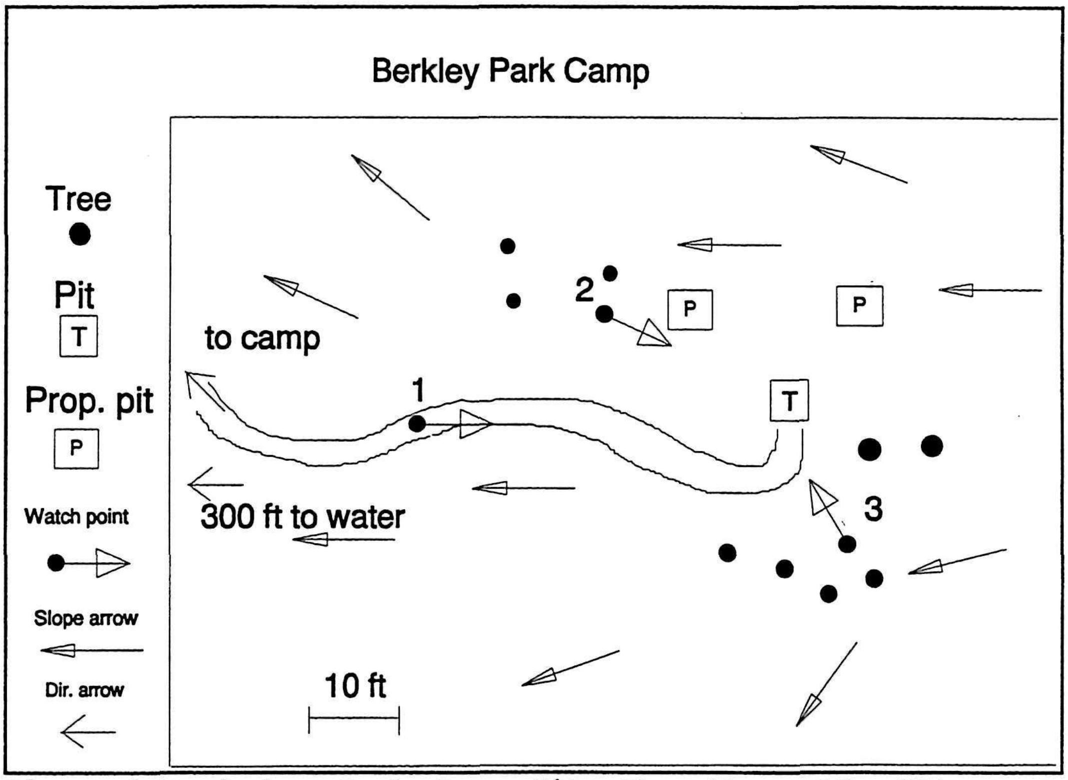

Figure 2 Berkeley Park Camp Site Map (Aug. 18, 92)

The pit is 300 feet uphill of a fast flowing stream used as a water source but contamination is unlikely because surface topography indicates water flow enters well down stream of the water source. Sites for future use are shown.

Gaps in the door and around the base are allowing extensive breeding of flies and should be repaired.

Recommendations:

- No resiting needed
- Major repairs

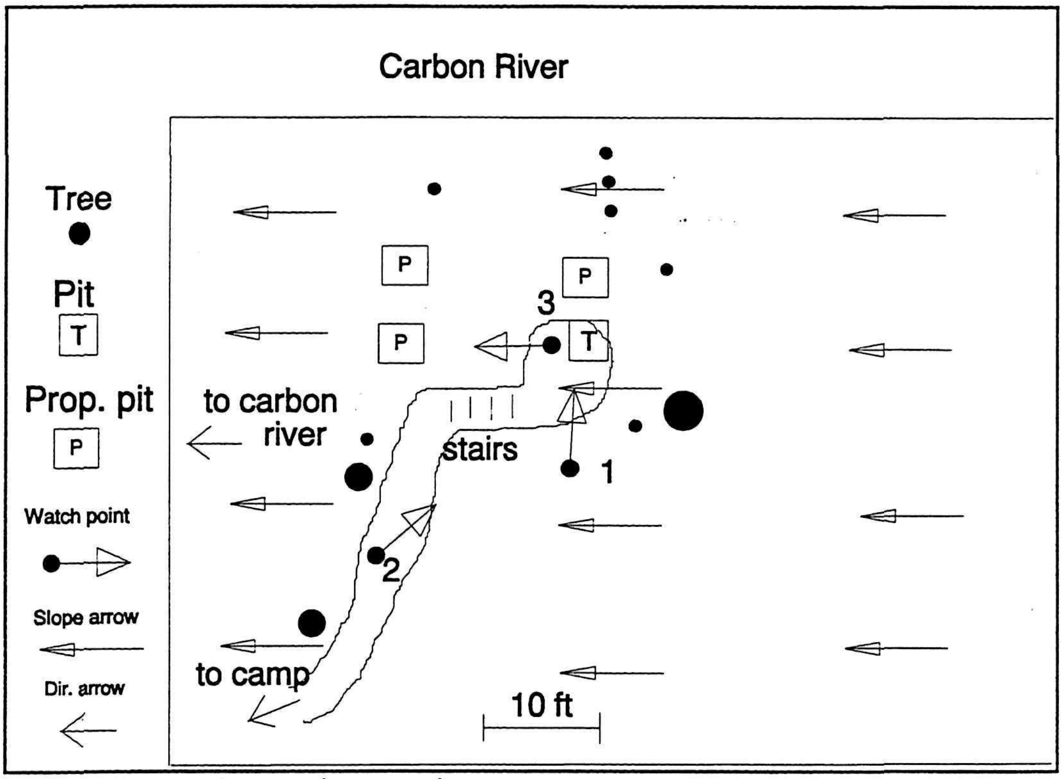

Figure 3 Carbon River Site Map (July 15, 92)

Carbon River Camp is several hundred feet from Carbon River which is large and in no danger from the pit toilet. Three future sites are shown.

Holes around the base require attention. The toilet seat could be turned around so that the user would not face toward the trail. This improves the comfort of users.

Recommendations:

- Resiting not needed
- Minor repairs

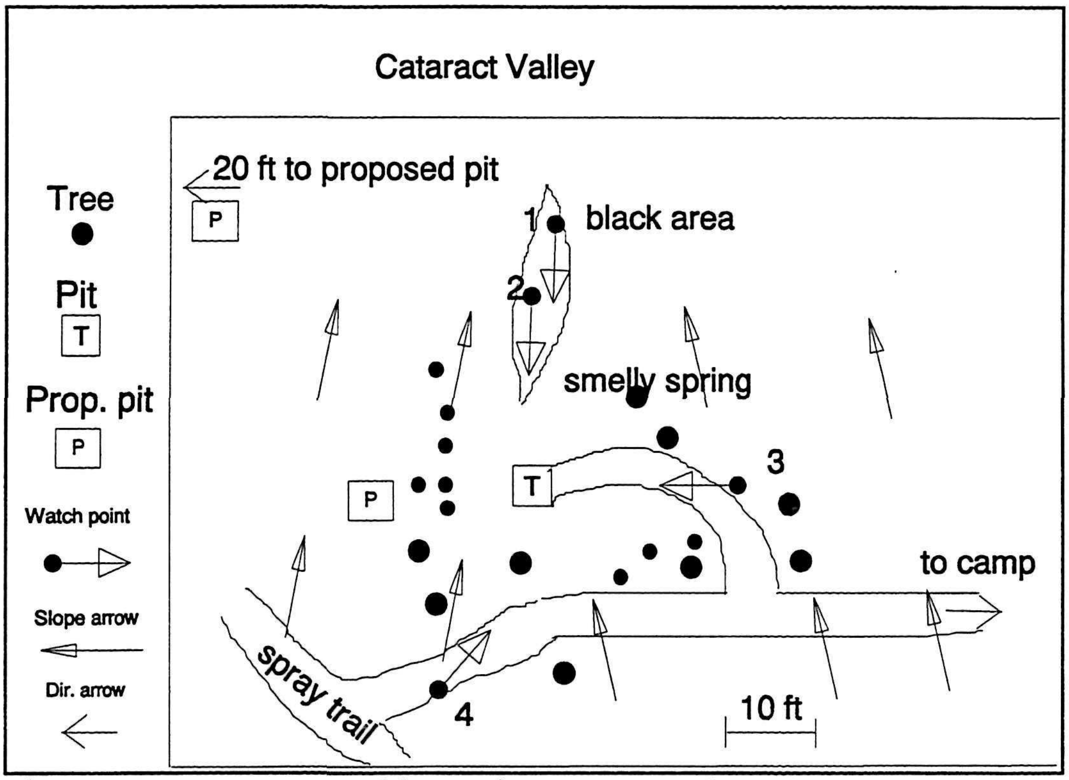

Figure 4 Cataract Valley Site Map (July 15, 92)

There are several marshy (wetland) areas near the pit. These indicate a high water table, however no water was noted in the pit. A foul-smelling spring downhill of the pit could have resulted from water routing through the pit. The pit should be relocated to one of the two pit sites shown on the site map to avoid contamination of the spring.

Holes around the base and in the structure need attention.

Recommendations:

- Resiting a low priority
- Minor repairs

Note: Groundwater was observed in the pit toilet during subsequent site visits in 1993 and 1994 by Park Service personnel. The southern site recommended for relocation (above) also had saturated soils during the 1994 visit.

Deer Creek

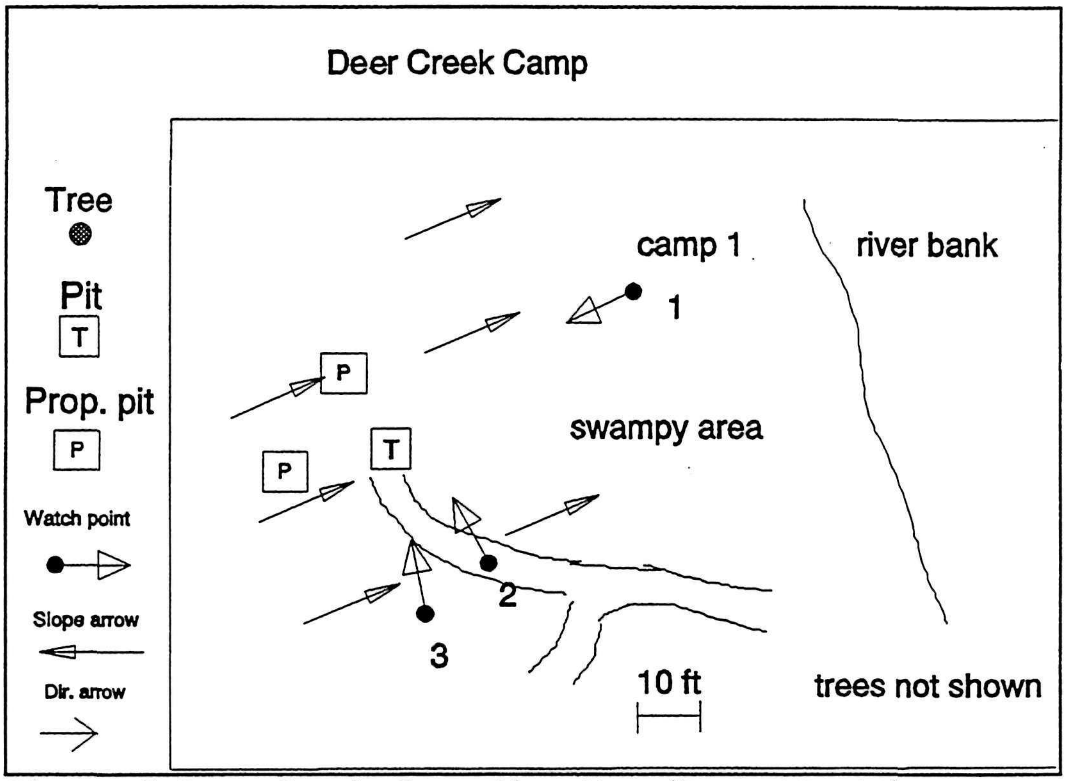

Figure 5 Deer Creek Camp Site Map (Aug. 17, 91)

Deer Creek Camp pit toilet is upslope of Deer Creek, but far enough away to be no danger to this large fast flowing river.

The structure is so very poorly ventilated that extra ventilation must be installed. There is ample evidence that campers favor use of the forest over use of the toilet.

Recommendations:

- No resiting necessary
- Major repairs needed

Note: Wilderness Plan states that some campsites should be moved farther from river. Pit toilet can be relocated farther from river and converted to Wallowa at this time.

Devil's Dream

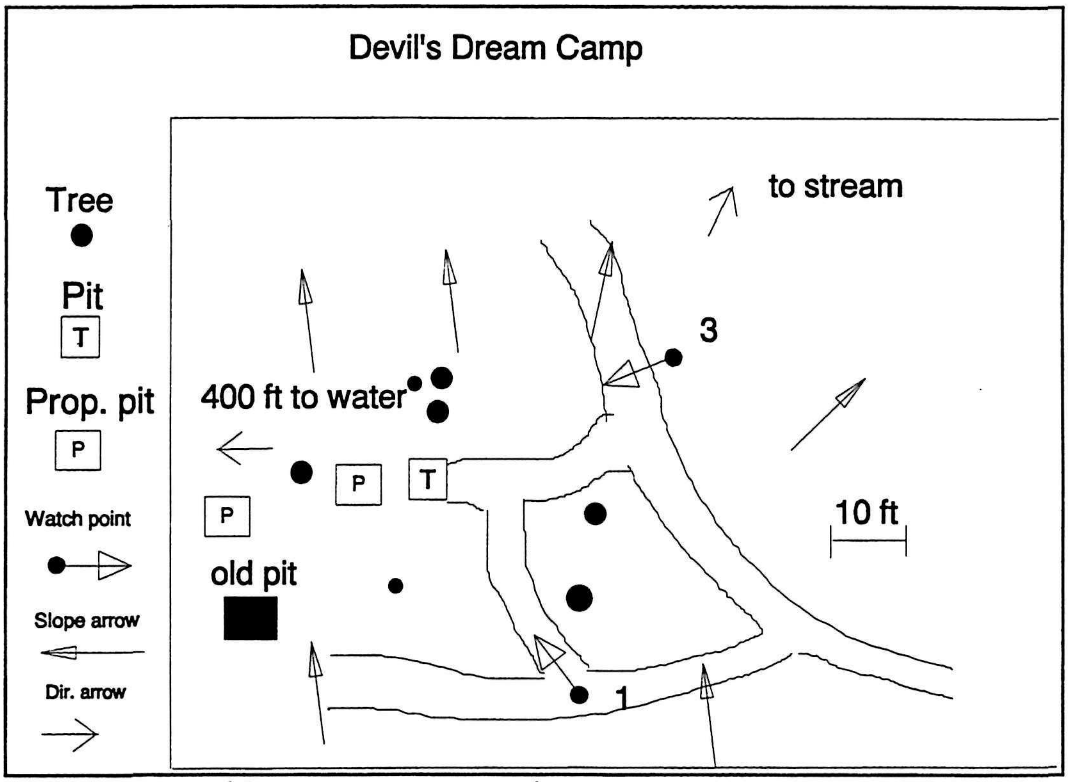

Figure 6 Devils Dream Camp Site Map (Aug. 23, 91)

Devils Dream Camp site is too far removed from surface waters to be a danger to surface water quality. Two sites for relocation are shown.

Recommendations:

- No resiting needed
- No repairs noted

Dick Creek

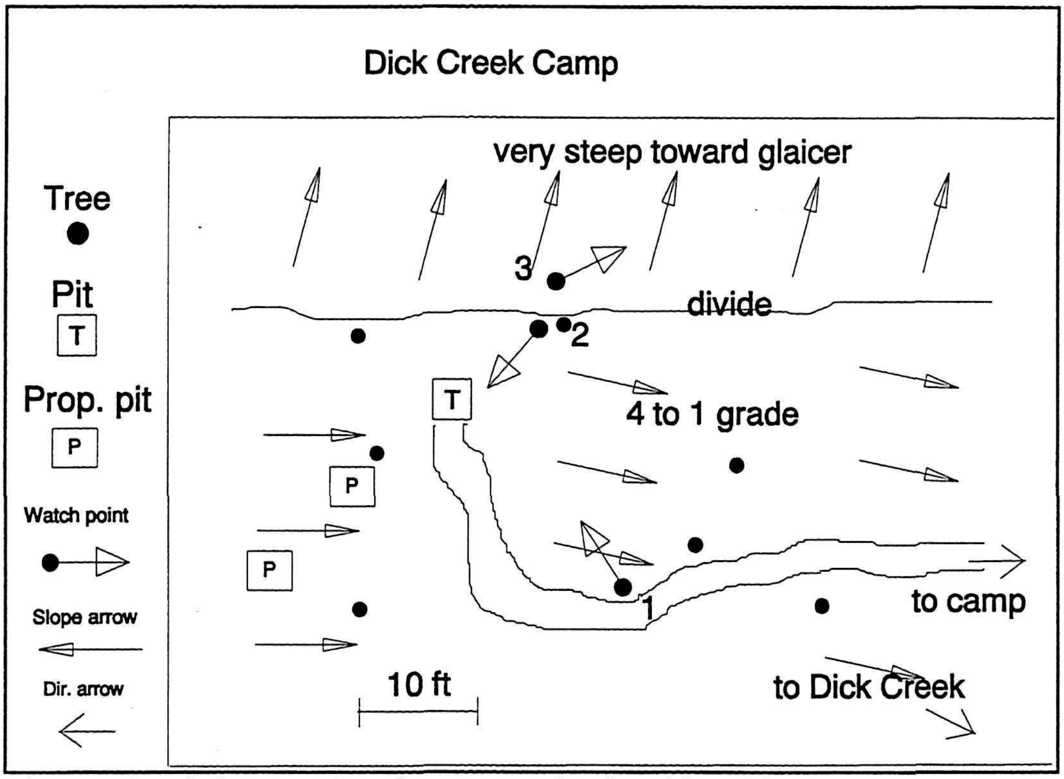

Figure 7 Dick Creek Site Map (July 13, 92)

Dick Creek pit toilet is in extremely rocky soil. The pit is built on a short base of stones. This construction method is a useful technique in shallow soils. Dick creek is a safe distance from the pit. A stream that travels along the edge of the glacier is 200 feet away and 100 feet below the pit, however this stream is large and considered safe from pit wastes. Future sites near the present pit are possible.

