# Donner Summit Public Utilities District

## Soil Characterization for Expansion of the Irrigation Disposal Area

**January 2011**

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Contents

# Donner Summit Public Utilities District Soil Characterization for Expansion of the Irrigation Disposal Area



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Section 1

# Introduction and Background

## 1.1 INTRODUCTION

The Donner Summit Public Utilities District (PUD) operates a wastewater treatment plant (WWTP) which receives sewage from communities in the Norden and Soda Springs areas, including the Sierra Lakes County Water District. The WWTP has an existing permitted capacity of 0.52 million gallons per day (Mgal/d), average dry weather flow (ADWF) basis. The WWTP produces a tertiary disinfected and de-chlorinated effluent for seasonal discharge (October through July) to the South Yuba River. When soil and weather conditions allow and during the months of August and September, the WWTP produces a tertiary disinfected effluent for land disposal in spray fields at the Soda Springs Ski Resort.

The existing irrigation area comprises approximately 45 acres of land associated with three ski runs (Figure 1). Prior to installation of the irrigation system, the area had been logged to create open ski runs, and the ski runs are managed by the ski resort to prevent tree growth. Thus, the irrigation area supports introduced annual grasses as well as natural grasses, forbs, and shrubs typically associated with alpine meadows. Four pressure zones associated with elevation were installed on each ski run, but the lowest zone (the A zone) is no longer used due to negligible infiltration of applied water. The upper three zones continue to provide effluent disposal and drain to a runoff/tailwater return system, consisting of ditches and a storage pond. Generally, runoff infiltrates back into the soil in the return system, and the pond collects a minimal amount of runoff. Runoff due to snowmelt, prior to the irrigation season, is allowed to bypass the tailwater return system through diversion gates.

In order to accommodate future planned growth, the land disposal area will need to be expanded. This report evaluates the irrigation disposal potential of areas owned by the ski resort adjacent to and west of the existing ski runs and spray fields. This area supports a relatively young (less than 40 years old) stand of mixed conifer forest and includes some apparently wetter areas of dense alder trees. The soils associated with these wetter areas were not characterized and were considered unsuitable for irrigation disposal, since the existing vegetation can not deplete naturally occurring water.


Figure 1
**Aerial Photograph of Soda Springs Ski Hill Showing Irrigated Area (Ski Slopes with Darker Green Color) and Surrounding Features**

## 1.2 SITE GEOLOGY AND SOILS

Geologic maps of the site indicate that the majority of the site is located on Quaternary glacial deposits overlying bedrock with small areas of granitic rock and basalt outcrops (Hudson, 1951 and Harwood 1980). The 1982 Soil Survey of the Tahoe National Forest Area (USFS, 1994) mapped the majority of the area at the site as a complex of Tallac very gravelly sandy loam and Cryumbrepts, wet, within two slope classes: less than and greater than 30 percent slope. The moderately deep, well drained Tallac soils have moderately rapid permeability, high erosion potential, a very low available water capacity, and have developed in glacial till and/or outwash. The Cryumbrepts, wet soils are undifferentiated poorly drained soils occurring in and along drainage ways.

Prior to installing the existing irrigation system, a detailed soil inventory was conducted by Davis2 Consulting Earth Scientists (Davis2, 1984). Davis2 indicated that the soils were less affected by glaciation, and largely affected by the presence of an andesitic mudflow bedrock. The site, including the potential expansion area, was mapped by Davis2 as the Ahart fine sandy loam in various phases distinguished by slope class, drainage class (moderately well vs. somewhat poorly drained), and whether the area had been eroded. Generally, the soils exposed in profiles were described by Davis2 as moderately deep, averaging 31 inches, moderately well drained, and having a moderate to high hydraulic conductivity.

# Section 2
# Soil Survey

## 2.1 METHODS

The intent of this soil survey was to identify soil properties in areas likely suitable for expansion of effluent irrigation. Therefore, the entire soil resource of the area was not characterized due to obvious concerns including slope and poor drainage. Preliminary locations of representative soil profiles were determined based on an evaluation of available data including recent aerial photography and topographic survey data. Actual profile locations were refined in the field based on actual site conditions including vegetation. Five soil pits were excavated using a small metal track excavator (Komatsu 95) generally to refusal or five feet. The soil profiles were described with respect to methods employed by the National Cooperative Soil Survey and criteria included in the USDA Soil Survey Manual and National Soil Survey Handbook. No laboratory analysis was conducted on the soils, and taxonomic classifications are based on field observations. Similarly, soil hydraulic properties were estimated based on observable conditions and soil texture relationships.

Erosion hazard was evaluated using the revised universal soil loss equation (RUSLE), and the rating was based on the ratio of calculated erosion (A) to erosion tolerance factors (T), where high erosion hazard corresponds to an A/T value greater than or equal to 1 while an A/T of 0.5 is considered moderate. The erodibility of the whole soil was determined by employing the Soil Erodibility Nomograph (Wischmeier et al, 1971) and correcting for surface rock fragments. Rainfall erosivity was calculated by inputting average temperature and precipitation into the RUSLE2 software program. The combined slope and length factor was determined from tables presented in Agriculture Handbook 703 (Reinard et al, 1997). The cover management factor was based on existing conditions and estimated to be 0.036 based on figures presented in Agriculture Handbook 703. The support practice factor was set at unity to reflect the inherent erosion hazard of the site.

## 2.2 SOILS

The majority of the site consists of soils that developed in glacial till. Generally, soils observed in the expansion area were moderately deep, fine sandy loams with 15 to 60 percent rock fragments occurring as gravels, cobbles, and boulders. The observed soils do not directly correspond to named soil series; however, they appear to be variants of named soil series found in the general area. This atypical condition may be associated with the presence and proximity of extrusive volcanic rocks (basalt and andesite) affecting soil development in a landscape largely derived from the glaciation of granitic bedrock. The soil phases observed, including pit locations, are delineated in Figure 2. As mentioned previously, soils in portions of the potential expansion area were not fully characterized due to inherent limitations to use. Thus, soil evaluations are limited to the area delineated in Figure 2.

