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September 27, 2003

Dear Director's Office-Nevada bureau of Mines and Geology,

Raymond 'Bud" Burke received an EDMAP grant in 2000 to map surficial geology in Newark Valley, Nevada. As a part of the agreement with EDMAP, the deliverables are supposed to be sent to NBM&G as well as to EDMAP. I was directed to address these packages to you, and that you could find out to whom in your office these materials should be sent.

Thank you so much for your help,

Joanna Redwine and Bud Burke

September 27, 2003

Dear Nevada Bureau of Mines and Geology,

Raymond 'Bud' Burke was awarded an EDMAP grant in 2001 to map parts of the Quaternary geology Newark Valley, Nevada, just east of Eureka, Nevada. My name is Joanna Redwine and I am the student who worked with Bud on this project. We are submitting a copy of our maps and final reports to your agency as well as to the EDMAP committee. We thank you for your support and hope you find these maps useful.

In order to accommodate a variety of scales of features needed for presentation in my MS thesis, maps were sometimes made at more than one scale. Here, I have included all of the maps that were made. In general, maps presented at scales of 1:48,000 and 1:24,000 were mapped in the same level of detail. However, the maps presented at scales of 1:12,000 have more detail in terms of sites with available additional information, and in terms of ease of seeing the smaller units. It is likely that the maps that are at scales of 1:24,000 are all that you will want. In addition to the maps promised and produced for EDMAP, I have mapped the remaining parts of Newark Valley, but did not finalize all of the maps for my thesis. I plan to finish these maps, hopefully, in the near future. If any edits of the maps submitted here or additional information is desired, please let me know.

Enclosed are 17 maps at a variety of scales. The maps included are:

Map	Scale
Pluvial Lake Newark and Surficial Geology of Parts of Newark Valley, East-Central Nevada.	1:150,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Beck Pass 7.5 Minute Quadrangle.	1:48,000
Preliminary Surficial Geologic Map of the Quaternary Units of the Cold Creek Ranch 7.5 Minute Quadrangle.	1:48,000
Preliminary Surficial Geologic Map of the Quaternary Units of the Cold Creek Ranch 7.5 Minute Quadrangle.	1:24,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Cold Creek Ranch NW 7.5 Minute Quadrangle.	1:48,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Cold Creek Ranch NW 7.5 Minute Quadrangle.	1:24,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Cold Creek Ranch NW 7.5 Minute Quadrangle.	1:12,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Christina Peak 7.5 Minute Quadrangle.	1:48,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Christina Peak 7.5 Minute Quadrangle.	1:24,000

Map	Scale
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Diamond Peak 7.5 Minute Quadrangle.	1:24,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Diamond Peak 7.5 Minute Quadrangle.	1:12,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Mooney Basin 7.5 Minute Quadrangle.	1:48,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Mooney Basin 7.5 Minute Quadrangle.	1:24,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Silverado Mountain 7.5 Minute Quadrangle.	1:48,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Silverado Mountain 7.5 Minute Quadrangle.	1:24,000
Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Silverado Mountain 7.5 Minute Quadrangle.	1:12,000
Photogeologic Map of the Surficial Geology of Part of the Pancake Summit 7.5 Minute Quadrangle.	1:40,000

I have included one paper copy of each map as well as a CD with a pdf file of each map and a pdf file of the legend. The legend is included on all maps that are at scales of 1:24,000 as well as the Cold Creek Ranch map at a scale of 1:48,000, and the basin wide map of Newark Valley at a scale of 1:150,000. The remaining maps do not have a legend attached to the map.

I have included a copy of an INQUA (International Quaternary Association) guidebook article that has in it a summary of my thesis (pages 30-37). In addition, I have included a report describing the methodology used in this mapping, the mapped units, and some resulting interpretations of the Quaternary history of Newark Valley. If more explanation of the maps or of the geology of Newark Valley is needed or wanted, I will be happy to send you a copy of my thesis. Please let me know if any additional edits are desired for these maps.