Holes in the base need attention.

Recommendations:

- Minor repairs
- Resiting not needed

Dick's Lake

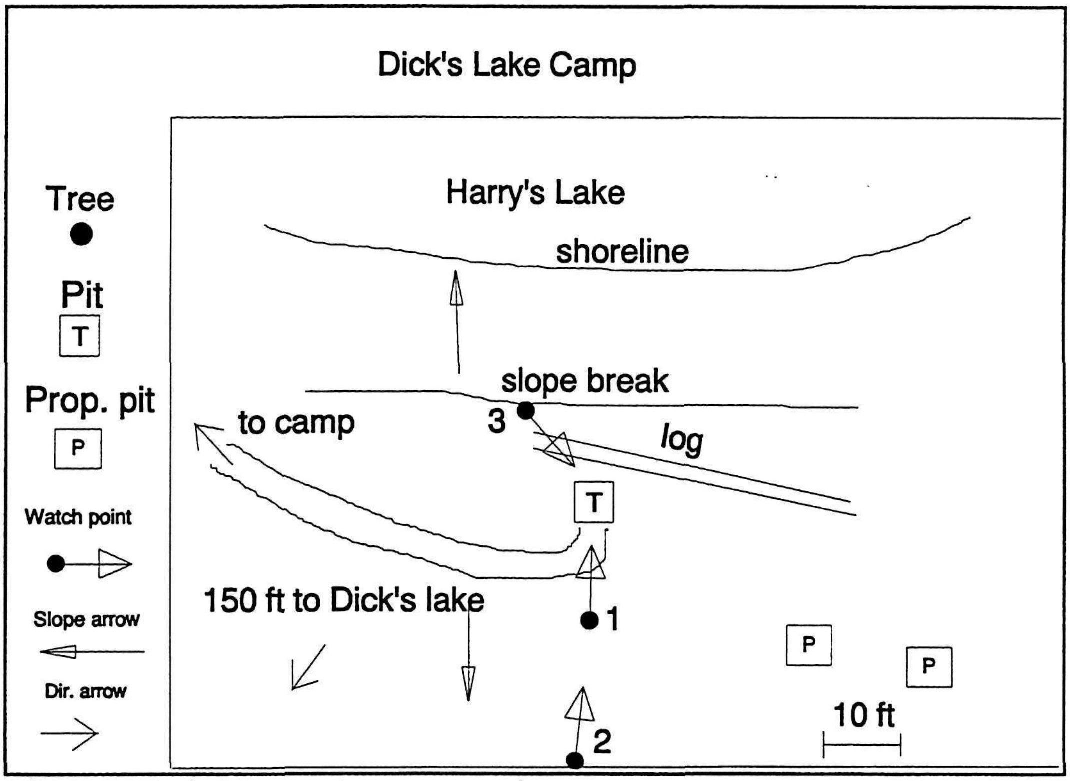

Figure 8 Dick's Lake Camp Site Map (Sept. 20, 91)

Ground water flow directions near the pit are unclear, but appear to be away from Harry's Lake, which is about 60+ feet from present site. In order to protect both lakes it is recommended that the pit be moved farther away from Harry's Lake as shown in figure.

Holes around the base need repairs.

Recommendations:

- Resiting a low priority
- Minor repairs

Note: Wilderness Plan indicates need to relocate campsite farther from Harry's Lake and pit toilet can be relocated at same time.

Eagle's Roost

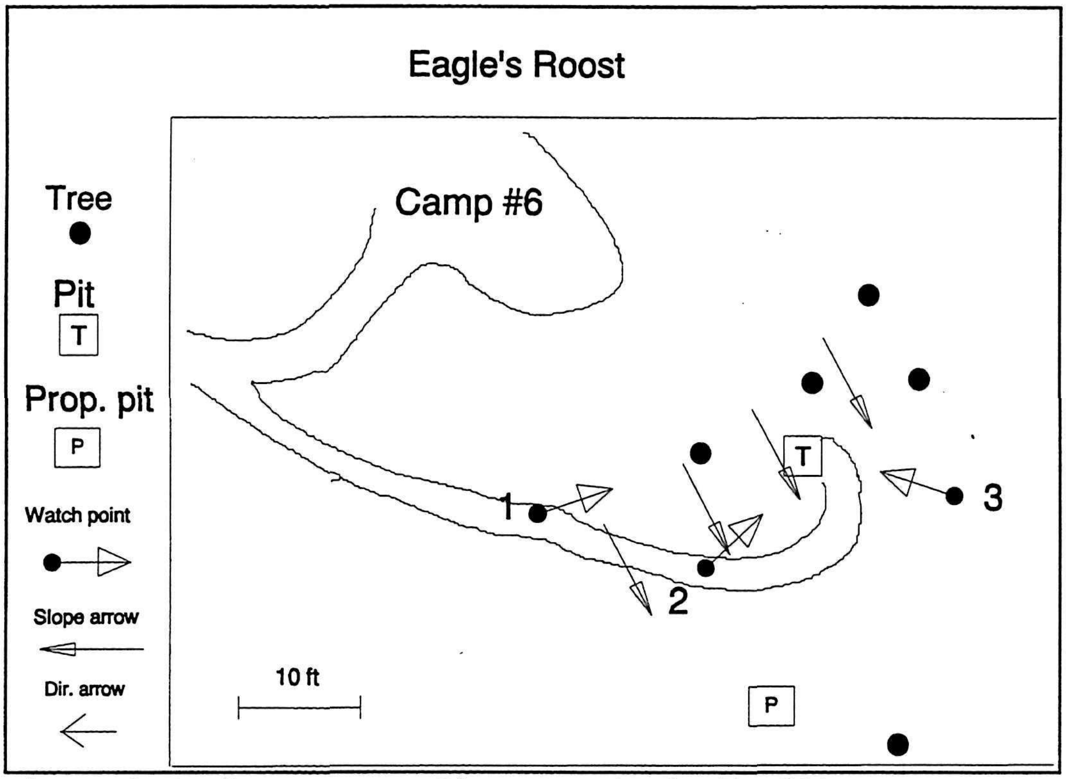

Figure 9 Eagle's Roost Site Map (July 7, 92)

There are no nearby surface waters to Eagle's Roost Camp site. The pit was full when reviewed and needs to be resited.

The toilet structure was in a state of disrepair. It appeared to be in danger of collapsing, and there were several large holes around its base leading directly into the pit. The seat was also cracked.

Options for relocation are limited by availability of a large enough level area. One possibility is shown on the map and another option is to resite in an existing camp site.

Recommendations:

- Resiting needed immediately (pit full)
- Major repairs

Note: Observations of groundwater in the pit toilet have been made frequently in the past by Park Service personnel, most recently during Sept. 1994. The relocation site proposed above was investigated, and groundwater was found at 27 in. depth.

Fire Creek

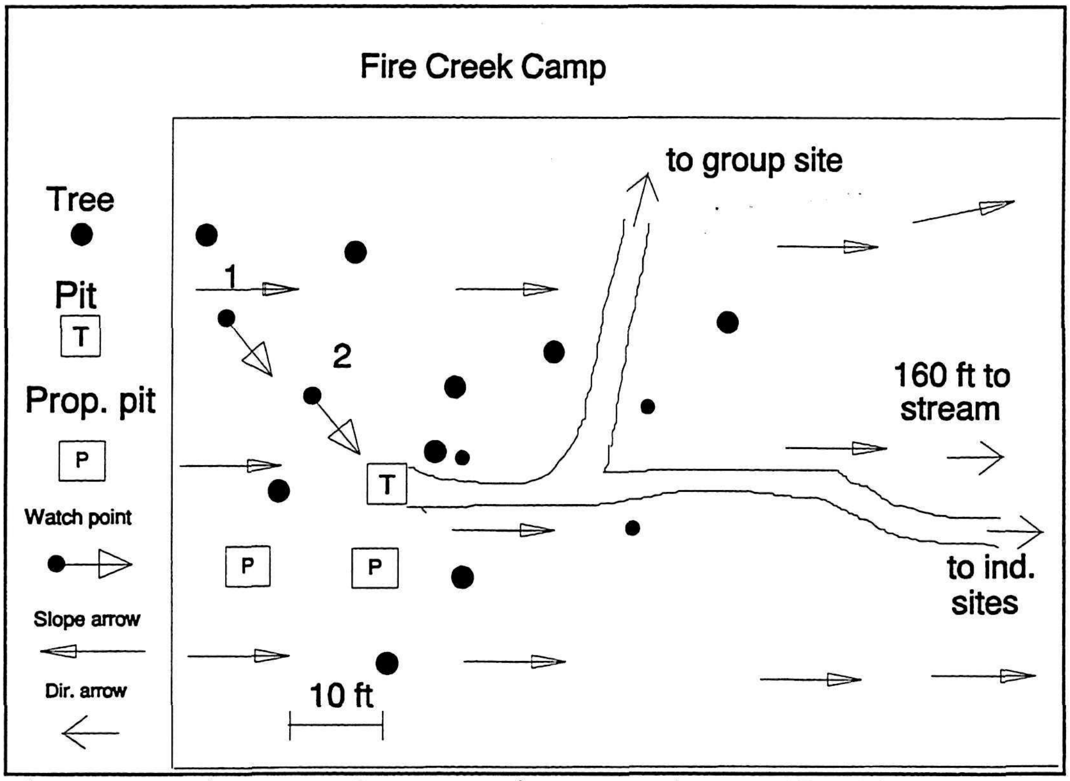

Figure 10 Fire Creek Camp Site Map (Aug. 17, 92)

Fire Creek pit is 160 feet uphill of a stream which is used as a source for campers. Ground water flow directions make contamination unlikely.

A large assortment of garbage, including a gas can, were found in the pit. Needles from the surrounding trees have fallen on the base of the toilet and are causing extensive decay, however the toilet was otherwise in good order.

Recommendations:

- No resiting needed
- Minor repairs

Forest Lake

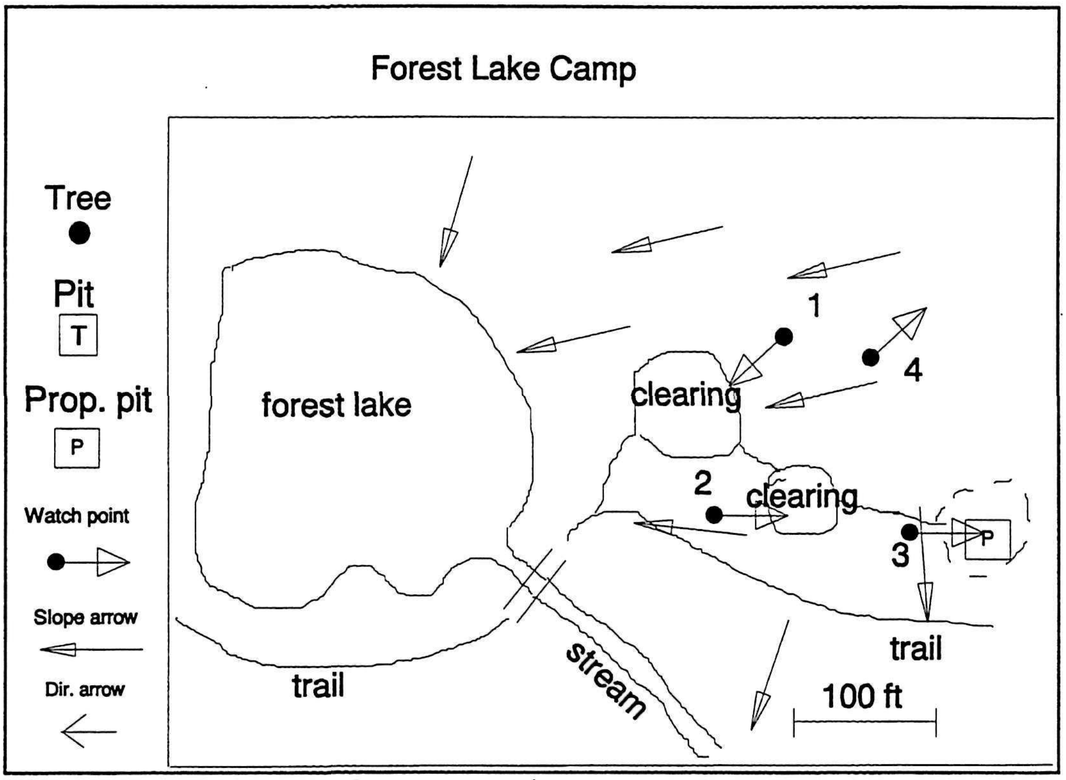

Figure 11 Forest Lake Camp Site Map (Aug. 11, 92)

There is no pit toilet at Forest Lake Camp and the impacts of this practice are clear. A pit should be constructed in the area shown on the map. It should be more than 150 feet from the stream and out of the drainage basin of Forest Lake. This site is the most immediate danger for water quality pollution in the Park.

The forest area surrounding the camp needs work to repair years of degradation caused by hikers.

Recommendations:

- Siting needed
- Repairs to forest

Glacier Basin

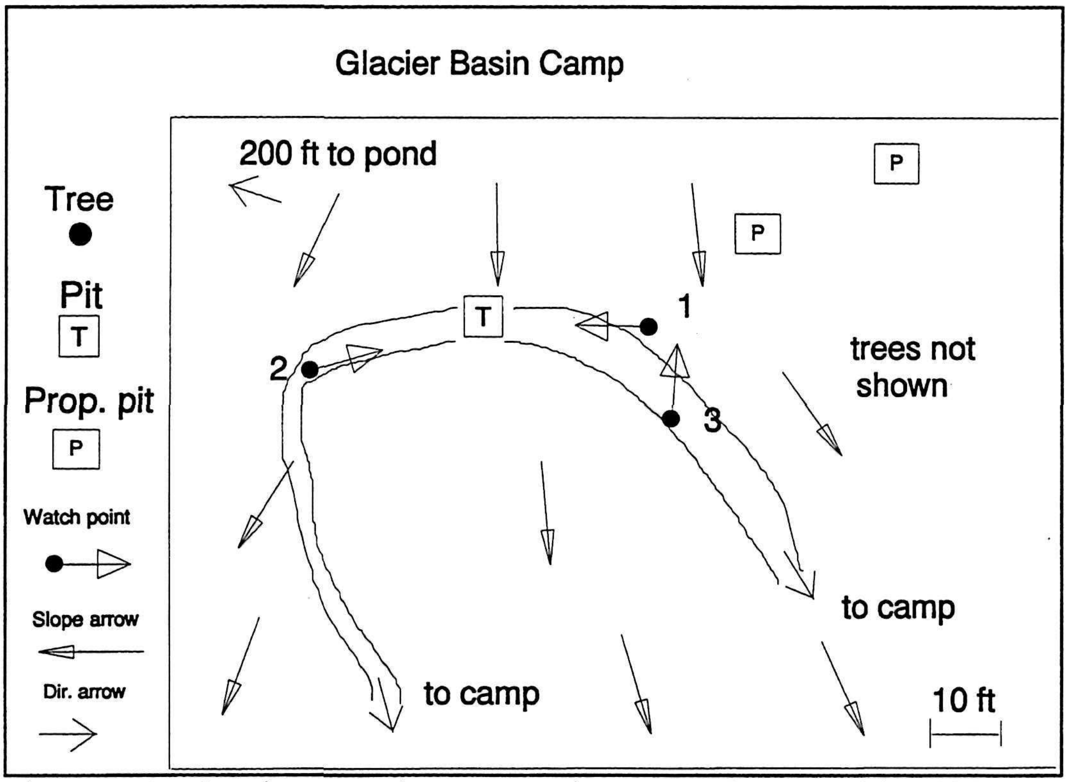

Figure 12 Glacier Basin Camp Site Map (Sept. 20, 92)

The direction of ground water transport of pollutants from the pit toilet is uncertain but could be toward the nearby pond in its present location. Relocation to a site farther from the pond would ensure non-impact.

The many large holes around the base of the toilet should be repaired.