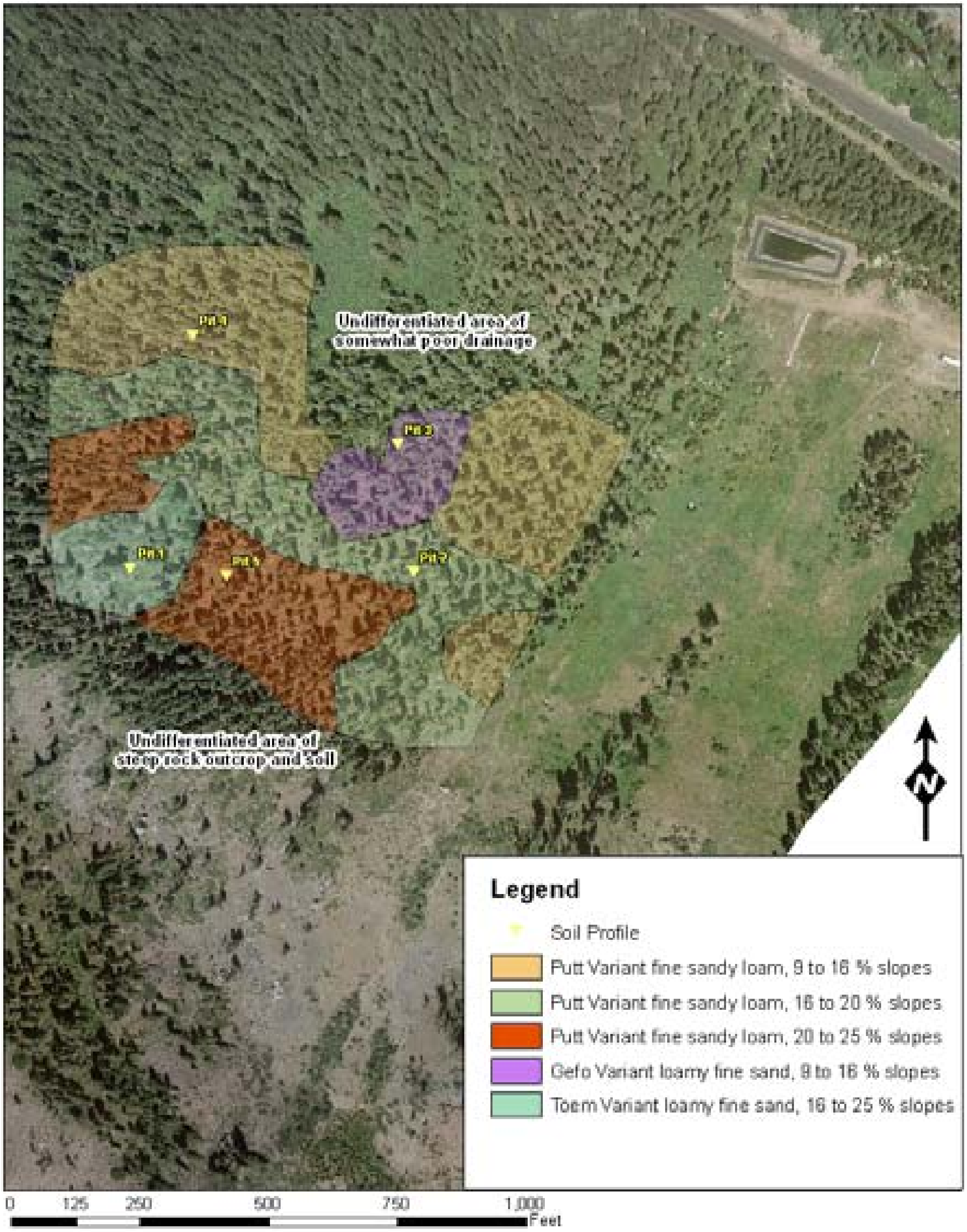


Figure 2
**Soil Map for the Potential Irrigation Expansion Area**

The majority of the site appears to be a variant of the Putt, very cobbly sandy loam occurring in three slope classes (9 to 16 percent slopes; 16 to 20 percent slopes; and 20 to 25 percent slopes) corresponding to increasing erosion hazard. A small area of a variant of the Toem gravelly sandy loam occurs in an area dominated by the out cropping of granitic bedrock. Additionally, a small area of Gefo variant (as described in the 1982 Soil Survey) occurs in a depositional area. This soil is similar to one of the soils observed by Davis2 in the 1984 test pits and considered atypical of the site. Descriptions of the soils are presented below and in the pedon description sheets presented in Appendix A. These soils are adjacent to undifferentiated soils with somewhat poor drainage to the north and undifferentiated steep soil and rock outcrop to the south.

### 2.2.1 Putt Variant

The Putt variant occurs on back slope and foot slope positions of mountains and has developed in glacial till and outwash. Profiles of the Putt variant (loamy skeletal, mixed, frigid, Typic Durixeralf or Durixerept) exposed at the site are presented in Figure 3. A representative profile of the Putt variant is as follows:

**Oe** 3 to 0 inches, moderately decomposed pine and fir needles.

**A1** 0-5 inches, very dark brown (7.5YR 2.5/2) moist, gravelly fine sandy loam; moderate fine subangular blocky structure, soft, non sticky and non plastic; many fine and common medium roots; 10 to 20 percent gravels, 3 to 15 percent cobbles; clear wavy boundary. (5 to 6 inches thick)

**A2** 5-12 inches, dark brown (7.5YR 3/3) moist, very gravelly fine sandy loam; weak fine subangular blocky structure, soft, non sticky and non plastic; common fine and medium roots; 5 to 36 percent gravels, 3 to 16 percent cobbles; clear wavy boundary. (0 to 12 inches thick)

**Bt** 12-27 inches, dark brown (7.5YR 3/3) moist, very cobbly fine sandy loam; moderate fine subangular blocky structure, slightly hard, non sticky and slightly plastic; few fine, medium, and coarse roots; few faint clay films; 10 to 30 percent gravels, 20 to 30 percent cobbles; abrupt wavy boundary. (0 to 24 inches thick)

**Bqm1** 27-40 inches, brown (7.5YR 5/4) moist, very cobbly loamy sand; massive, very hard, nonsticky and slightly plastic; few fine and medium roots in a matt at the surface; thin laminar cap coating mineral grains and bridging casts; 10 to 25 percent gravels, 15 to 36 percent cobbles and paracobbles; clear wavy boundary. (11 to 22 inches thick)

**Bqm2** 40-60 inches, gray (10YR 5/1) moist, very cobbly loamy sand; massive, extremely hard and indurated, non sticky and non plastic; few fine and medium roots in a matt at the surface; thin laminar cap coating surface of horizon; 10 to 25 percent gravels, 15 to 55 percent cobbles and paracobbles; clear wavy boundary. (17 to 25 inches thick)