I want to thank you for awarding us this grant money. I learned a huge amount about mapping and about Quaternary geology, and I had a great time doing it.

Again,

Thank You!!!

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Surficial Geologic Maps of the Quaternary Units of Parts of Newark Valley, East-Central Nevada.

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September, 2003

A summary of the M.S. thesis by Joanna L. Redwine, and a report to go with maps made for EDMAP and funded by EDMAP, two student grants from the Geological Society of America, the Jonathan O. Davis scholarship from the Desert Research Institute, Reno, and a Humboldt State University Geology Club grant.

Introduction

Seventeen maps, including one partially finished basin-wide map, at a scale of 1:150,000 and sixteen maps covering all or parts of eight 7.5 minute USGS quadrangles at scales of 1:48,000, 1:24,000, and 1:12,000, were made of surficial geologic units of parts of Newark valley, east-central Nevada. This summary includes descriptions of Quaternary units in Newark Valley, inferences made from the characteristics and the relative ages of the Quaternary surficial units, and a summary of the pluvial lake history of Lake Newark, including ages and characteristics of multiple ages of shorelines.

Mapping of Surficial Quaternary Units

As an integral component of the pluvial Lake Newark paleoclimate study, surficial geology and geomorphic maps were made of Quaternary deposits in portions of Newark Valley. These maps identify alluvial fans, lacustrine deposits, and faults. Geomorphic maps were made of portions of nine of the seventeen USGS 7.5 minute quadrangles that comprise Newark Valley. These maps are a compilation of information from a variety of sources and levels of investigations and are presented here as a work in progress. Mapping was compiled on 1990 black and white, 1:40,000 scale air photos for the entire basin. In addition, 1965 black and white 1:15,700 scale photos were used for locations near Lone Mountain of the Silverado Mountain quadrangle and near Cold Creek Reservoir including parts of both the Cold Creek Ranch and Christina Peak quadrangles. Detailed field checking of units mapped on air photos was conducted in portions of the basin, covering parts of the following 7.5 minute quadrangles: Cold Creek Ranch NW, Christina Peak, Diamond Peak, and Silverado Mountain. A photogeologic map of part of the Pancake Summit quadrangle has slightly different units than the other geologic maps. The remaining portions of those 7.5 minute quadrangles, as well as part of Mooney Basin and a small part of Beck Pass quadrangles, were mapped from air photos with limited field checking and are presented at scales of 1:48,000 and 1:24,000. The Cold Creek Ranch 7.5 minute quadrangle was mapped at a scale of 1:24,000 using air photos with limited reconnaissance level field checking. This quadrangle is also included at a scale of 1:48,000. All completed maps have been incorporated into an incomplete basin wide map at a scale of 1:150,000. Some of the basin does not have detailed geomorphic mapping completed, but does have shoreline information related to the history of pluvial Lake Newark. The entire basin has been mapped at a scale of 1:24,000, and these results are in a variety of stages of completion. Station numbers indicate sites of more detailed information tabulated and presented in Table 1.

Alluvial Fans. Alluvial fans were differentiated into four relative ages based on shades of gray in air photos, amount of dissection, topographic position, slope, and relation to shorelines within Newark Valley. Age estimates of alluvial fan units Qf1, Qf2, and Qf3, in order of increasing age, were based on their relation to the two suites of shorelines within the valley. Where no direct shoreline relations were available, alluvial fan units were correlated to these age estimates based on qualitative age parameters and were mapped as Qf1a, Qf2a, and Qf3a. Qf4 has no physical relation to shorelines in the valley and therefore is not subdivided. The darkest alluvial fans in the air photos are the youngest alluvial fans and the lightest alluvial fans are the oldest alluvial fans. The color change is most likely related to an increase in $CaCO_3$ content with time as well as increasing erosion that exposes pedogenic carbonates at the ground surface. Depth of dissection and number of channels in alluvial fans increases with increasing age. Topographic position of alluvial fans, in general, is higher for older fans than for younger fans. Measured slopes of alluvial fans within a given area, in a very general sense, decrease with decreasing age. Qf1 alluvial fans (the youngest) have soils with maximum stage I to I+ $CaCO_3$ stage morphology. Qf3 alluvial fans appear to have a maximum stage III to IV $CaCO_3$ morphology. Intermediate alluvial fans appear to have intermediate levels of soil development and $CaCO_3$ accumulation. Soil development has only been assessed on a reconnaissance level in gully exposures at this time, and no complete soil descriptions have been made.