Recommendations:

- Resiting a low priority
- Major repairs

Golden Lakes

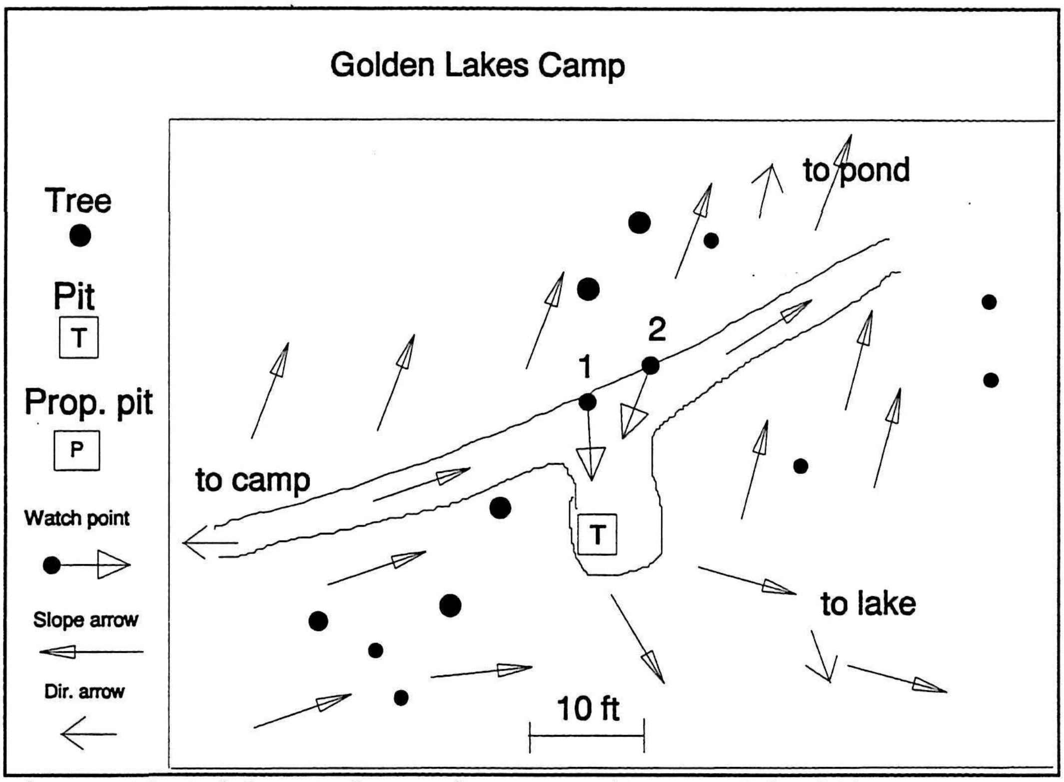

Figure 13 Golden Lakes Site Map (Sept. 16, 91)

An experimental carry/compost disposal system was installed at Golden Lakes Camp one year before this review. Carry/composting toilets are described under alternative human wastes systems.

Recommendations:

- Develop management techniques for Compost toilets
- Resiting not necessary

Note: Groundwater had been observed in the pit toilet at Golden Lakes Camp for several years. It appears that the toilet was situated on a perched water table; consequently, the experimental compost system is being studied at this site.

Granite Creek

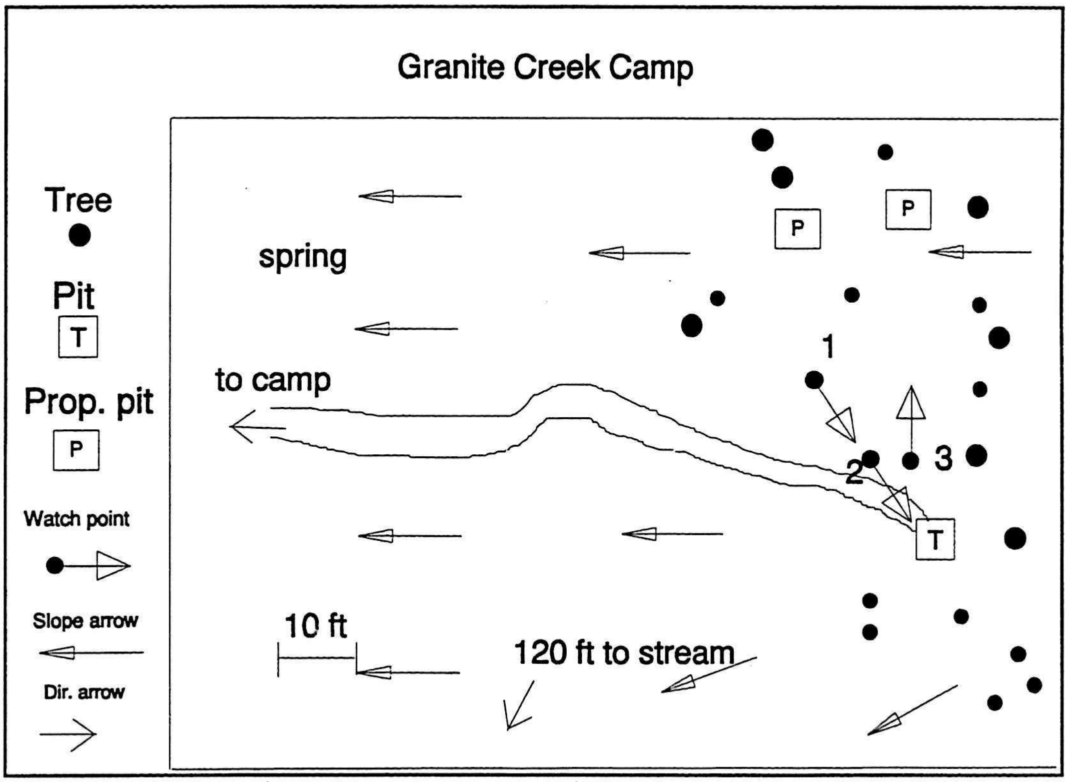

Figure 14 Granite Creek Camp Site Map (Aug. 19, 92)

The pit is 150 feet from a stream. A small spring close by indicates a locally high water table although no water was found in the pit. Pollutant transport to the spring is possible but spring flow was trivially small and not considered important as a water source. The pit was full and sites for relocation are shown.

Holes around the base were allowing fly access to the pit and should be repaired.

Recommendations:

- Resiting needed, pit full
- Minor repairs

Indian Bar #1

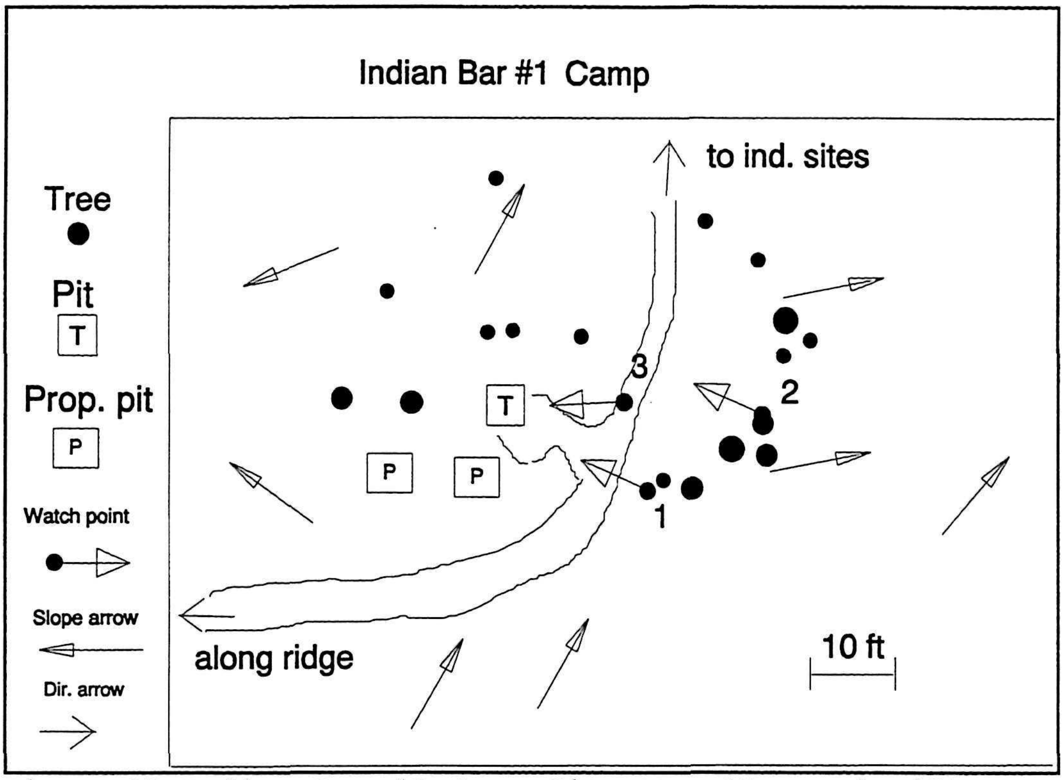

Figure 15 Indian Bar #1 Camp Site Map (Sept. 9, 92)

This pit serves the individual campsites at Indian Bar. It is approximately 1/8 mile from the camp and is well located so that no waters are in danger of pollution.

The seat cover is broken in half and holes around the base need to be repaired.

Recommendations:

- No resiting needed
- Major repairs

Indian Bar #2

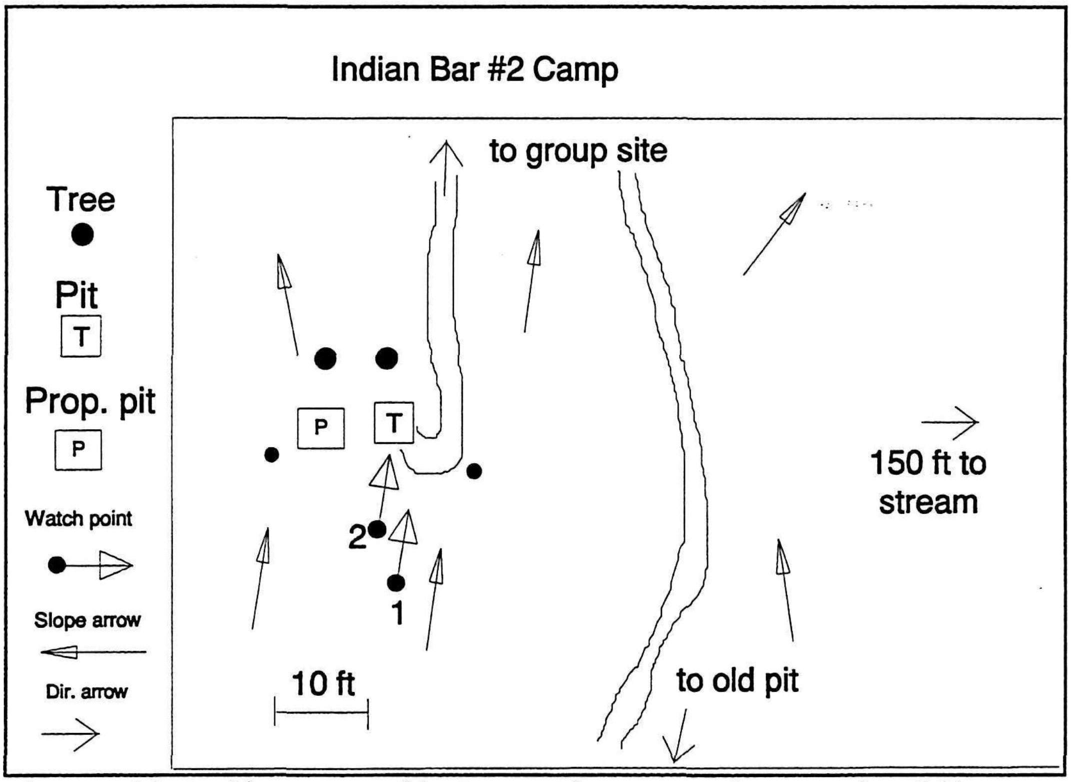

Figure 16 Indian Bar #2 Camp Site Map (Sept. 9, 92)

This pit serves the group site at Indian Bar and is 125 feet uphill of a stream. Surface topography make it unlikely that the stream receives waters which have passed through the pit. The pit was full and should be relocated in the site shown or farther uphill in the old pit site.

The toilet was in good condition except for a hole in the wooden base of the seat.

Recommendations:

- Resiting needed, pit full
- Minor repairs

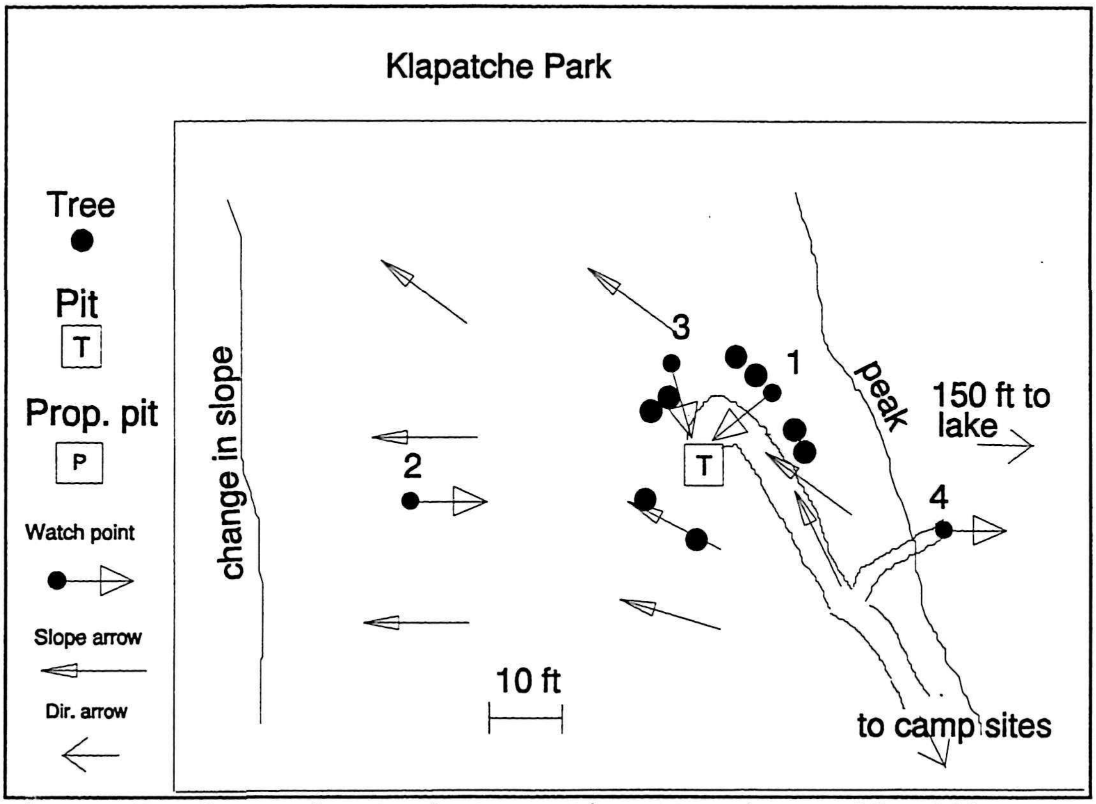

Figure 17 Klapatche Park Camp Site Map (Aug. 23, 91)

The present site is less than 200 feet for the lake, but the lake is apparently safe because the pit is 25 feet beyond the crest of the ridge between the lake and the pit. Underground seepage travels away for the lake.

Efforts should be made to insure water does not pond near the pit.

Future pits could be placed near the present one. There are several places which could provide adequate cover. To insure the underground seepage does not travel to the lake future pits should be placed 25 feet farther from the lake.

Recommendations:

- Low priority for resiting
- No repairs

Kotsup Creek (Proposed)

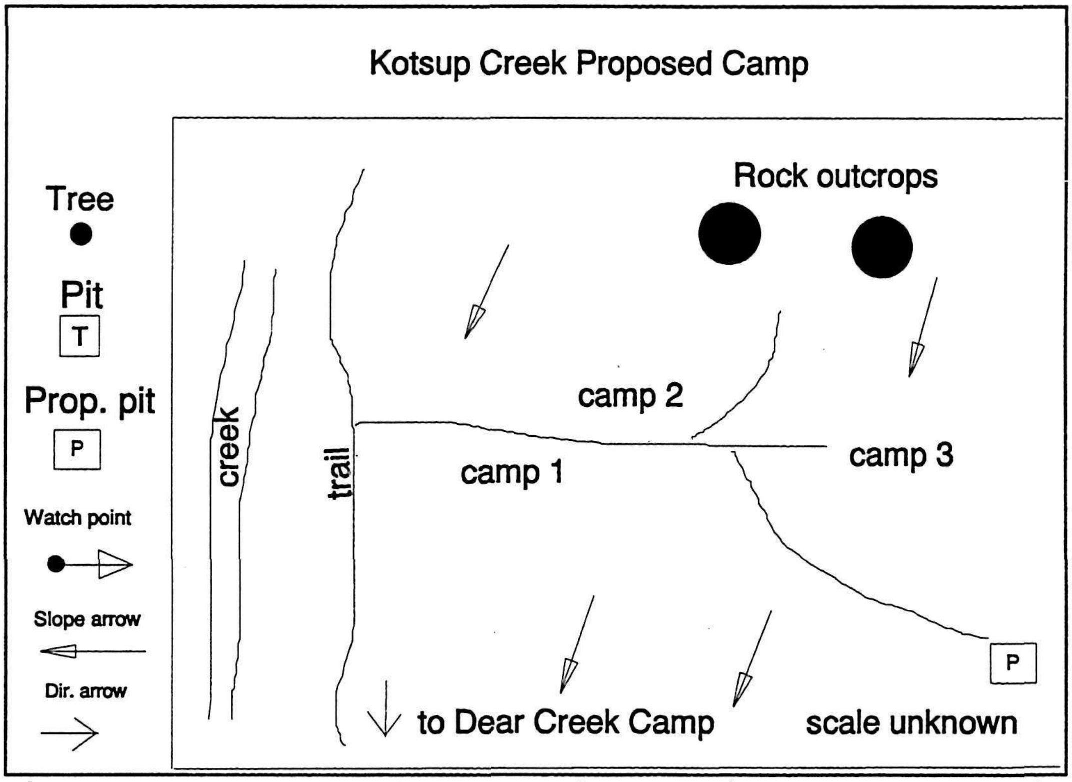

Figure 18 Kotsup Creek Proposed Camp Site Map (Sept. 13, 92)

Kotsup Creek Camp is a proposed campsite near Deer Creek Camp. There is no danger of contamination of nearby waters; all are several hundred feet distant. A proposed site for the pit is shown.