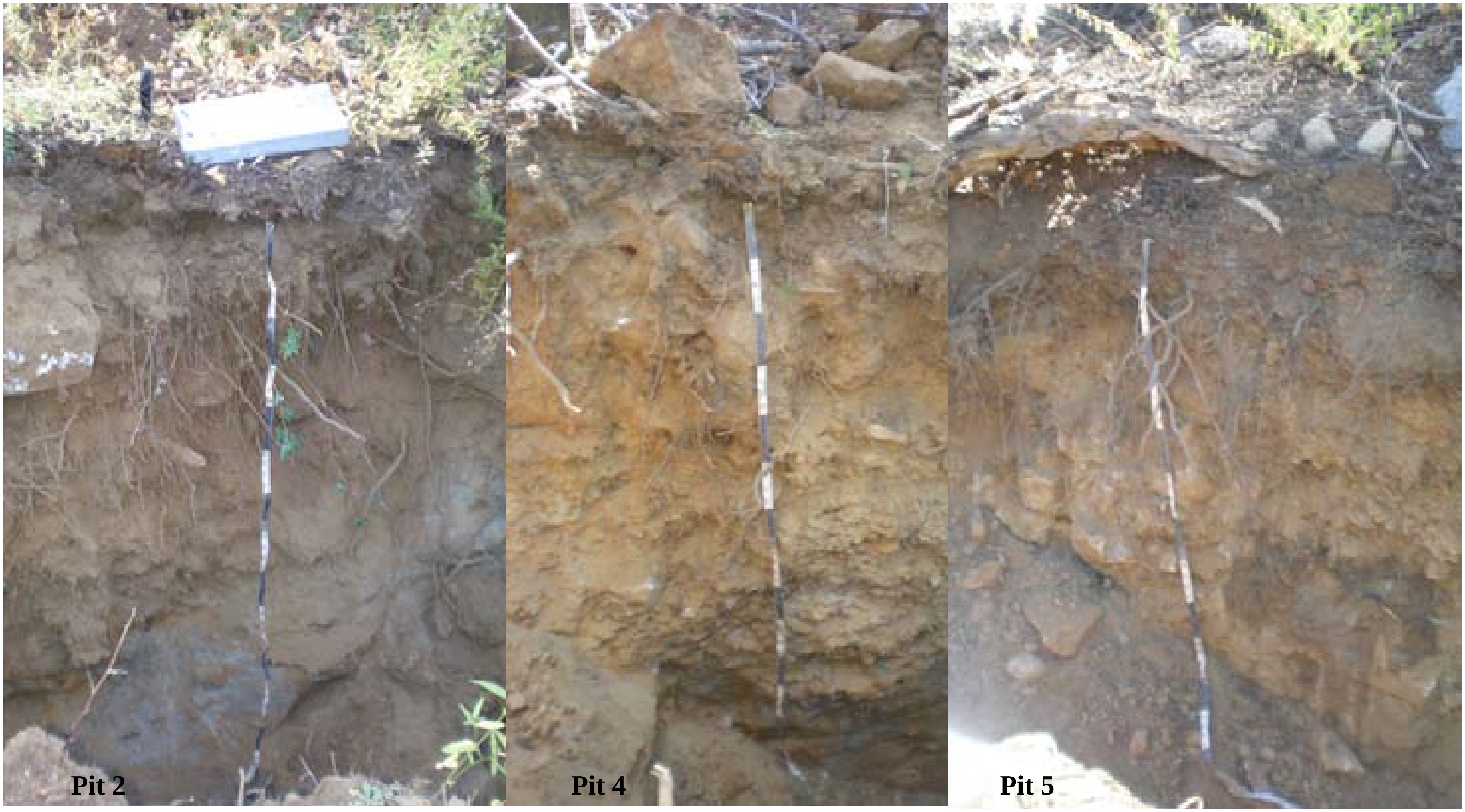


Figure 3
**Profiles of the Putt Variant Exposed in the Potential Expansion Area**
**(Tape Divisions Represent 10 cm)**

The Putt variant consists of moderately deep, well to somewhat excessively drained soils, with low or very low hydraulic conductivity in the compacted and cemented duripan. Drainage in these soils occurs as lateral flow rather than deep percolation, and excess irrigation water will increase soil moisture down slope. It is unlikely that mechanical removal of the duripan through ripping will improve soil moisture status, since the underlying glacial till is dense, relatively shallow over bedrock, and adequate drainage occurs laterally in the soils. Additionally, the large stones and boulders across the site and within the soil are not conducive to ripping. Runoff from the Putt variant soils is high, and erosion hazard ranges from moderate to high. Plant available water holding capacity is generally low (1.8 inches). Thus, irrigation timing should be based on frequent shallow applications.

The Putt variant was divided into three phases based on slope class representing moderate (9 to 16 percent slopes), moderately high (16 to 20 percent slopes), and high (20 to 25 percent slopes) erosion hazards. The delineation of these phases is presented in Figure 2. Due to high erosion potential, the area identified as Putt variant 20 to 25 percent slopes (shaded red in Figure 2) should be avoided during irrigation system construction and associated vegetation removal. The lower slope classes will require erosion control practices during and after irrigation system construction, and existing vegetation should be maintained on these soils to the extent possible to prevent erosion.

Since the observed soils do not fall within the range of characteristics of a named soil series, they have been presented as a variant of a named soil series, the Putt. Discrepancies between the observed soils and the Putt are detailed below. The taxonomy of the official Putt series does not account for the soil's diagnostic horizons, including the umbric epipedon (acidic, organic matter enriched, thick surface horizon) and duripan (silica cemented root restrictive layer). Additionally, there is evidence of clay illuviation in the subsoil of the Putt series, but taxonomy does not include the presence of an argillic horizon. The Putt variant observed has an umbric epipedon, a duripan, and may or may not have an argillic horizon. Additionally, the Putt series has andic properties (low bulk density associated with amorphous extrusive volcanic minerals), and it is assumed that the soils at the site have andic properties. In some locations, the subsurface rock fragments are just below the requirements for the skeletal particle size modifier (32 vs. 35 %). The observed Putt variant would be a taxadjunct to the Putt, in that the site has a frigid temperature regime as opposed to the mesic temperature regime of the Putt series.

### 2.2.2 Toem Variant

The Toem variant occurs on shoulders and backslopes of hill slopes and has developed in colluvium and weathered granitic bedrock. A representative profile of the Toem variant (loamy skeletal, mixed, frigid, Humic Dystroxerept), presented in Figure 4, is as follows:

**A1** 0-7 inches, very dark brown (7.5YR 2.5/2) moist, loamy fine sand; weak fine subangular blocky structure, soft, non sticky and non plastic; common fine roots; 8 percent gravels; clear wavy boundary.

**A2** 7-20 inches, dark brown (7.5YR 3/3) moist, very gravelly fine sandy loam; weak medium angular blocky structure, soft, non sticky and non plastic; common fine and few medium and coarse roots; 35 percent gravels, 20 percent cobbles; abrupt wavy boundary.

**Cr** 20-35+ inches, fractured, highly weathered, soft granodiorite.  Roots confined to fractures 3 inches apart from 23 to 33 inches and greater than 10 inches apart below 33 inches.

Figure 4
**Profile of the Toem Variant Exposed in Pit 1**
**(Divisions Represent 10 cm, Numbers are Inches)**

The Toem variant consists of moderately deep, somewhat excessively drained soils, with very low hydraulic conductivity in the weathered bedrock. Runoff from these soils is high and erosion hazard is moderate. Plant available water holding capacity is low (1.5 inches). The Toem variant occurs with 10 percent granitic rock outcrop on approximately 1 acre of the site (Figure 3). The slopes range from 16 to 25 percent. Management concerns are similar to the Putt variant.

The Toem variant differs from the official Toem series in that it has greater than 35 percent rock fragments in the particle size control section, has predominantly fine sand in the sand size fraction, and has hues of 7.5 YR. There is no named soil series representative of the observed soil.

### 2.2.3 Gefo Variant

The Gefo variant occurs adjacent to drainage ways and has developed in alluvium and glacial outwash. A representative profile of the Gefo variant (coarse loamy, mixed, frigid, Pachic Humixerept), presented in Figure 5, is as follows:

**Oi** 2-0 inches, partially decomposed pine and fir needles

**A1** 0-6 inches, very dark brown (7.5YR 2.5/2) moist, gravelly loamy fine sand; moderate medium subangular blocky structure, soft, non sticky and non plastic; common fine roots; 18 percent gravels; clear wavy boundary.

**A2** 6-16 inches, very dark brown (7.5YR 2.5/3) moist, gravelly loam; weak coarse subangular blocky structure, slightly hard, slightly sticky and non plastic; many fine, common medium, and few coarse roots; 16 percent gravels; clear wavy boundary.

**A3** 16-27 inches, dark brown (7.5YR 3/3) moist, gravelly loam; massive, slightly hard, slightly sticky and non plastic; common medium and few fine roots; 16 percent gravels; clear wavy boundary.

**C1** 27-37 inches, brown (7.5YR 4/3) moist, loam; massive, slightly hard, slightly sticky and non plastic; few medium and fine roots; 8 percent gravels; gradual wavy boundary.

**C2** 37-60+ inches, brown (7.5YR 4/3) moist, gravelly loam; massive, slightly hard, slightly sticky and non plastic; few medium roots; 18 percent gravels.

An area of approximately one acre was identified as the Gefo Variant with slopes ranging from 9 to 16 percent (Figure 2). Very small areas of this soil likely occur as inclusions in the Putt variant, 9 to 16 percent slopes. Additionally, a similar soil was described by Davis2 in a similar landscape position on the adjacent ski slope (Area III, Figure 1)

The Gefo variant consists of very deep, well drained soils with moderately high hydraulic conductivity. Runoff from these soils is moderate and the erosion hazard is moderate. Plant available water holding capacity is high (8.2 inches). These soils appear more productive than the majority of the site, which is likely due to their capacity to retain a greater amount of naturally occurring moisture. Although deep soils with high water holding capacity are generally desirable for irrigated agriculture, irrigation disposal in this area may not be feasible during the early irrigation season (late spring early summer) due to the presence of natural moisture. However, these soils could provide for significant disposal capacity during the late season, and based on their landscape position, subsurface drainage and potentially run off from the adjacent upslope soils would likely be captured and retained in these soils during the entire irrigation season.

The Gefo variant observed is representative of the Gefo variant described in the 1982 Soil Survey of the Tahoe National Forest Area (USFS, 1994). There is no named soil series representative of the Gefo variant.

Figure 5
**Profile of the Gefo Variant Exposed in Pit 3**
**(Divisions Represent 10 cm, Numbers are Inches)**

Section 3

# Irrigation Disposal Land Use Recommendations

Approximately 16.5 acres were characterized for soil properties related to the irrigation disposal of effluent. Generally, the soils are limited by 1) a root restrictive and relatively impermeable layer approximately 25 inches deep; 2) large amounts of gravels, cobbles, and boulders; and 3) moderate to high erosion potential. The first two limitations also result in low water holding capacity. The erosion potential of the site is apparent in several gullies throughout the expansion area. Further, Davis2 reported the ski runs were eroded, and evidence of deposition was observed in the expansion area adjacent to the ski runs during this characterization. Thus, disturbance to the soil and existing vegetation should be minimized and conducted with attention to erosion control. In addition, the surface soils are somewhat hydrophobic when dry, and care should be taken to maintain them in a moist state to minimize runoff.

The majority of the site consists of a moderately deep Putt variant soil. Although this soil is somewhat excessively to well drained, drainage occurs through lateral flow not deep percolation, and excess irrigation water will result in wetter conditions down slope. This lateral drainage is likely the source of moisture in the lowest pressure zone of the existing irrigation system and likely contributes to poor disposal observed in this “A zone”. Water holding capacity of the Putt variant is generally low, less than 2 inches, reducing the volume of water per application; however, frequent applications will be necessary to maintain optimum soil moisture for plant growth. Based on slope, fine sand textures, and hydrophobicity of the surface soils, application rates should be 0.25 inches per hour or less. Irrigations should be planned for depletion of half of the plant available soil moisture, approximately 1 inch, which may be required as often as every three days.

The Putt variant soil was divided into three map units based on slope class and erosion potential. The Putt variant, 20 to 25 percent slopes occurs on 3.5 acres in the expansion area (highlighted in red in Figure 2) and has a high erosion potential. Disturbance to this area should be avoided, since this area exhibits evidence of soil creep, Figure 6, and clearing and excavation activities in this unit could result in excessive erosion and loss of productive soil. Irrigation of this unit should be at very low rates and from transmission lines installed in less sloping areas.

The Putt variant 16 to 20 percent slopes occurs on 4.9 acres across the site and has moderately high erosion potential. Care should be taken in this unit to minimize erosion during disturbance, such as mulching exposed areas and placement of waddles or felled logs along the contour of the slope to trap/retain sediment. The retention of existing trees and shrubs on the site would be beneficial in minimizing erosion, and minimize the need for mechanical means of erosion control. The Toem variant is adjacent to this map unit as well as the steeper slope class.

Figure 6
**Bent Trees Indicating Soil Creep in the Putt Variant 20 to 25 Percent Slopes Map Unit**

The Putt variant 9 to 16 percent slopes occurs in generally two areas: a 2.8 acre eastern block separated by a band of 16 to 20 percent slopes and a 3.5 acre western block (Pit 4). This soil has a moderate erosion hazard and is less limiting than the other slope classes. However, erosion control practices will be necessary during disturbance. The western block drains to the northwest, and utilizing existing runoff controls will be difficult, due to the location of the large wetland area. The eastern block could be equipped with runoff controls that tie into the existing system. This map unit is adjacent to and likely contains small areas of the Gefo variant.

The Toem variant 16 to 25 percent slopes occurs in a 1 acre block and is associated with the outcropping of granitic bedrock. With slightly coarser texture and increased volume of surface rock fragments than the Putt variant, erosion hazard potential of this soil is moderate, similar to the Putt variant 16 to 20 percent slopes. The water holding capacity of the soil is slightly lower, at 1.5 inches, than the Putt variant. However, the weathered granitic rock has the potential to store moisture and some percolation likely occurs through fractures in the bedrock. Thus, management of this unit should be similar to that of the Putt variant 16 to 20 percent slopes.

The Gefo variant 9 to 16 percent slopes occurs in a small, approximately 1 acre, area and has a moderate erosion hazard. This soil has formed in a deep alluvial fan deposit and similar soils likely occur in very small areas adjacent to concentrated flow paths. Although the Gefo is a deep soil and conducive to irrigation, it may remain wet longer after the spring thaw, due to its 8 inches of plant available water holding capacity, than the adjacent Putt soils, providing a potentially shorter irrigation season. However, irrigation of this soil at the low rates and volumes required by the Putt variant will not likely result in over saturation and runoff in these soils, even when irrigated in the early irrigation season. Moreover, the reduced irrigation volume will likely result in a moisture deficit in these deeper soils, and the presence of the Gefo variant along natural drainage paths and generally down slope of the bulk of the expansion area is beneficial in providing for capture and retention of at least some surface runoff and subsurface flow.

For all soil types, vegetation should be managed to provide for trees, shrubs, and annual grasses and forbs where feasible. Some preliminary and maintenance thinning of trees and tall shrubs will likely be necessary, to prevent shading of understory growth, to allow access to the irrigation system, and to minimize fuels to prevent catastrophic wild fire. All vegetation, as well as large rocks, will need to be removed to install the irrigation mains; however, where possible, disturbing strips rather than the entire site and leaving buffer strips of existing vegetation would be beneficial for erosion control, especially along natural drainage paths. The site should be seeded and irrigated immediately after installation to ensure revegetation occurs prior to the winter.