Recommendations:

- Siting possible

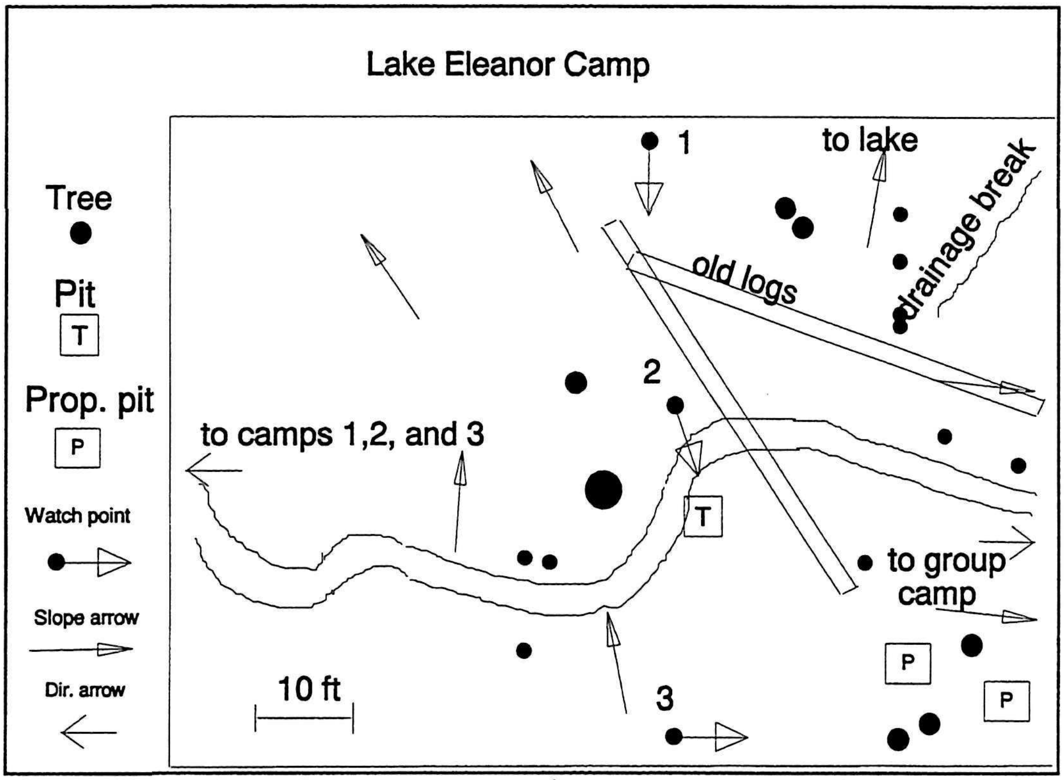

Figure 19 Lake Eleanor Camp Site Map (Aug, 16, 92)

The ground water flow direction near the pit is unclear. It is possible, but uncertain, that water is flowing toward the lake and therefor the pit should be resited. Safer locations are shown for resiting.

Holes down into the pit should be repaired and the broken seat should be replaced.

Recommendations:

- Resiting a low priority
- Major repairs

Lake George

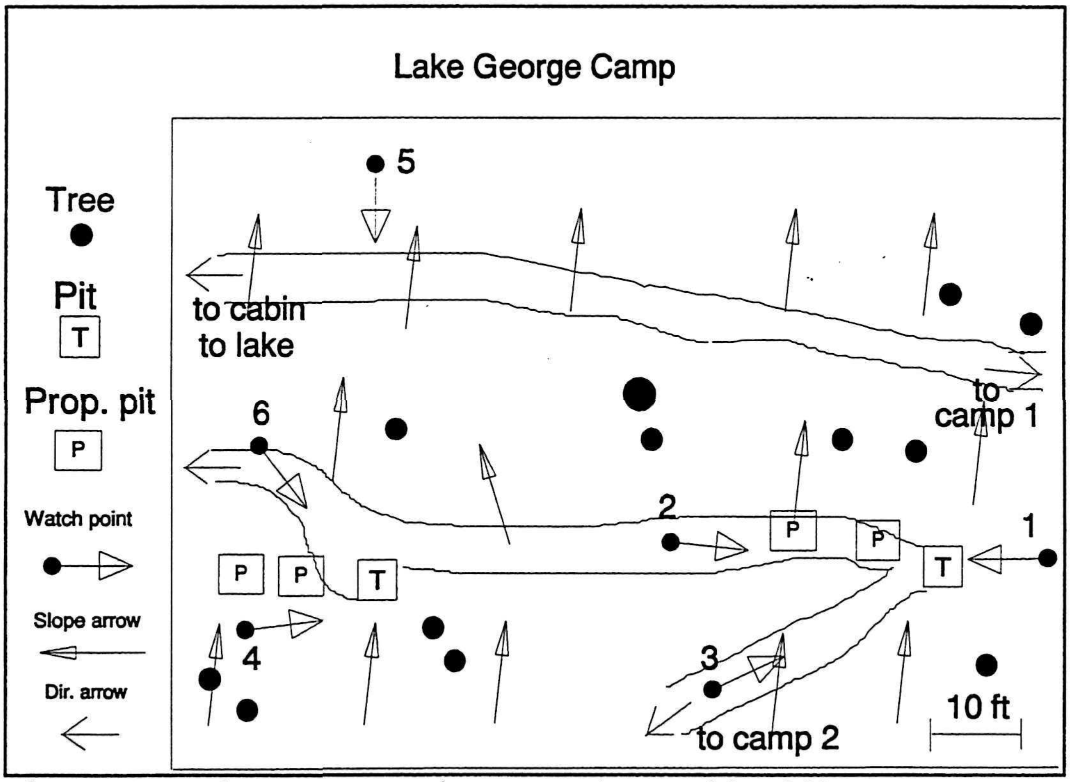

Figure 20 Lake George Site Map (June 20, 92)

The two pits used at Lake George are well placed and underground water flow is away from the lake. There was no apparent signs of water in either. Two potential resiting locations are shown for each.

Both toilets were well maintained although one had a significant amount of garbage.

Recommendations:

- Resiting not needed
- No repairs

Lower Crystal Lake

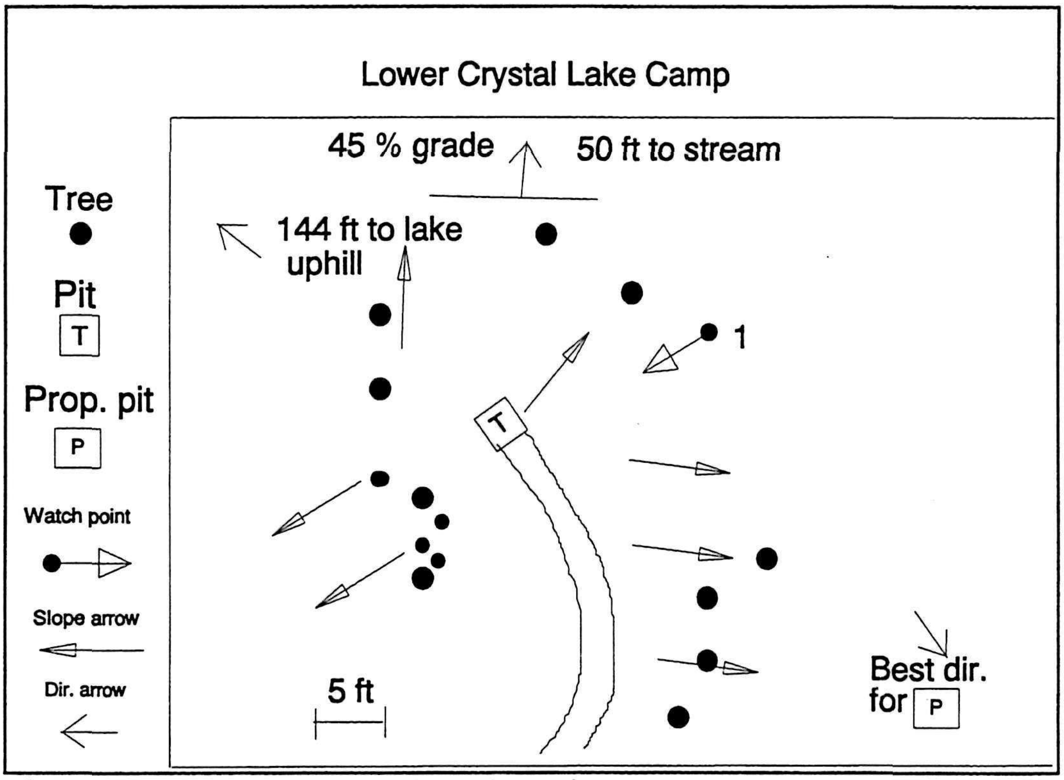

Figure 21 Lower Crystal Lake Site Map (Sept. 15, 91)

Lower Crystal Lake pit toilet is downhill of the lake. The only water quality concern is the nearby stream. This stream is used as a water source uphill of any point that pit wastes can enter and is not a problem. Future pits should be sited farther downhill and away from the stream to insure water quality.

The pit was in good condition and will not need resiting for some time.

Recommendations:

- Pit resiting not necessary
- No repairs

Maple Creek

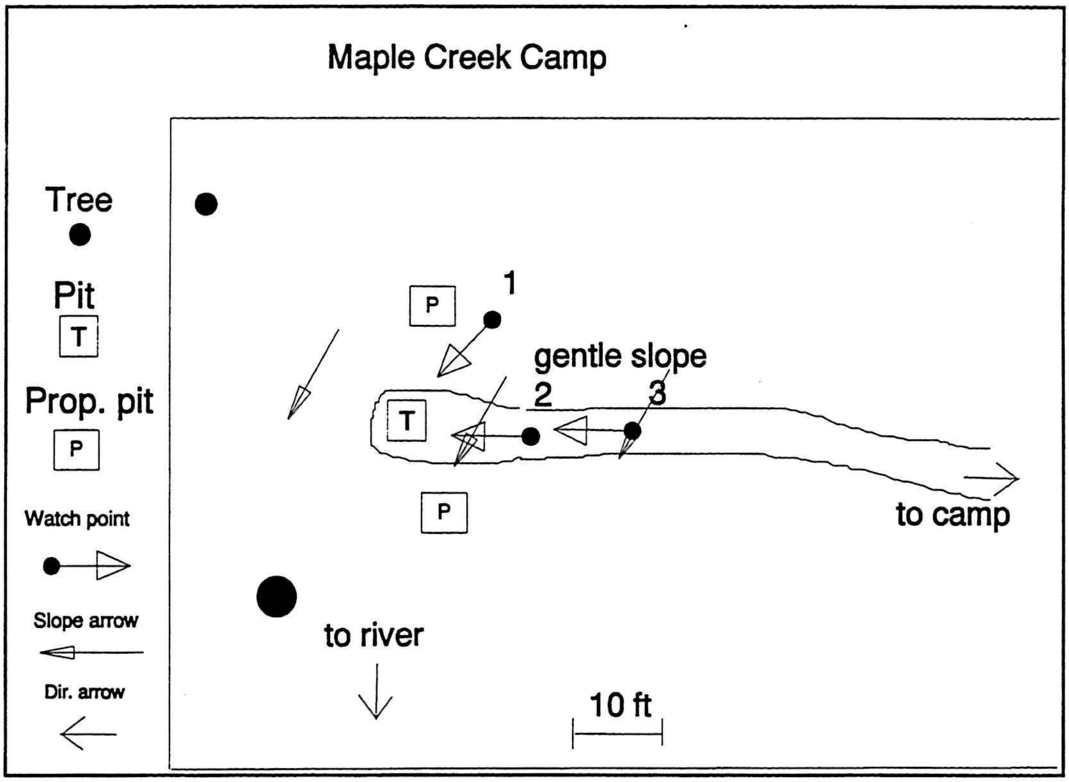

Figure 22 Maple Creek Site Map (June 22, 92)

The pit for Maple Creek Camp is more than 100 feet from Stevens Creek which is a large fast flowing stream and in limited danger. The present site is acceptable and a future relocation site is shown.

A poor fitting seat has turned the pit into a breeding ground for flies.

Recommendations:

- Resiting not necessary
- Major repairs

Mowich River (north)

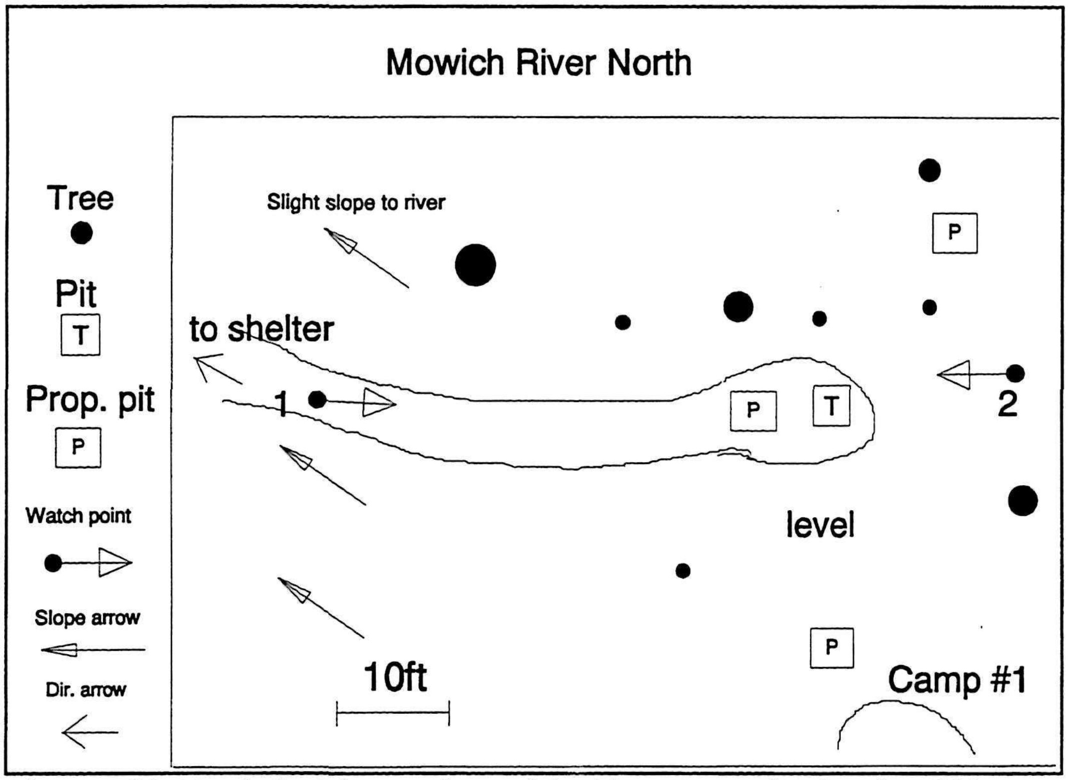

Figure 23 Mowich River (north) Site Map (July 8, 92)

Mowich River Camp has three pit toilets. Mowich River Camp (north) is the most northern. All are in the floodplain of Mowich River. There are a significant number of river rocks showing through the ground surface around the campsite. Mowich River is large and in no danger. A shelter and one campsite are served by this pit and the wastes are at a low level.

The house was in good condition but upgrades are needed to make it fly proof.

Recommendations:

- Resiting not necessary
- Minor repairs

Mowich River (middle)

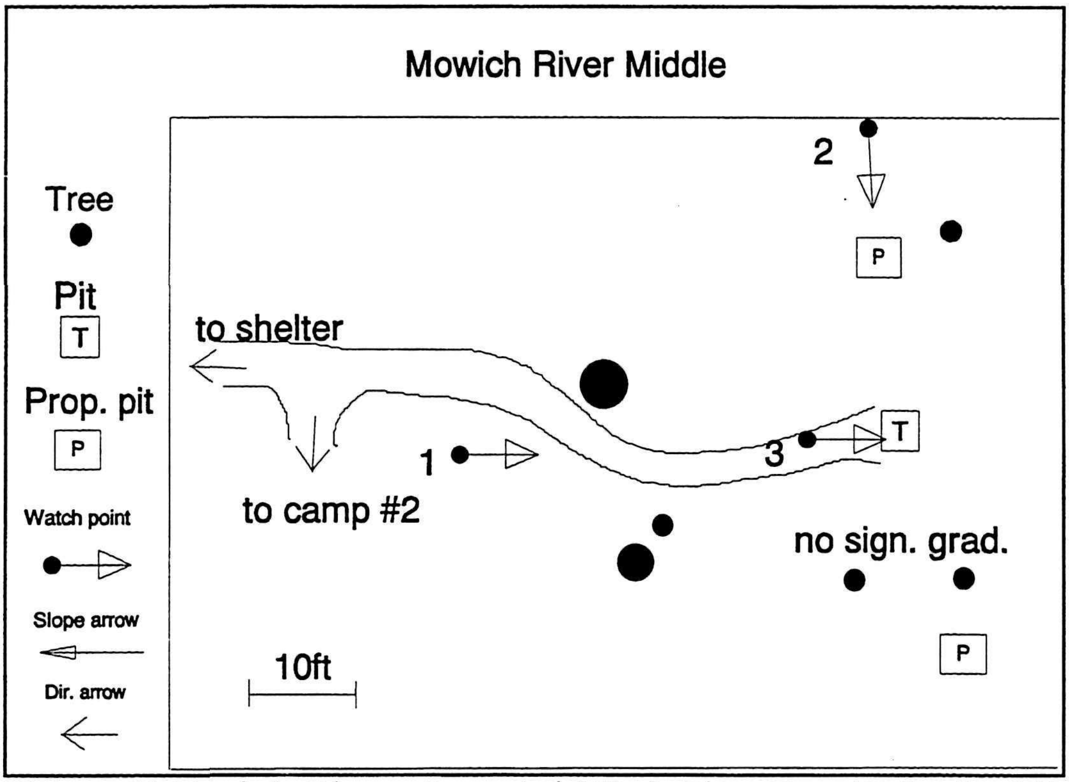

Figure 24 Mowich River Camp (middle) Site Map (July 8, 92)

There is a small stream near the pit but it is not a water quality concern because there is no gradient toward the stream. The wastes were low in the pit. Possible relocation sites are shown.