Diversity in vegetation results in variations in canopy cover as well as root zones, which reduces erosion by intercepting rain drops and stabilizing different depths within the soil, respectively. Although establishment of grass is a critical component of erosion control directly after a disturbance, annual grasses can be less effective than deeper rooted vegetation (and diverse vegetation populations) for erosion control, especially during spring snowmelt events and over the long term. Additionally, employing existing vegetation in the erosion control program would likely increase its effectiveness and decrease the programs cost.

Evergreen trees can evapo-transpire an estimated 1.25 times as much water as reference grass (grass maintained in and grown under standardized conditions). Additionally, the tree roots at the site have likely colonized fractures in the impermeable duripan and may provide preferential flow paths to deeper percolation and additional moisture storage. Generally, forest productivity in the Sierra Nevada is moisture limited and efforts to control competition have resulted in increased tree growth. The relatively thin and low moisture holding capacity of the soils suggests that this site is moisture stressed, and the application of additional water could greatly improve the forest productivity. A tribute to this increased productivity is apparent at the site. Where irrigation is currently occurring on the fringe of the forested area, there is a thick understory as well as dense forest vegetation (Figure 7). In contrast, the non irrigated area supports less overall vegetation (Figure 8).

Figure 7
**Dense Forest and Understory in an Area of the Putt Variant 9 to 16 Percent Slopes Currently Irrigated**

Figure 8
**Forest and Understory in an Area of the Putt Variant 9 to 16 Percent Slopes Not Irrigated**

Although maintaining existing vegetation would be beneficial for erosion control and would increase the disposal potential of the site in the late summer, shade provided by trees may delay snow melting and use of the site for irrigation in the early summer. If this concern and/or other site management issues require clear cutting the site and maintaining low canopy vegetation similar to the existing ski runs, additional mechanical means should be employed to provide flow breaks perpendicular to the slope, trap sediment, and dissipate the energy of runoff. Removing vegetation from existing drainages will require construction of major bank and channel stabilization projects. Such erosion control measures will need to be constructed during system installation and maintained and upgraded as a dynamic long term erosion control program.

It should be noted that irrigation of the site at the recommended rates and frequencies poses a very low risk of erosion, and the erosion control measures are necessary for natural events associated with snow melt runoff and high intensity rainfall events.

An additional concern at the site includes a wetland directly down slope of the expansion area. Runoff controls should be constructed to allow natural runoff (from winter rains and spring snow melt) to continue along current flow paths feeding this wetland. The use of gated diversion structures in existing drainage courses should be sufficient to allow for runoff control during the irrigation season, without impeding natural surface flow during the late spring. Additionally, it should be expected that surface flow of water from this wetland area will continue to occur regardless of whether the expansion area is irrigated or not. The majority of the expansion area can be utilized without disturbing the wetland.

Section 4

# Disposal Capacity Evaluation and Recommended New Irrigation Area

In this section, key parameters used in water balance calculations for sizing the disposal area are discussed, a water balance and sensitivity analysis are presented, and a recommended irrigation disposal expansion area is identified.

## 4.1 WATER BALANCE PARAMETERS

The DSPUD Facilities Plan presented preliminary information regarding disposal area requirements, based on a water balance developed for a 1 in 100 year precipitation event occurring in August or September. The water balance has been revisited and refined based on information obtained through this soil characterization and evaluation study. Specifically, assumptions associated with the effectiveness of precipitation, irrigation efficiency, and evapotranspiration (ET) are reviewed. Due to climatic conditions, the month of September provides the most conservative design condition, requiring a large land area and storage, and is used for this assessment.

As mentioned in the Facilities Plan, summer precipitation near Donner Summit is associated with large thunderstorms where a large volume of precipitation occurs over a short period of time, and as such, much of the rainfall is not effective to meet the moisture requirements of the vegetation. The low available water holding capacity of the soils and frequency of irrigations also reduces the effectiveness of precipitation at the site, in that there is very little storage available in the soil.

To provide an outside boundary condition on the high side, the monthly effective precipitation method (USDA NRCS, 1993) was used to calculate the effective precipitation for a 1 in 100 year September. A soil water storage factor was calculated assuming that rainfall fell with perfect irrigation timing, that is precipitation events occurred in lieu of and when irrigation events were scheduled throughout the month. Since irrigation timing for the site is recommended to occur once half the available water has been depleted, the amount of available water holding capacity (i.e. soil moisture depletion) available for storage will always be between 0 and 50 percent. Thus, the storage factor was conservatively calculated assuming half the available water holding capacity was available for storage. Under this scenario 2.75 inches of the 5.43 inches of precipitation falling would be available for vegetation uptake, or 51 percent of the precipitation would be effective during a 1 in 100 year September precipitation event. However, as noted, this is an outside boundary condition on the high side, and the actual 1 in 100 year September effective precipitation will be lower because rainfall will not actually be distributed over the month and timed to coincide with irrigation requirements. With actual rainfall being concentrated in a few days, it is likely that much more than 49 percent of the rainfall will runoff and will not be available for plant uptake.

As another rough estimate of what the effective precipitation could be, consider a hypothetical case in which 1 inch of precipitation was distributed over the month and was fully utilized for plant uptake, while the remainder of the 100 year precipitation (4.43 inches) fell in one event and, due to soil available water holding capacity and other limitations, only 0.5 inches was effective. In this case, which is similar to observed rainfall distributions during extreme September events (e.g. 1986 and 1989), a total of 1.5 inches of 5.43 inches would be effective, giving a precipitation effectiveness factor of 0.28 for the month.

Based on the above, and considering that most of the runoff from major rainfall events is allowed to bypass the runoff collection system, the precipitation effectiveness factor of 0.5, which was presented as a conservative high estimate in the Facilities Plan, is confirmed to be quite conservative. Therefore, a value of 0.4 is used in a "base-case" water balance presented herein and, as was done in the Facilities Plan, a sensitivity analysis is presented to show the impacts of varying this parameter.

The Facilities Plan employed a conservative estimate of irrigation efficiency (the fraction of irrigation water actually being evapo-transpired), 90 percent, to account for runoff recovery and to be conservative with respect to discharge as opposed to vegetation productivity. Such a high irrigation efficiency is likely unachievable at the site given slope conditions and the low water holding capacity of the soils. At a minimum, spray and evaporation losses would be 10 percent, and likely much more due to frequent applications and irrigation during the day. Some runoff and deep percolation losses will also occur, and although there is a runoff collection system, the volume available for reuse will be far less than that collected, due to percolation in the coarse textured earthen trenches. An irrigation efficiency of 80 percent is likely the maximum achievable at the site, and is still conservative with respect to minimizing the discharge. Therefore, the 80 percent value is used for irrigation efficiency in the water balance calculations presented herein.