The seat and the screens for the house need to be replaced.

Recommendations:

- Resiting not needed
- Minor repairs

Mowich River (south)

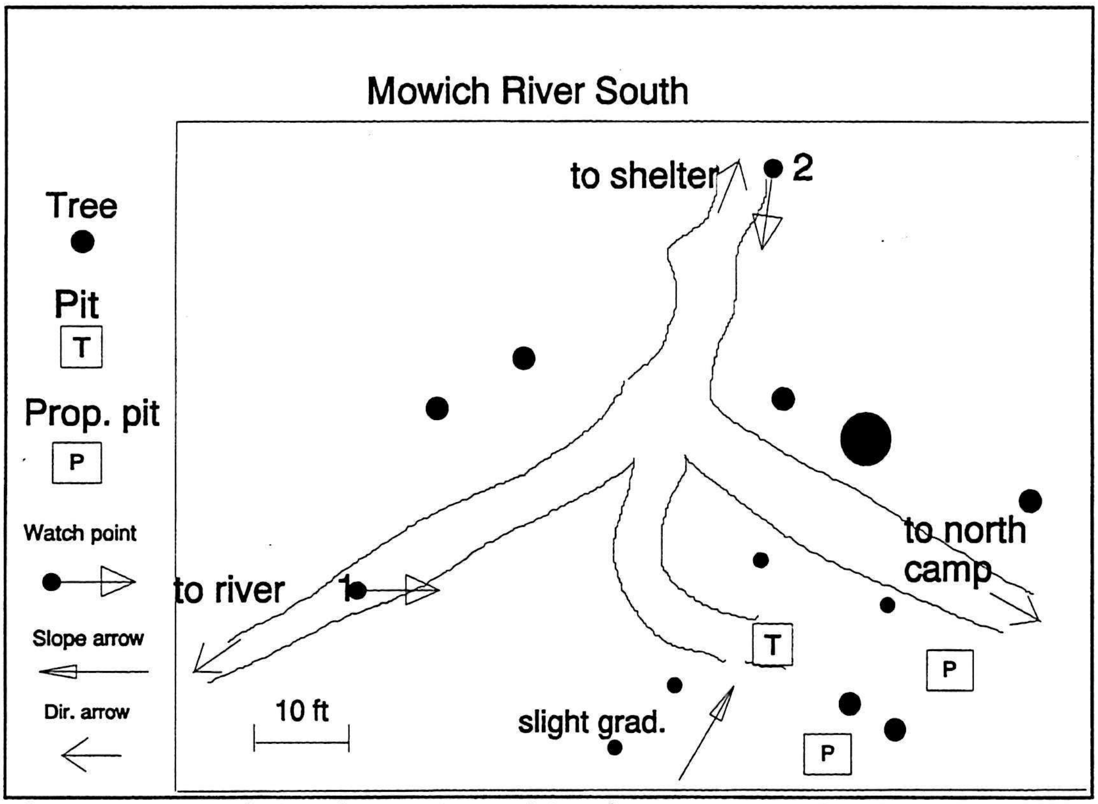

Figure 25 Mowich River (south) Site Map (July 8, 92)

This pit does not pose a threat to water quality due to the size of the nearby rivers. Resiting locations are shown.

When reviewed the seat and cover were broken and fly screens were needed.

Recommendations:

- Major repairs
- Resiting not necessary

Mystic Lake

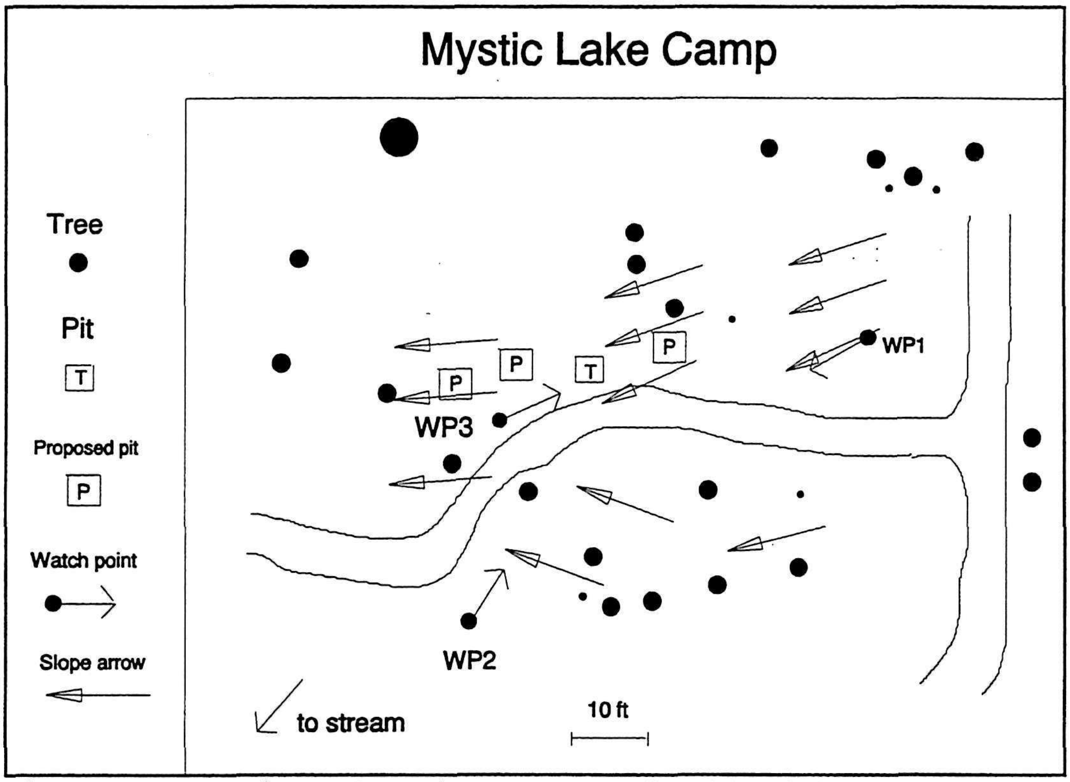

Figure 26 Mystic Lake Site Map (July 14, 92)

Mystic Lake Camp is downhill of Mystic lake. A stream approximately 300 feet from the pit is not considered a problem because topography indicates ground water flow directions parallel to the stream. Surface water runoff from trails is a potential problem and steps should be taken to insure runoff water does not flow directly into the pit.

At the time of the review flies and odors from the pit were a significant problem. There were holes directly into the pit and the door of the house was not closing properly. The wastes in the pit were 3 inches above ground level and the pit should be relocated immediately to one of the three relocation sites shown.

Recommendations:

- Resiting needed immediately (pit full)
- Major repairs

Nickel Creek

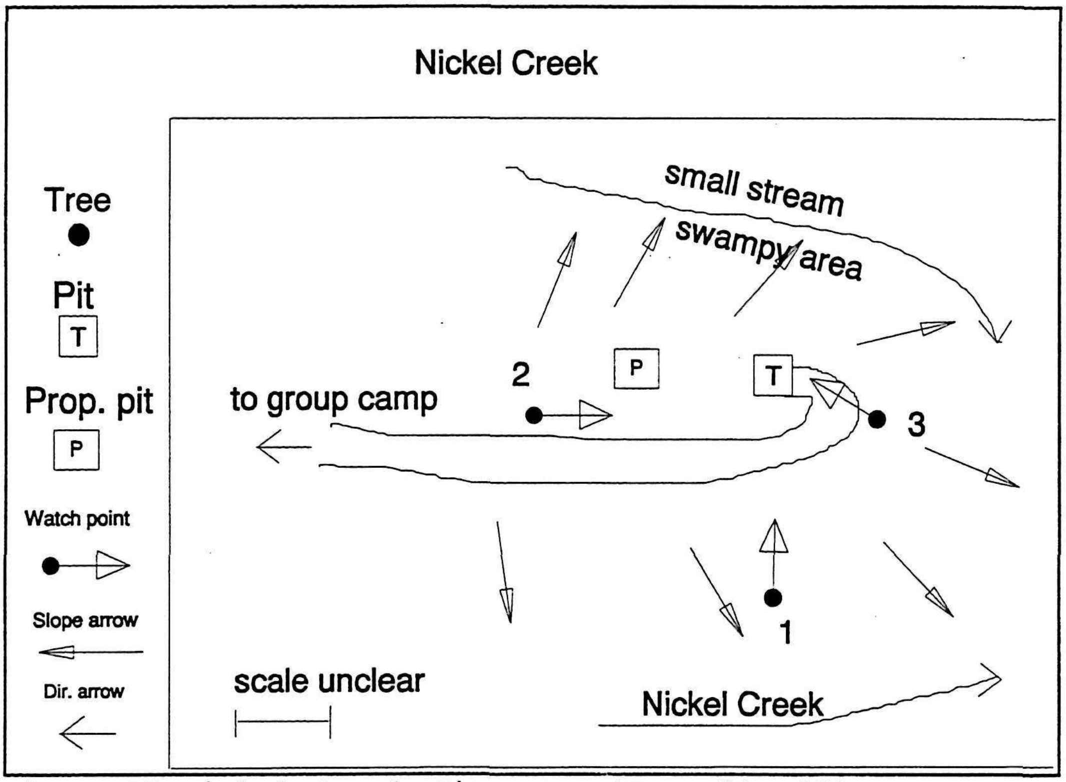

Figure 27 Nickel Creek Site Map (June 21, 92)

The Nickel Creek camp pit is on a wedge of land between Nickel Creek and a small stream. These waters could potentially be affected, although Nickel Creek is a large stream. The small stream is not a source of water for the campers. However, a domestic drinking water intake is located immediately downstream of this site. A swampy area near the small stream could also potentially be affected. There are no signs of water in the pit. The present location should be studied further as potential surface water impacts are unresolved. A proposed new site is shown.

There was garbage in the pit and the house had holes around its base leading directly into the pit.

Recommendations:

- Resiting under study
- Minor repairs

North Puyallup

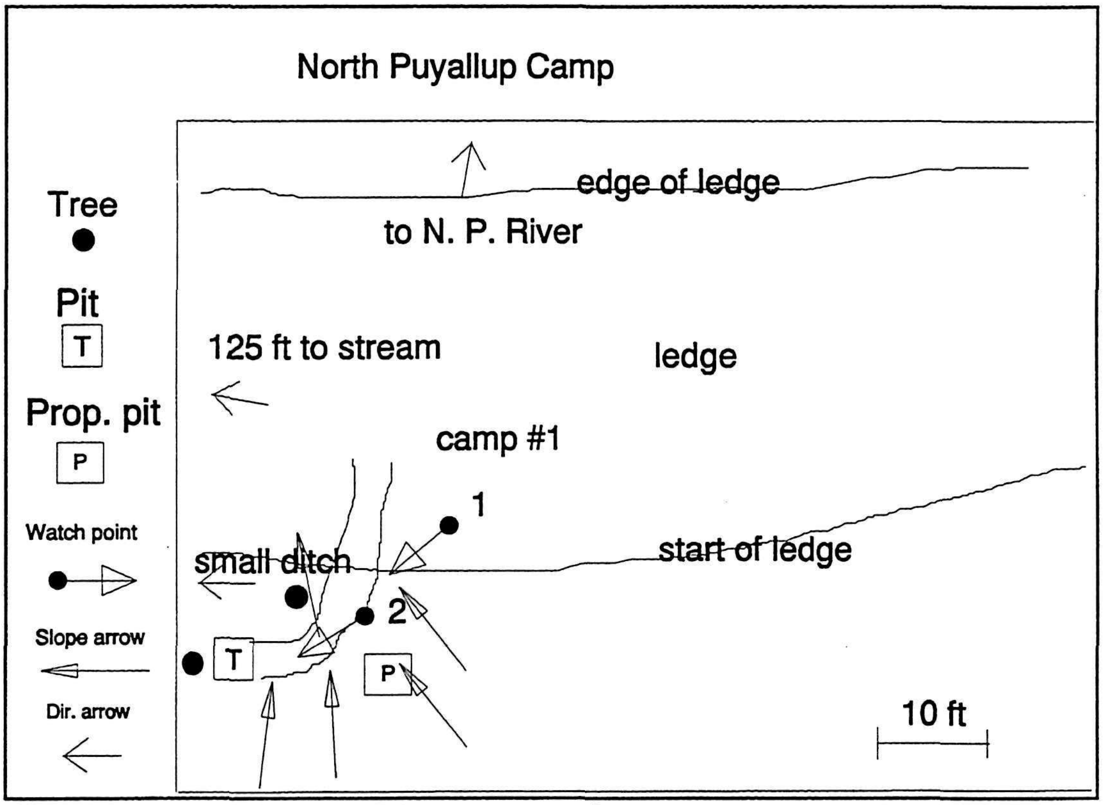

Figure 28 North Puyallup Camp Site Map (Aug. 19, 91)

Placing a pit on the camp ledge is not a recommended because the ledge, built as a road, was probably designed to have good drainage and therefore does not make for an ideal site.

It is recommended to place the new site 10 feet west of the present site. This leaves the pit in an undisturbed soil position but would require some work to level the spot and additional work to insure no surface water can pour directly into the new pit.

Recommendations:

- Resiting not needed
- No repairs

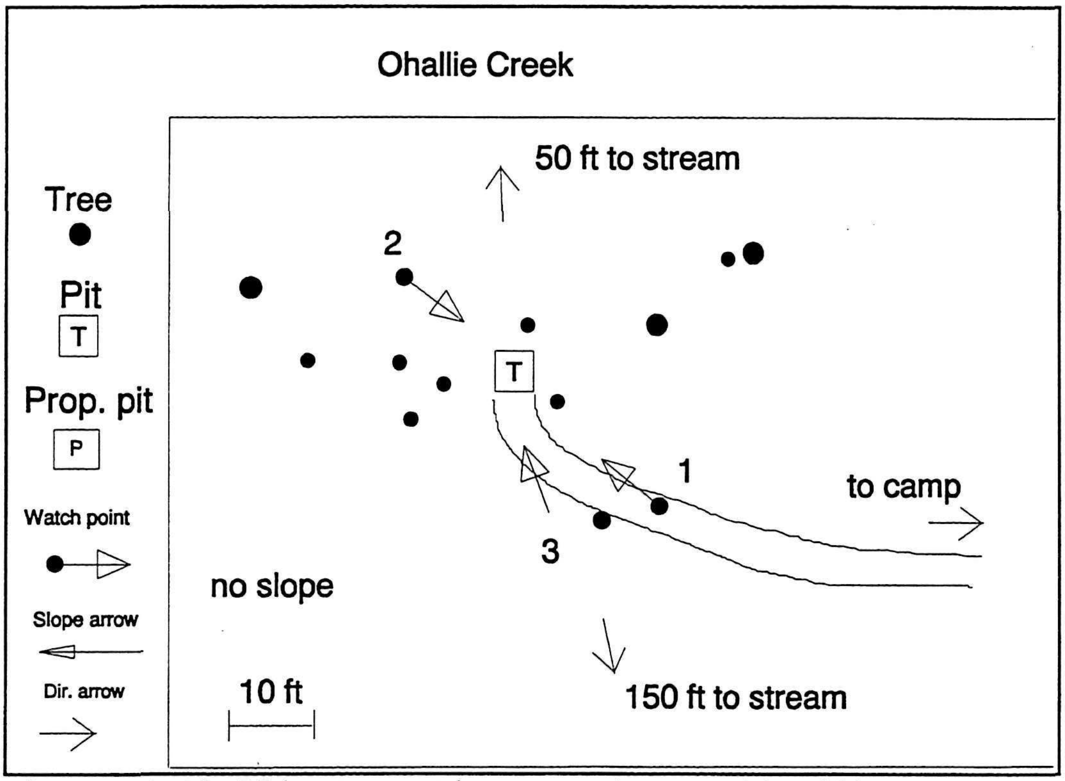

Figure 29 Olallie Camp Site Map (Sept. 10, 92)

The gentle slope encompassing the site makes water quality impacts in either of the nearby streams unlikely if unsaturated conditions hold, however the pit was flooded when reviewed. Future monitoring should gage the extent and frequency of flooding and relocate accordingly.

The toilet was clean and in good repair.

Recommendations:

- Resiting under study
- No repairs

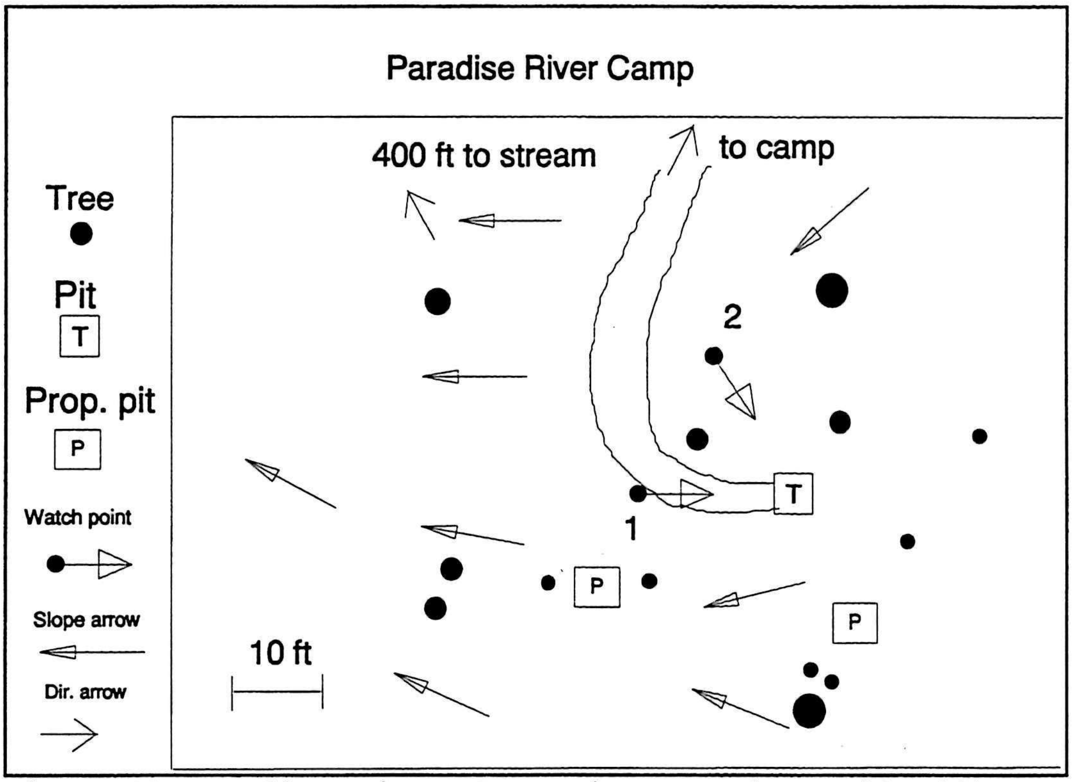

Figure 30 Paradise River Camp Site Map (Aug. 20, 92)

There are no waters likely to be impacted by this pit toilet. Although no water was seen during this survey, groundwater has been frequently observed in this pit. Study of site conditions should continue to determine if resiting is necessary. Sites for future pits are shown.

The toilet was in good working condition with only one small hole penetrating to the pit.

Recommendations:

- Continue to study site conditions
- Minor repairs

Pyramid Creek

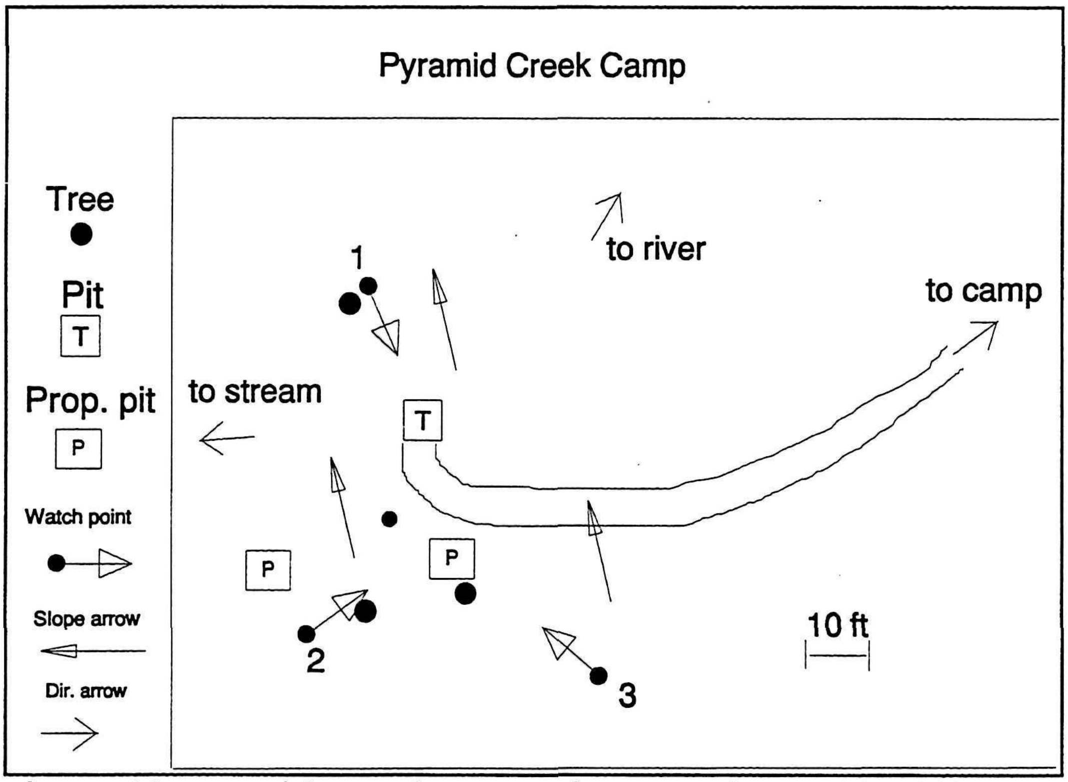

Figure 31 Pyramid Creek Camp Site Map (Aug. 25, 91)

The nearby surface waters are in no danger from Pyramid Creek pit toilet because there is little gradient to the ground surface and Pyramid Creek is large and fast flowing. A location for resiting is shown on the map.

Recommendations:

- No resiting needed
- No repairs noted

Shriner Peak

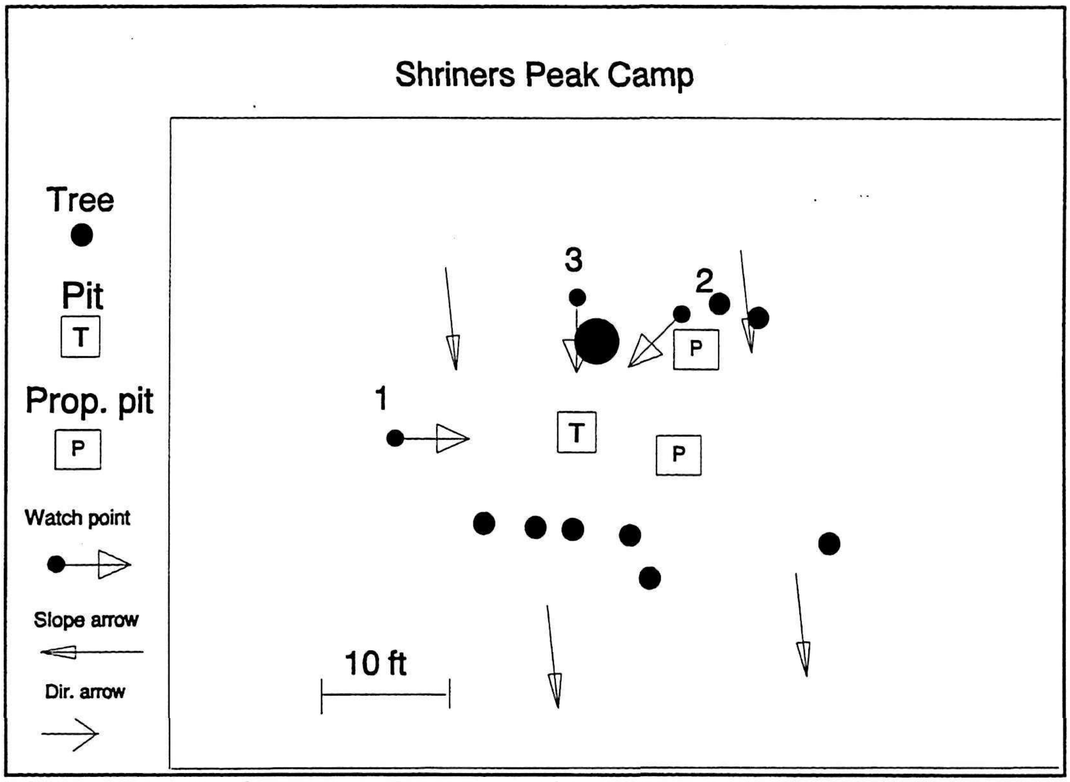

Figure 32 Shriner Peak Camp Site Map (Sept. 12, 92)

Shriner Peak Camp has no nearby waters therefore water quality is not a siting concern. Future sites are shown.

The broken seat should be repaired.

Recommendations:

- No resiting needed
- Major repairs

Snow Lake

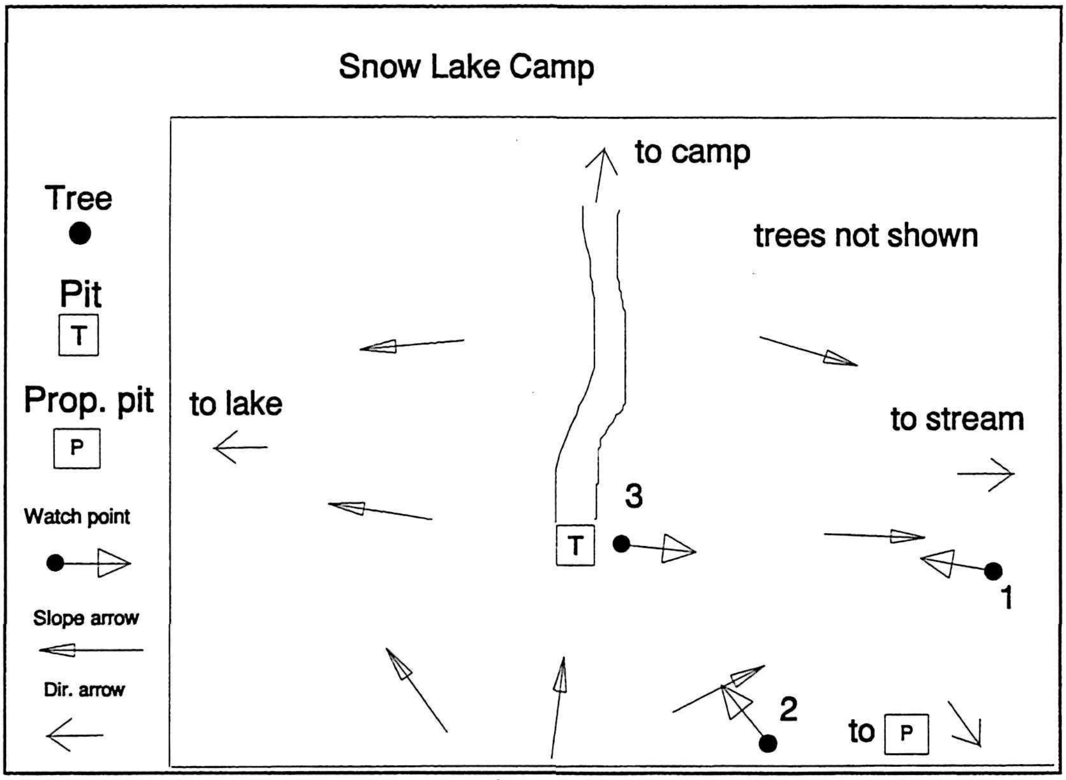

Figure 33 Snow Lake Camp Site Map (Aug. 12, 91)

Ground water was flooding the pit when it was reviewed. It is also likely that contaminated ground water flows into Snow lake. The pit should be relocated to the area indicated on the map.

The plastic seat was in bad working order and should be replaced with a wooden one.

Recommendations:

- Resiting needed
- Major repairs

South Puyallup

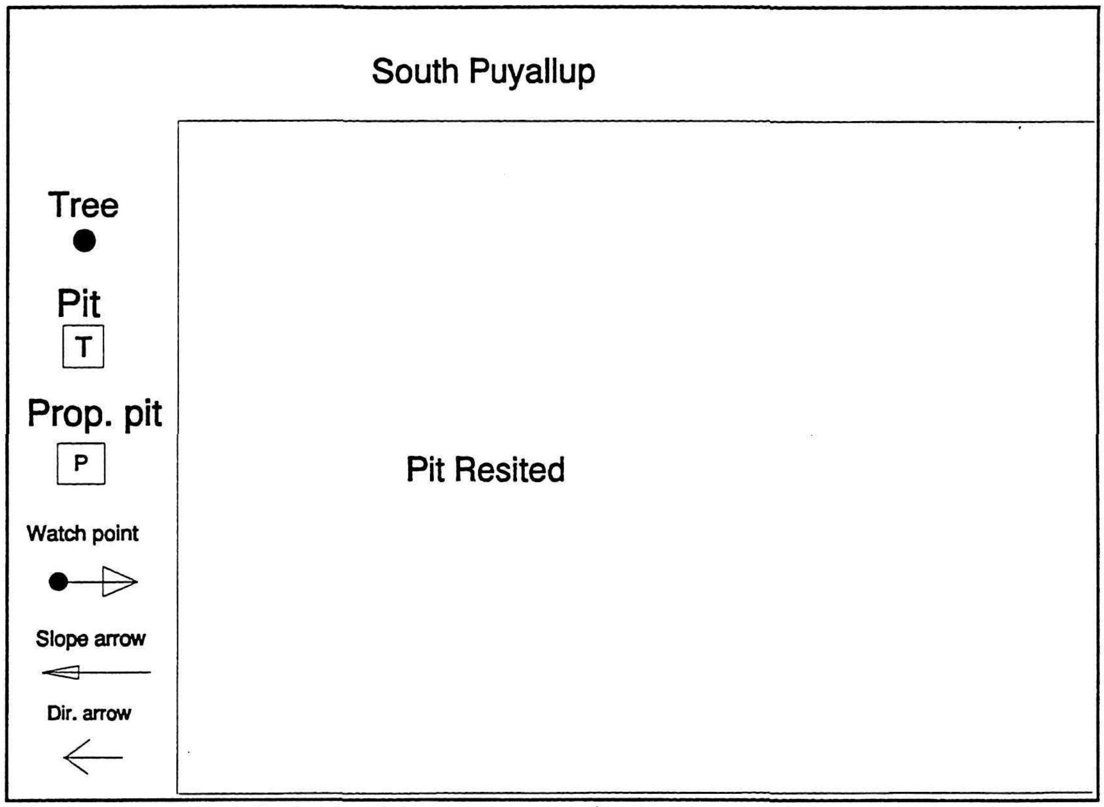

Figure 34 South Puyallup Camp Site Map (Aug. 21, 91)

The reviewed site is hydrologically unfavorable. The pit was only 15 feet from a small seasonal stream. It is likely the pit was impacting the stream. The pit has been relocated to an area downstream of the present site, but no new site map was draw.

Recommendations:

- Resiting was needed
- No repairs

Summerland

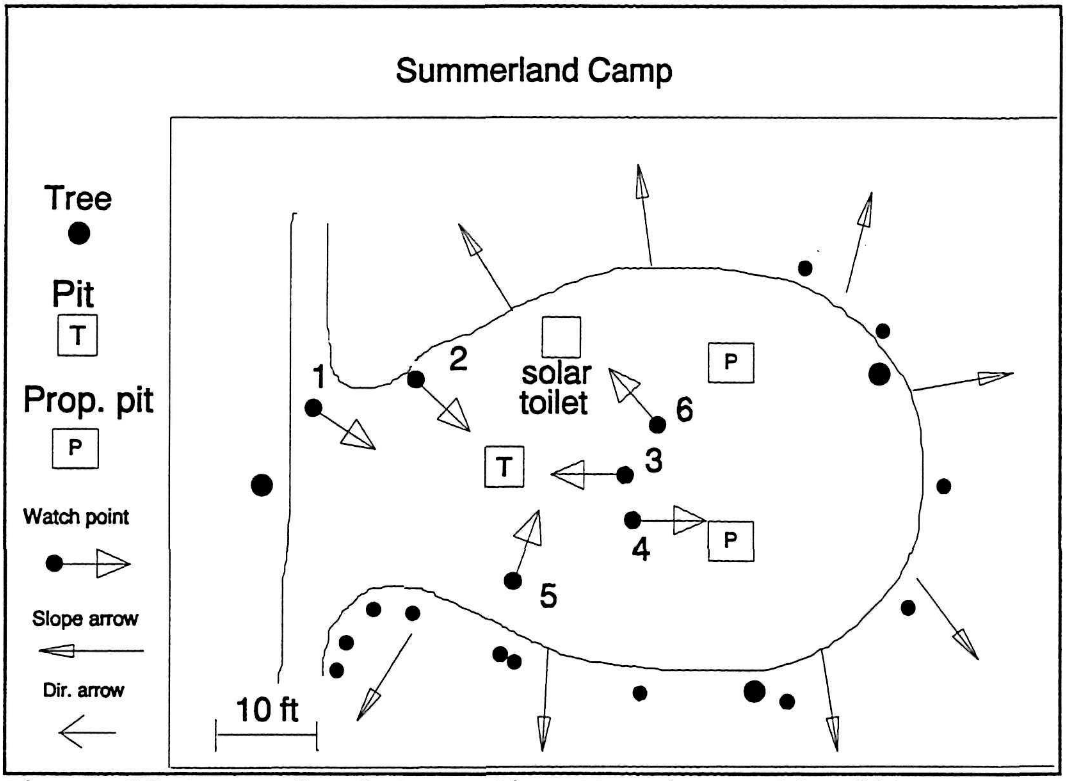

Figure 35 Summerland Camp Site Map (Aug. 12, 92)

The nonfunctional solar toilet should be removed from this site. The canvass walls surrounding the unhoused toilet should be replaced with a less intrusive form of barrier. The soils are thin, making shallow pits a necessity, but water quality impacts are not a direct concern. There are two sites for future use shown on the site map. An alternative system such as a composting toilet is a viable alternative for this site.