The water balance in the Facilities Plan is based on reference grass ET, which is an actively growing grass under standardized conditions. The grass growing at the site does not have these standard conditions; Although grass ET is generally equivalent to reference grass ET, there are periods when the two will differ. One such period is the later stages of the growth cycle, when the grasses begin to produce seed. It is likely that this growth cycle occurs in late September and into October at the site, and the overall water demand is likely reduced. In an effort to model these changes, the September ET was reduced by a factor of 0.9 for the water balance discussed below.

## 4.2 WATER BALANCE CALCULATIONS AND SENSITIVITY ANALYSIS

The modifications described above and an updated wastewater influent flow have been incorporated into a revised "base-case" disposal water balance for a 1 in 100 year September, which is presented in Table 1. This water balance is based on a precipitation effectiveness factor of 0.4 and net carryover storage of 2 Mgal of the September flows (stored effluent to be re-treated and discharged to the South Yuba River in subsequent months). As indicated, for this base case, the total irrigation land area requirement would be about 37 acres. Since the existing useable irrigation area is about 34 acres (from Facilities Plan), approximately 3 additional acres would be needed.

The impacts on land area requirements of different precipitation effectiveness factors and different amounts of carryover storage are illustrated in Figure 9. As indicated in the figure, with 2 Mgal of carryover storage, varying the precipitation effectiveness factor from 0.3 to 0.5 results in land area requirements ranging from about 33 to 43 acres. With 34 acres existing, the additional land requirement would range from zero to 9 acres with 2 Mgal of carryover storage. Over the same range of precipitation effectiveness factors, the land area requirement would be about 15 to 20 acres greater with no carryover storage. Since most of the existing 1.56 Mgal Emergency Storage Tank and the future 0.90 Mgal equalization storage capacity can be made available for carryover storage use, it certainly makes sense to do so in a 100 year return frequency rainfall event for the month of September.

The water balance calculations and the resultant land area requirements discussed above are based on clearing the irrigation area and growing only grasses. If substantial irrigation into areas with trees is considered, the land area requirement for the month of September could be slightly lower (but irrigation early in the summer could be delayed).

Table 1
**Base-Case Irrigation Land Area Requirements for Future Flows: Water Balance for a 1 in 100 Year September Precipitation Event (0.4 Precipitation Effectiveness and 2 Mgal Storage)**

| Parameter | September |
| --- | --- |
| **Input Data** | |
| Influent Flow, Mgal/d | 0.21 |
| Precipitation, Inches | 5.43 |
| Precipitation Effectiveness Factor | 0.4 |
| Grass ET, Inches | 5.13 |
| Irrigation Efficiency, % | 80 |
| Allowable Net Volume to Storage, Mgal | 2 |
| **Calculations** | |
| Total Influent Volume for Month, Mgal | 6.3 |
| Total Volume to Irrigation for Month, Mgal | 4.3 |
| Total Water Demand, Inches | 6.41 |
| Effective Precipitation, Inches | 2.17 |
| Maximum Possible Irrigation, Inches | 4.24 |
| Irrigation Land Area Required, Acres | 37.3 |

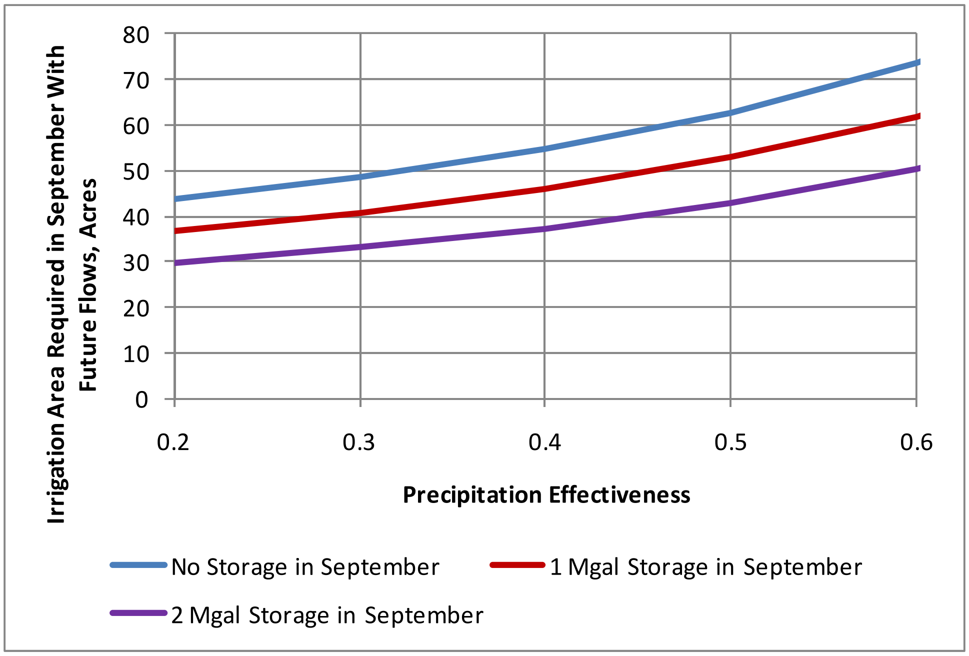


Figure 9
**Irrigation Land Area Requirements, Sensitivity to Storage and Precipitation Effectiveness**

## 4.3 RECOMMENDED IRRIGATION EXPANSION AREA

Based on the analyses presented herein, it is recommended that the irrigation disposal system at the Soda Springs Ski Area be expanded by approximately five acres, using the area shown in Figure 10. As shown in the Figure, the proposed expansion area does not extend all the way to the eastern boundary of the soil investigation area, because existing sprinklers are located at or near this boundary and spray into the area.

Key reasons for the recommended expansion area are summarized below:

1. The expansion area is immediately adjacent to the eastern-most ski run that is currently irrigated.
2. The expansion area fully utilizes the eastern block of the Putt variant 9 to 16 percent slope and that portion of the Putt variant 16 to 20 percent slope area that is uphill from it. These areas are favorable for use based on the soils investigation presented herein. Additionally, the expansion area utilizes the Gefo variant 9 to 16 percent slope, which has deep soil conducive to increased late season irrigation. This area will provide flexibility due to inclement weather and potentially offset storage demands in September.
3. The existing runoff recovery system can be extended easily to serve the proposed expansion area.
4. The approximate 5 acre area accommodates a 1 in 100 year September precipitation effectiveness factor up to about 0.44.