Recommendations:

- Resiting needed, pit full
- Major repairs

Sunrise

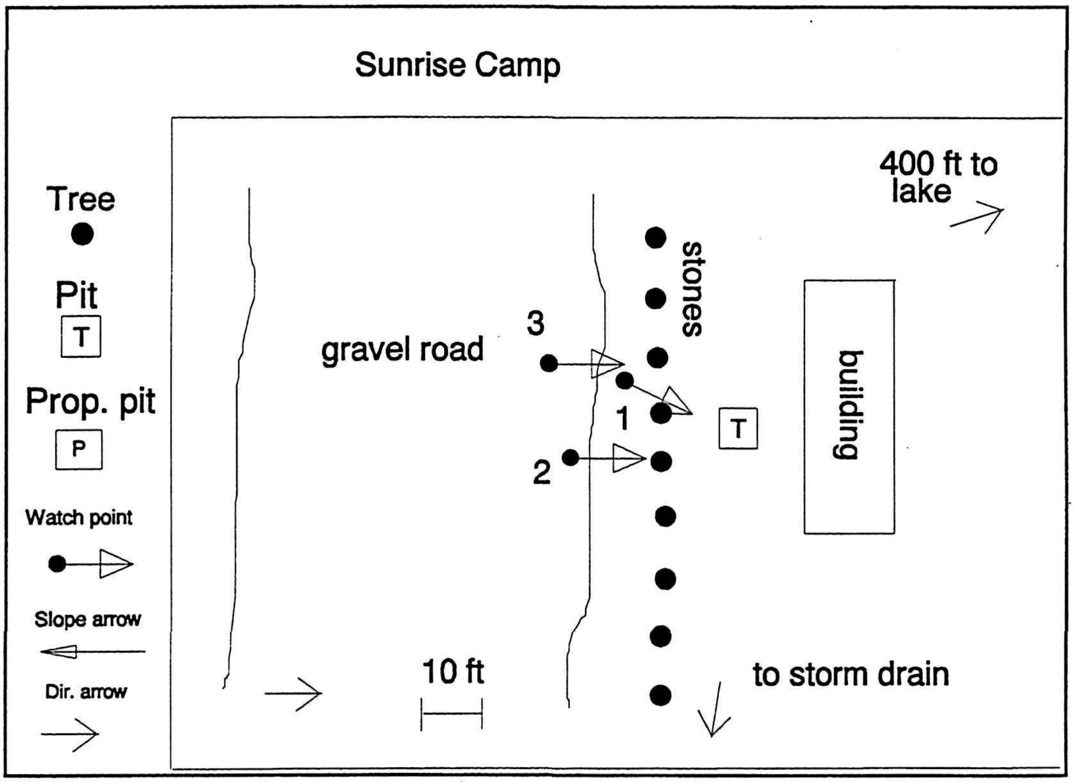

Figure 36 Sunrise Camp Site Map (Aug. 19, 92)

Sunrise camp pit toilet receives extensive use from day hikers and campers. Ground water from beneath the pit ultimately drains into the nearby lake. For these reasons and because a service road to the camp already exists it is recommended that a vault toilet system be constructed similar to that at Mowich Lake Campground. However, plans have been made for the service road to be obliterated and the area restored to natural conditions which may affect this recommendation.

The poorly constructed vent pipe was not controlling odors or flies from the pit.

Recommendations:

- Remove pit
- Minor repairs

Tamanos Creek

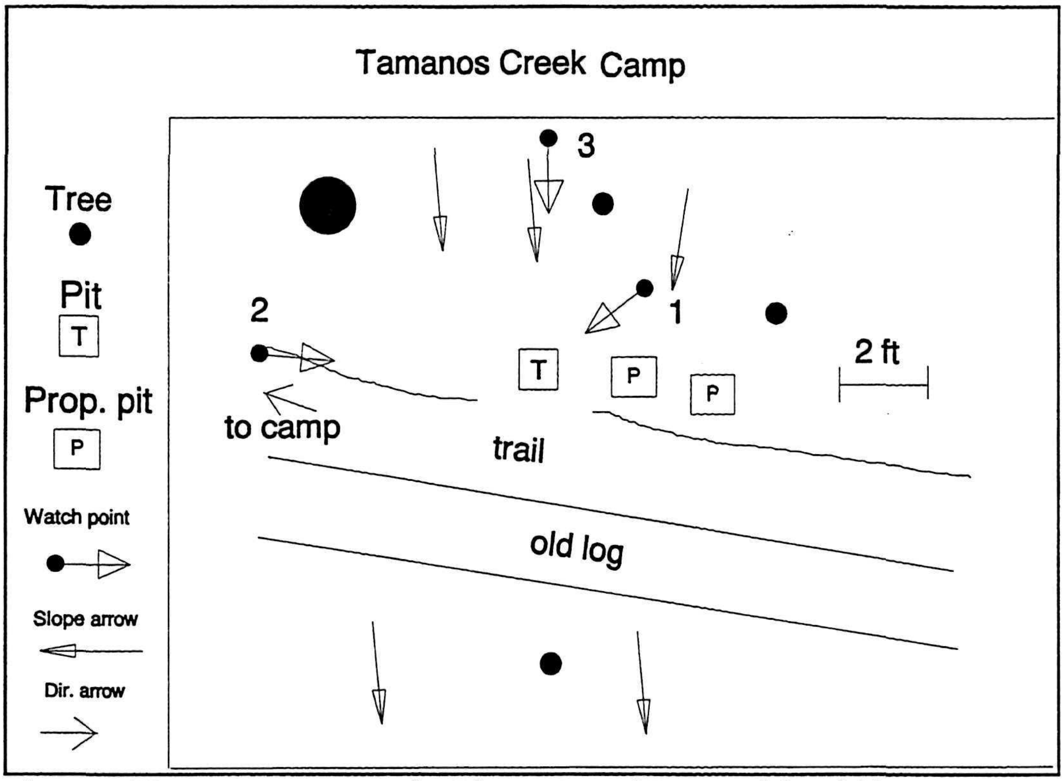

Figure 37 Tamanos Creek Site Map (Sept. 18, 91)

Surface waters are too far distant to be a concern for the pit. Relocation sites are shown.

Repairs are needed to stop the apparent surface runoff directly into the pit.

Recommendations:

- No resiting needed
- Minor repairs

Three Lakes

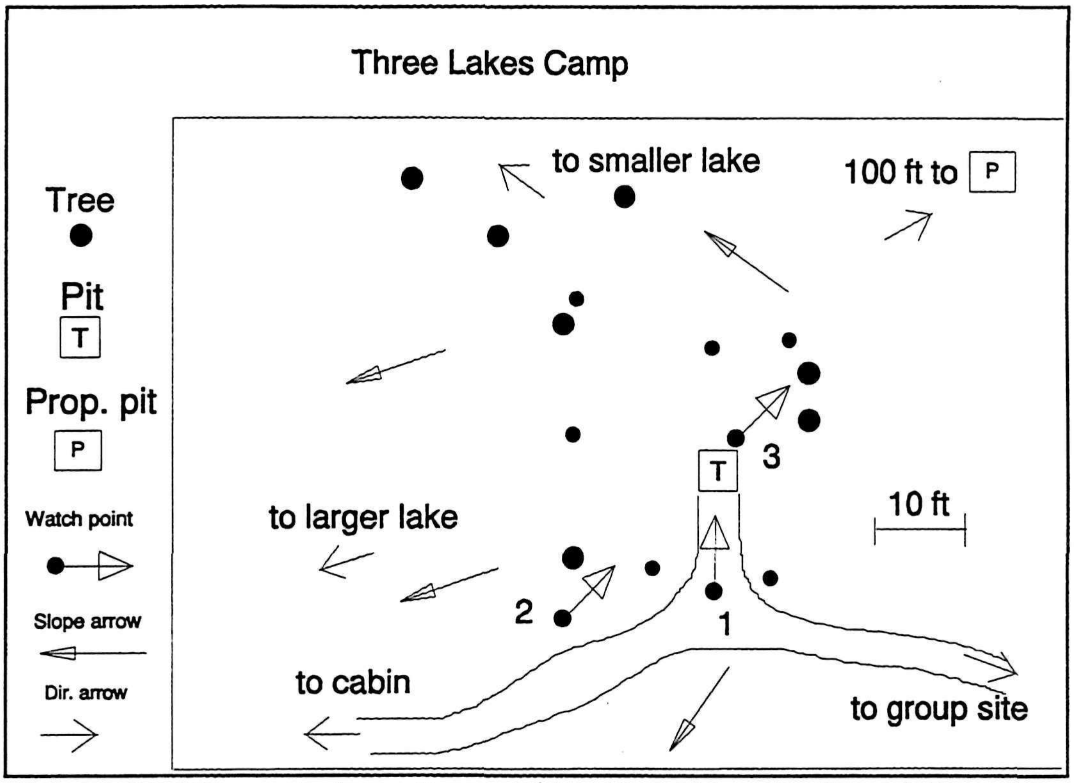

Figure 38 Three Lakes Camp Site Map (Sept. 14, 92)

The likely direction of ground water flow makes it possible for two of the three lakes to be impacted by the present pit site. The pit is adequate distance from the lakes so impacts would only be manifested in the long-term. Resiting should be accomplished when time permits. An area for relocation is shown, but the distance to this relocation site may be limited by the Park boundary.

There was no seat cover or seat and they should be installed.

Recommendations:

- Resiting a low priority
- Major repairs

Upper Crystal Lake

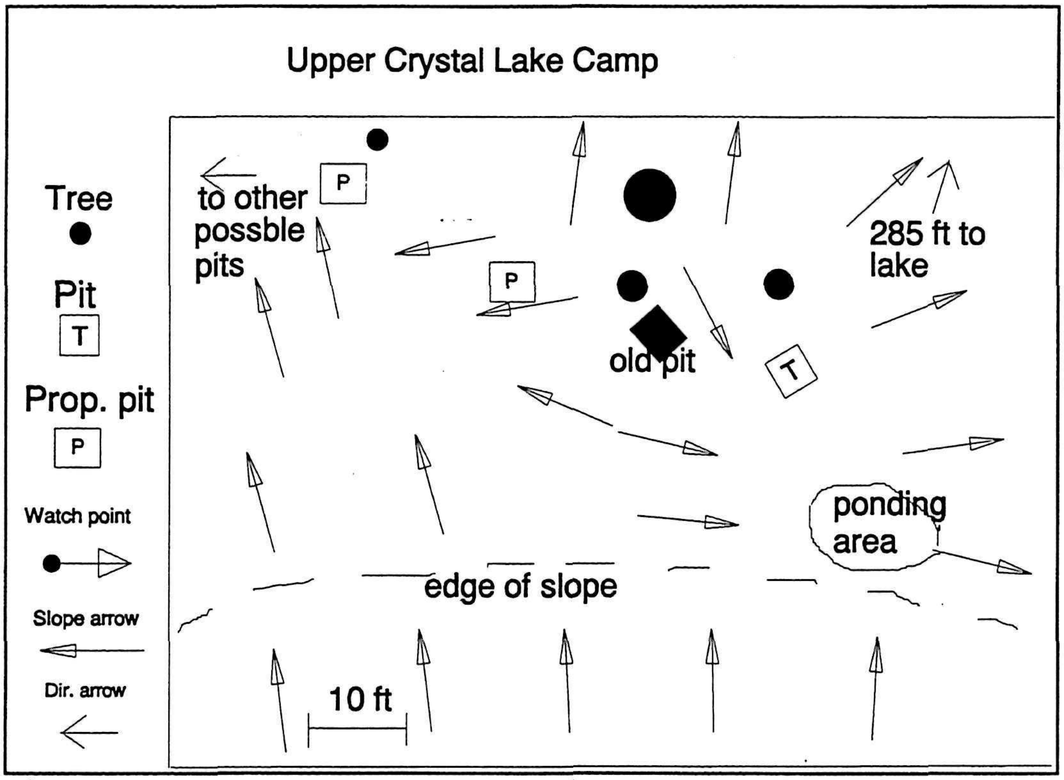

Figure 39 Upper Crystal Lake Site Map (Sept. 15, 91)

The likely direction of groundwater flow for the present pit toilet site is in the drainage basin for Upper Crystal Lake, and although not in close proximity to the lake, it could have an long-term impact on its water quality. It is recommended that the pit be moved downslope to the west where groundwater flow is more certainly away from the lake. This should be possible without relocating the camp.

The structure needs repairs around the base because the pit was dug too large.

Recommendations:

- Pit resiting needed
- Major repairs

Upper Palisades

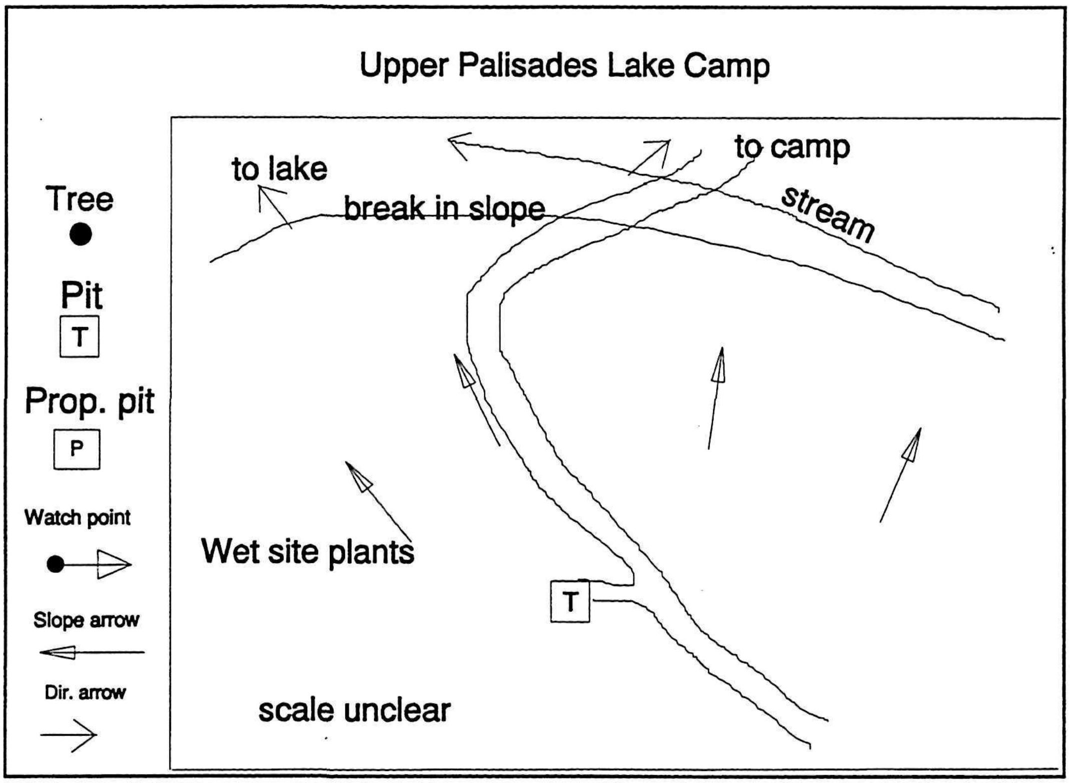

Figure 40 Upper Palisades Camp Site Map (Sept. 21, 91)

The likely direction of groundwater flow indicates that pollutants from the pit are being transported toward the lake. The pit should be relocated outside of the lake's drainage basin. This might be possible without relocating the camp. The pit is full so relocation should be accomplished immediately.

Holes around base need to be closed.

Recommendations:

- Resiting needed, pit full
- Minor repairs

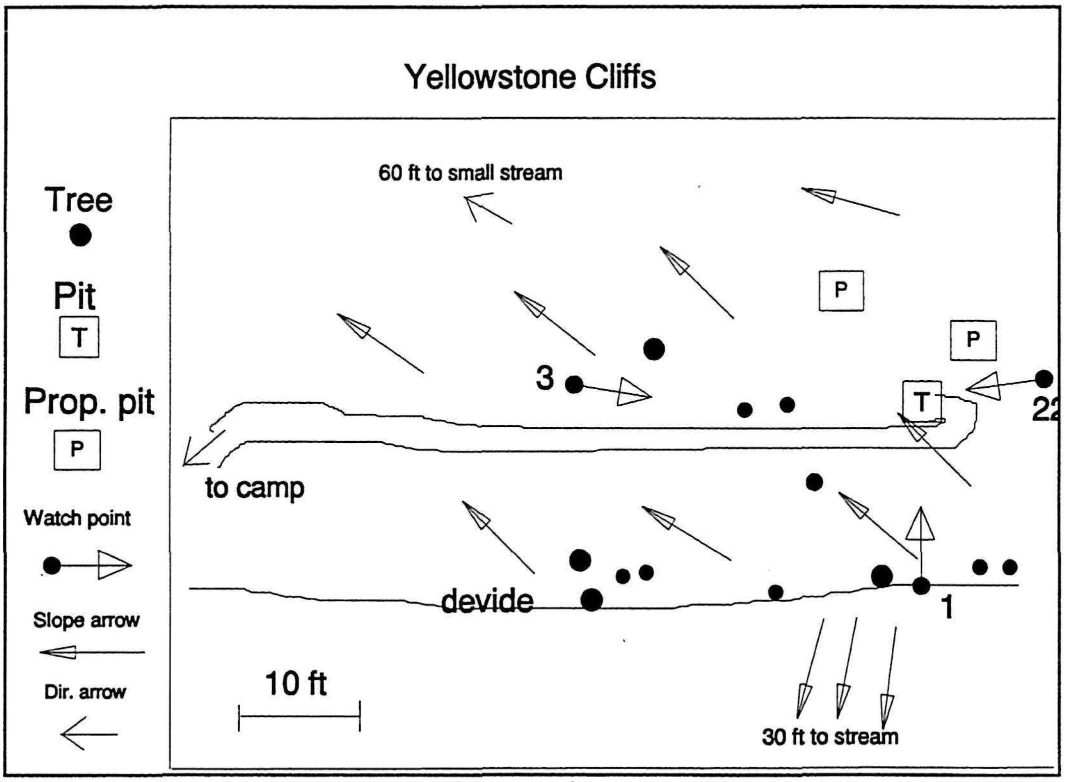

Figure 41 Yellowstone Cliffs Site Map (July 12, 92)

The pit toilet is upslope from two streams. One of the streams is small and serves as the camp water supply. This stream is 60 feet from the pit and is in danger. The other stream is 30 feet away but is much larger and faster flowing. Park Service personnel have reported observing groundwater in this pit. It is recommended that the pit be resited downhill of the camp.

The toilet was in good repair.

Recommendations:

- Pit resiting needed
- No repairs

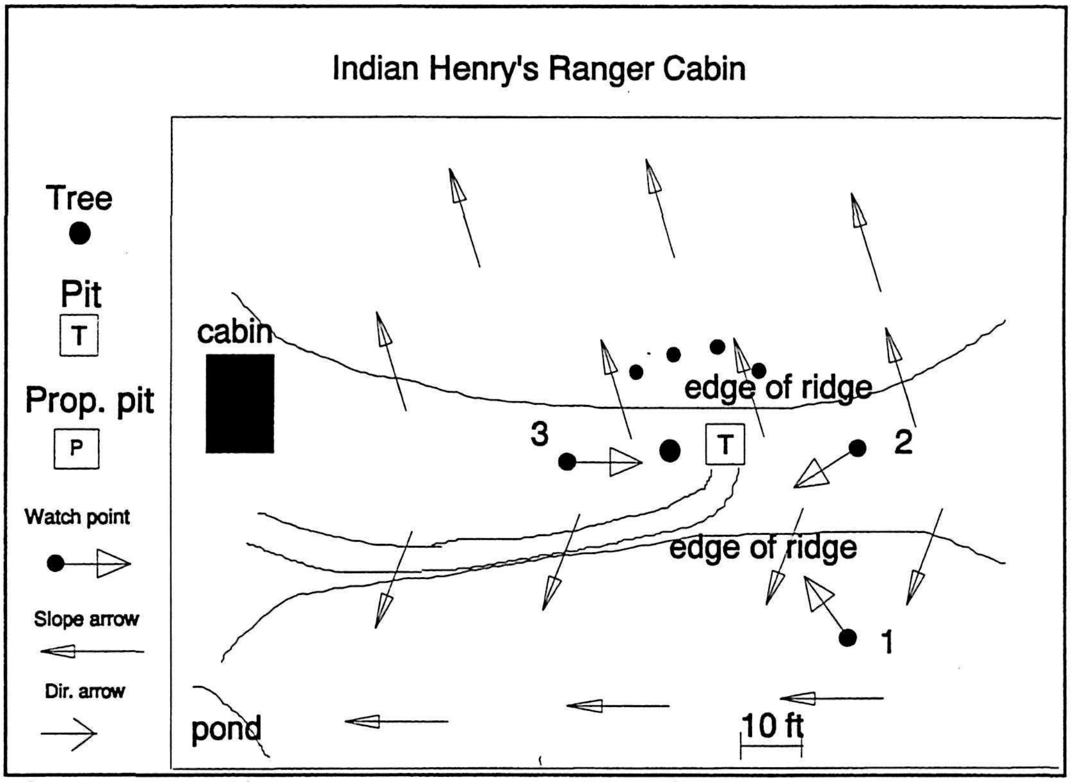

Figure 42 Indian Henry's Ranger Cabin Map (Aug. 8, 91)

The nearby surface waters are in danger from this pit which serves only the ranger cabin. The pit should be replaced by a composting toilet system to completely insure water qualities. This is an ideal location for the use of a composting system.

The house was in good condition

Recommendations:

- Composting Toilet should be installed
- No repairs

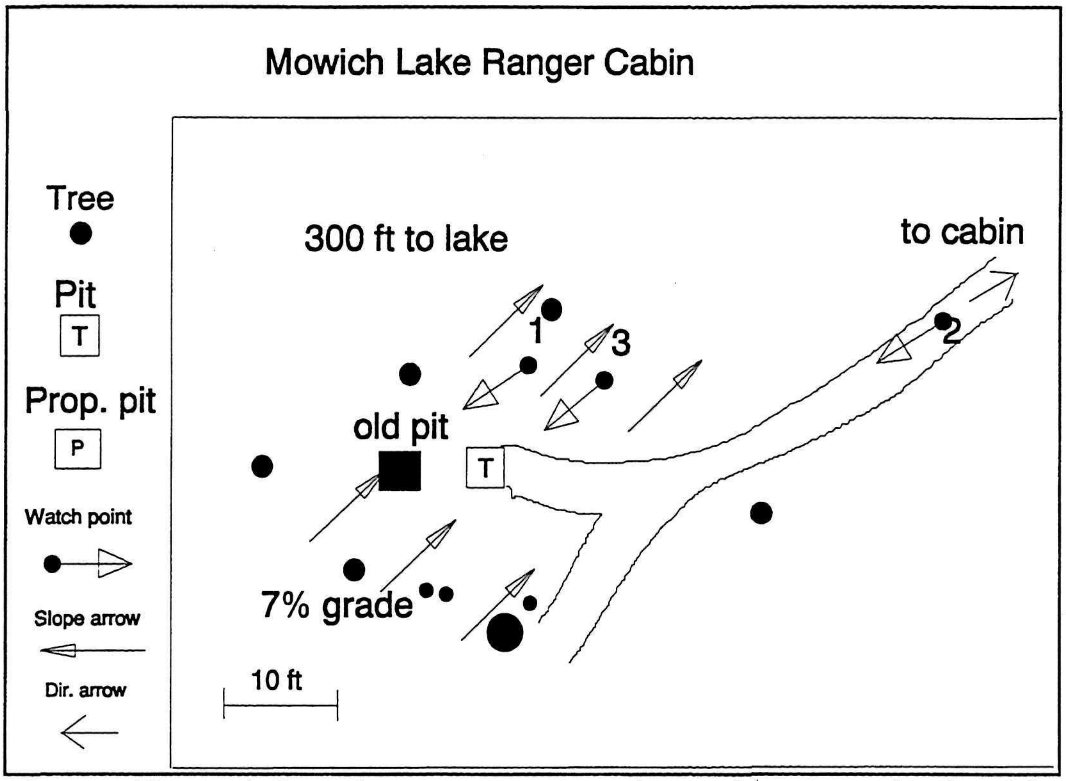

Figure 43 Mowich Lake Ranger Station Site Map (July 10, 92)

This toilet is used only by Rangers. The pit is located 300 feet uphill of the lake and the hill slope is a 7 % grade. Water was noted in the pit when it was reviewed. Mowich lake has been listed as having a low sensitivity to nutrient inputs (Marshall and Nelson, 1991). This is an ideal location to judge the impact of very small loading on a large lake. Rangers could also be required to use the facilities that have been installed at the nearby camp. A composting toilet could be installed for the rangers use.

Recommendations:

- Resiting a possibility
- Possible location for composting toilet
- Possible location where calculations could show lake is safe

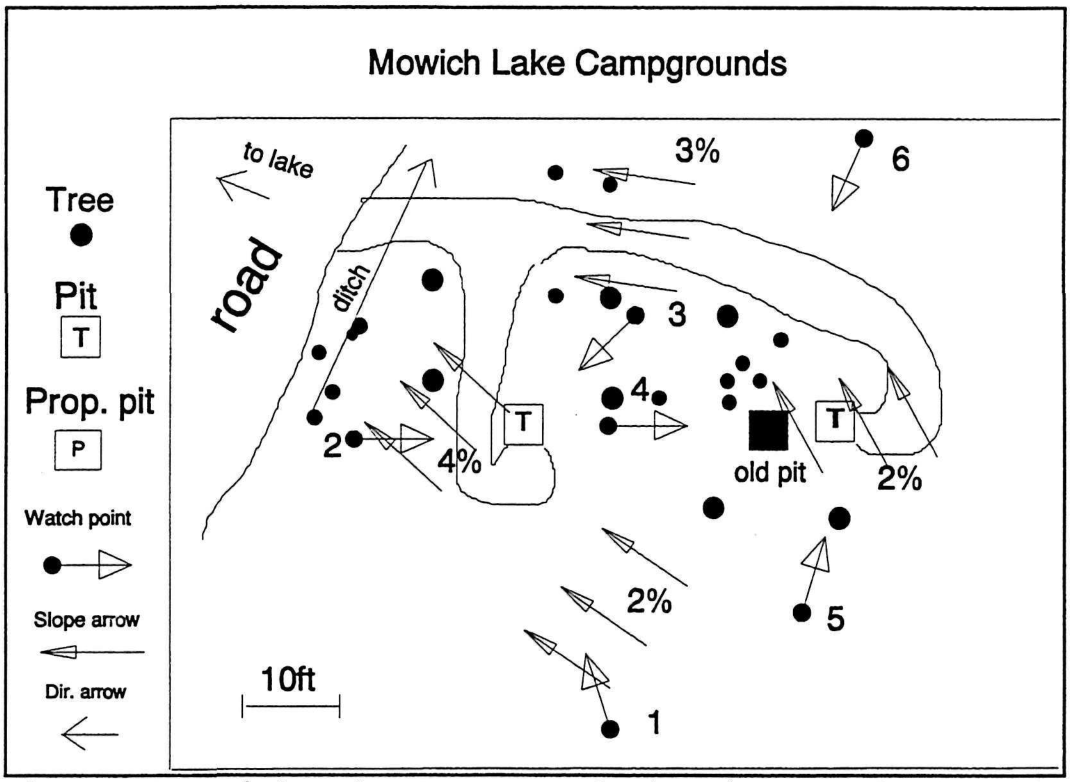

Figure 44 Mowich Lake Campground Pit Sites (July 10, 92)

These two toilets were in use before the new vault toilets were constructed and are used only when the vaults are unusable because the road is impassable. Both toilets were flooded with water flowing toward the lake. It is recommended that both pits be closed and the garbage in the pits taken away.

Recommendations:

- Remove Toilets
- Cleanup needed

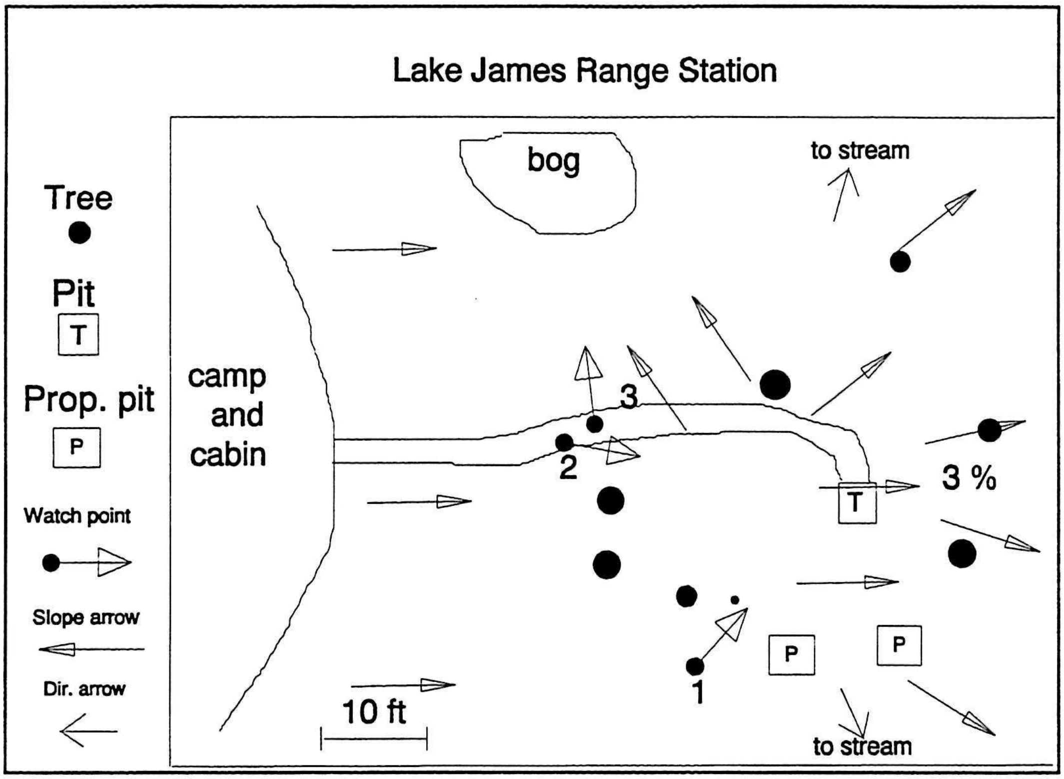

Figure 45 Lake James Ranger Station Site Map (July 12, 92)

This site services both the Ranger Station and the temporary campsite adjacent to the cabin. The nearest surface water is a boggy area approximately 40 feet away and 5 feet downhill. There is potential for pollutants to travel to this boggy area, but the potential for damage is not critical due to the nature of the impacted water. Resiting will not be required for some time.

The house was in excellent repair. The door has a one inch gap at the top that should be eliminated.

Recommendations:

- Resiting not needed
- No repairs

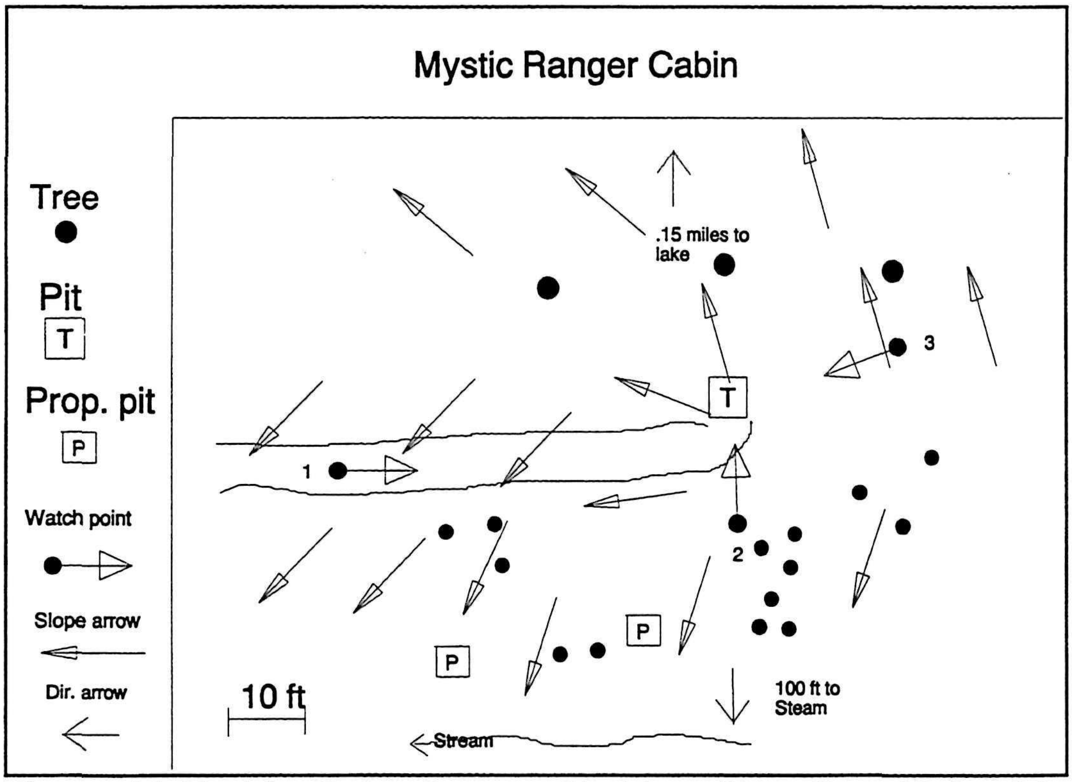

Figure 46 Mystic Lake Ranger Station Site Map (July 14, 92)

The pit toilet used by rangers at Mystic Lake is located on a ridge above Mystic Lake. Ground water directions are unclear. Wastes traveling toward the lake must pass through 0.15 miles of soil to enter the lake. Alternatively wastes traveling toward a local stream must only go 100 feet to impact water which is later used by the campers. Pit loadings are limited to ranger use. It is recommended that the site be closed to protect water qualities of the lake and stream. Rangers could make use of the Mystic Lake Camp pit toilet.

When reviewed the house was tilting badly and needed fly screens.

Recommendations:

- Close site
- Major repairs needed

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interest of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-251 April 1995