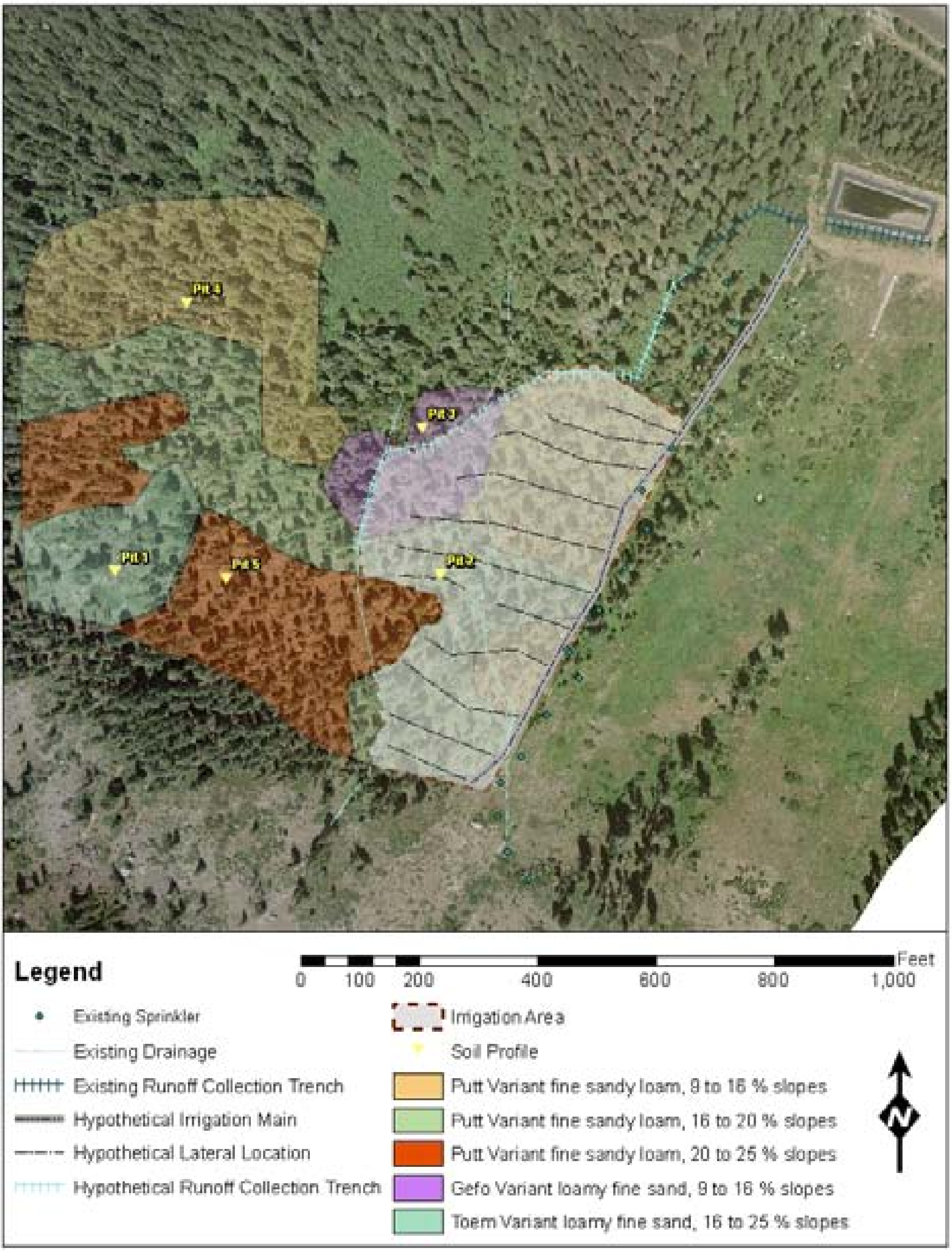


Figure 10
**Proposed Irrigation Expansion Area and Conceptual Layout**

Appendix A

# Pedon Description Sheets

Project: DPSD
Date: 9/30/10

Soil Phase: taxonomic variant
General Location:
Sample/Pit ID: Pit 1
Legal Description:
Lat/Long:
Slope %:
Veg/Crop:
Landscape Position: BS
Parent Material: colluvium/resid
Drainage Class: SW Ex D
Ksat (limiting): v low
WRD: 1.52"
Eff Depth: MD
Aspect: NE
Run Off: H

| Horizon | Depth (in) | Boundary | Hue | V/C | Texture | %C | %RF | Structure gr | Structure sz | Structure type | Consistence Wet | Consistence Stk | Consistence Pls | Roots | Mottles % Sz | Mottles Color | Mottles Loc | Mottles Shp Hrd | Surface Features | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | 7 | CW | 7.5YR | 2/2 | kfs | 6 | 8 gr | 1 | f | sbk | DS | Ø | Ø | cf | | | | | | |
| A2 | 20 | AW | " | 3/3 | vgr fsl | 6 | 20 CB 35 gr | 1 | m | ABK | DS | Ø | Ø | f&c cf | | | | | | |
| Cr | 35+ | highly weathered granodiorite | | | | | | | | | | | | ff | | | | | fract ~ 3' apart | |
| | | | | | | | ~~cont~~ | fractures >10" apart below 33" | | | | | | | | | | | | |
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Comments: surface 25% boulders, cobbles 20% gravels
~ 10% Rock outcrop

umbric
paralithic

$0.1 \times 7 \times .92 + 0.15 \times 13 \times 0.45$
$0.644 + 0.8775 = 1.52"$

$K_{fe} = 0.16$
$K_{w} = 0.07$

loamy-skeletal
PS control sect 25-50 cm 55% RF 8% C

lo-sk [illegible] Dystroxerepts

Taxon variant → skeletal → boulders → fine sand

Project: DSPUD
Date: 9/30/10

Soil Phase Putt taxadjunct General Location ______ Sample/Pit ID Pit 2

Legal Description ______ Lat/Long ______ Slope % ______

Veg/Crop ______ Landscape Position BS of Mountain ~~bk~~ Parent Material till

Drainage Class WD Ksat (limiting) L WRD 3.8" Eff Depth MD Aspect N Run Off H

| Horizon | Depth (in) | Boundary | Hue | V/C | Texture | %C | %RF | Structure gr | Structure sz | Structure type | Consistence Wet | Consistence Stk | Consistence Pls | Roots | Mottles % Sz | Mottles Color | Mottles Loc | Mottles Shp Hrd | Surface Features | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oi | 0.5-0 | CM | Partially decomposed fir & Pine needles | | | | | | | | | | | | | | | | | |
| A1 | 5 | CW | 7.5YR | 2.5/2 | fsL | 8 | 10 gr 3 cb | 2 | m/f | gr | DS | NS | NP | mf cm | | | | | | sli hydrophobic |
| A2 | 11 | CW | 7.5YR | 3/3 | LFS | 3 | 5 gr 2 cb | 2 | f | SBK | DSo | NS | NP | mm ff&c | | | | | | sli Hydrophobic |
| Bt1 | 23 | CS | " | " | vgr fsL | 12 | 10 gr 30 cb | 2 | f | SBK | DSH | NS | NP/SP | mm fc | | | | | ff ct | |
| Bt2 | 35 | GW | " | " | gr fsL | 12 | 16 gr 5 st | 1 | f | SBK | DSo | NS | NP | C | | | | | ff ct | |
| Bqm1 | 57 | GI | 10YR | 5/1 | gr LFS | 5 | 25 gr 8 cb | 0 | | Ma | DH | SS | NP | mat | 7.5YR 3/4 stain along fractures & near cobbles; infilled | | | | | strongly cemented |
| Bqm2 | 60+ | Indurated till similar to above | | | | | | | | | | | | Ø | | | | | | |
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Comments: 10% Boulders / cobbles surface cover

$0.15 \times 5 \times .67 + 0.1 \times 6 \times .92 + 0.15 \times 12 \times 0.6 + 0.15 \times 12 \times 0.84 = 3.8$

(0.655 0.552 1.08 1.5)

umbric
upper 50cm of argillic
argillic PSCnt RF = 32.4% C = 12% $K_{fe} = 0.24$
Duripan Coarse loamy $K_w = 0.18$

Co-L, mixed Frigid Typic Durixeralf
→ isomesic
→ 2vs 10-5K
→ SCF between Bqm horizons in putt not done
→ andic properties?

Putt → losk, mixed, mesic Andic Dystroxerept

Project: OSPWD
Date: 10/1/10

Soil Phase: Gefo variant (from TNF ss) — General Location: SE of SE corner of major wetland — Sample/Pit ID: Pit 3
Legal Description: — Lat/Long: — Slope %: 10-15
Veg/Crop: Fern/lodgepole/Fir — Landscape Position: FS/Fan — Parent Material: outwash alluvium
Drainage Class: WD — Ksat (limiting): MH — WRD: 8.2" — Eff Depth: VD — Aspect: N — Run Off: M

| Horizon | Depth | Boundary | Hue | V/C | Texture | %C | %RF | Structure gr | Structure sz | Structure type | Consistence Wet | Consistence Stk | Consistence Pls | Roots | Mottles % Sz | Mottles Color | Mottles Loc | Mottles Shp Hrd | Surface Features | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oi | 2-0 | Slightly decomposed pine/fir needles | | | | | | | | | | | | | | | | | | |
| A1 | 6 | CW | 7.5YR | 2.5/2 | grLFS | 5 | 18% | 2 | M | SBK | DSo | Ø | Ø | cf | | | | | | Hydrophobic |
| A2 | 16 | CW | 7.5YR | 2.5/3 | grL | 5 | 16% | 1 | C | SBK | DSo-Sh | SS | NP | mf Sf | | | | | | |
| A3 | 27 | CW | 7.5YR | 3/3 | grL | 7 | 16% | 0 | m | | DSH | SS | NP | [illegible] | | | | | | |
| C1 | 37 | gW | 7.5YR | 4/3 | L | 8 | 12% | 0 | m | | DSH | SS | NP | [illegible] | | | | | | |
| C2 | 60+ | | " | 4/3 | grL | 6 | 18% | 0 | m | | DSH | SS | NP | fm | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
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Comments: <2% Surface ≥ cobbles 5% gravel

.492 3.0 1.5 3.2
0.1 × 6 × .82 + .17 × 21 × .84 + .17 × 10 × .88 + .17 × 23 × .82

Kf = .28
Kw = .20

umbric PS Cont Sect 25-100cm · ~15% RF ~7% C Gefo variant

Coarse loamy

Coarse-loamy, mixed, frigid Fluventic Humic Dystroxerepts

Project: 05PMD
Date: 9/29/30

Soil Phase: Putt taxadjunct | General Location: W of large Wetland | Sample/Pit ID: Pit 4
Legal Description: | Lat/Long: | Slope %:
Veg/Crop: | Landscape Position: BS/TS | Parent Material: Glacial till
Drainage Class: WD/MW | Ksat (limiting): VL/L | WRD: 1.84 | Eff Depth: MD | Aspect: N | Run Off: H

| Horizon | Depth (in) | Boundary | Hue | V/C | Texture | %C | %RF | Structure gr | Structure sz | Structure type | Consistence Wet | Consistence Stk | Consistence Pls | Roots | Mottles % Sz | Mottles Color | Mottles Loc | Mottles Shp Hrd | Surface Features | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oa | 14-0 | highly decomposed conifer litter | | | | | | | | | | | | | | | | | | |
| A1 | 5 | CW | 7.5YR | 2.5/2 | CB FSL | 5 | 15 CB 10 gr | 2 | F | SBK | DSo | NS | NP | CF FM | | | | | | |
| Bt | 22 | GW | " | 3/3 | VCBFSL | 12 | 30 CB 20 gr | 1 | M | ABK | DSo | SS | NP | FF CM | | | | | FF CF | |
| Bgm1 | 33 | CW | 7.5YR | 5/4 | Highly fractured 1 | | | | | | VH | | | FFM | | | | | | Fract C1 cm apart |
| Bgm2 | 50 | GI | 10YR | 5/1 | Bedwelded | | | 3 | F | ABK | EH | | | FF in mottled contact | | | | | | thin fract ~4' apart |
| C | 72+ | | 10YR | 5/1 | CBFSL | 5 | 16 CB | | | omm | MSo | NS | NP | 0 | | | | | | Soft moist till w/ weathered casts |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | | |

Comments: 10% Boulders & 15% cobbles surface cover.

0.56 1.275

.15 X 5 X .75 + .15 X 17 X .5 = ~~2.1~~ 1.84 (Potentially ~ 1/4" of AW in 1st Bgm)

Umbric PSCont Entire argillic (5-22)" loamy-skeletal

argillic mixed frigid

Duripan ~~CF between Bgm in pit~~ ~~US mesic~~

Kf 0.28

Kf = 0.15

lo-Skeletal mixed frigid Typic Durixeralf

Tinker/variant

Project: DSP SWD
Date: 10/1/10

Soil Phase: Putt taxadjunct
General Location: Central to Expansion area between P1&2 and upslope
Sample/Pit ID: Pit 5
Legal Description:
Lat/Long:
Slope %: 20%
Veg/Crop:
Landscape Position: BS
Parent Material:
Drainage Class: SWEx
Ksat (limiting): V Low
WRD: 1.8"
Eff Depth: MD
Aspect: NE
Run Off: Hi

| Horizon | Depth | Boundary | Hue | V/C | Texture | %C | %RF | Structure gr sz type | Consistence Wet Stk Pls | Roots | Mottles % Sz Color Loc Shp Hrd | Surface Features | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14-0 | Moderately decomposed Pine & Fir needles | | | | | | | | | | | |
| A1 | 6 | CW | 7.5YR | 2.5/2 | vgrFSL | | 20gr 10CB | 1 M SBK/gran | DS | mf | | | |
| A2 | 18 | CW | 7.5YR | 3/3 | vgrFSL | 3 | 16CB 26gr | 0 Ma | DMf | CF2M | | | |
| Bw | 27 | AW | 10YR | 4/3 | LS | 3 | 20CB 20GR | 2 f SBK | DVH Ø Ø | fmBk | | | discontinuous 2" thick; some cemented fragments |
| Band | 40 | AW | 10YR | 5/4 | LS | 3 | 36CB 25gr | Ma | D EH | Ø | | | 2-4" thick; silica cemented |
| Bqud | 60+ | Indurated Glacial till 50% cbl & CB | | | | | | | | Ø | | | " " |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

Comments: center of pit on old skid trail w/ significant compaction. Described

$0.15 \times 6 \times .7 + .15 \times 12 \times .48 + .07 \times 9 \times .5 = 1.8$

(.63, 0.864, .315)

Kfe = 0.28
Kw = 0.43

Umbric — PS cont 20-27" loamy-skeletal
Cambic — 50% RF, 3% C
Duripan — loamy-skeletal, mixed Typic Durixerepts (potentially andic)

Tinker variant Duripan
- ...
- FSL
- ...(7.5YR)