Desert pavement, thickness of the vesicular A (Av) horizon (Gile et al., 1981), and desert varnish were also examined as relative age parameters. Desert varnish did not successfully distinguish ages of surfaces because of the high percentage of $CaCO_3$ rich rocks that do not develop desert varnish. Av horizons do appear to increase in thickness with an increase in age of the surface, however, these data were not adequately measured to be used as a distinguishing parameter. Desert pavement appears to increase in development from the Qf1 to Qf2 surface, then decrease with time. This parameter was not consistently used. Young beach deposits, partially remobilized young beach deposits, and alluvial deposits that interfinger with one another are generally unmappable at the scales used for this mapping project and were mapped as Qi (indistinguishable). Additional landforms were distinguished and mapped as described in the legend.

Three, or possibly four, general relative ages of alluvial fans were recognized in Newark Valley. Within each relative age range, it is likely that there is a variety of actual alluvial fan ages. Alluvial fans classified as Unit Qf4 are the oldest units recognized in the valley. These fans are characterized by, relatively deep dissection (unmeasured), discontinuous surfaces, poor preservation, and light gray to off-white colors on air photos. It is possible they are similar in age to fans identified as unit Qf3. Unit Qf3 alluvial fans are characterized by their light gray to off-white colors in air photos, deep dissection by gullies up to 15 m deep, and surface slopes from 7 to 8 degrees. Unit Qf3 has stage III to IV $CaCO_3$ development in soil profiles that have not been formally described at this time. These fans have cut into or been buried by, shorelines of OIS 6 age, which appear to be roughly pedologically correlative to Unit Qf3. Unit Qf2 is identifiable by a medium gray color on air photos, moderate dissection by gullies from 3 to 5 m, and surface slopes from 5 to 7 degrees. Unit Qf2 fans generally occupy a lower topographic position than do fans of units Qf3 and Qf4. Unit Qf2 buries the oldest suite of shorelines in Newark Valley of estimated OIS 6 age. Shorelines of OIS 2 age often cut into or bury fans of unit Qf2 (Silverado Mountain quadrangle). Alluvial fans of Qf1 age are characterized by a dark gray color on air photos, minimal dissection with gullies generally from 1 to 2 m deep, surface slopes from 4 to 8 degrees, a lower topographic position than units Qf2, Qf3, and Qf4, with occasional bar and swale topography; and they overlie shorelines of OIS 2 age. Some alluvial fans within this relative age assignment (unit Qf1) have patterned ground possibly indicative of freeze-thaw conditions, smectitic clays, or salt accumulations. Regardless of the cause for the patterned ground, its occurrence may be related to the age of the unit, and the amount of pedogenic calcium carbonate accumulated within the deposit. With few exceptions, modern alluvium has been mapped as unit Qf1.

Thus far, the age of Unit Qf3 has been assigned to OIS 6, the age of Unit Qf2 to OIS 4, and the age of Unit Qf1 to OIS 2. However, if alluvial fans are deposited coeval to, or slightly before, shoreline highstands, Unit Qf3 would be related to its overlying shorelines of OIS 6 age, Unit Qf2 would be related to its overlying shorelines of OIS 2 age, and Unit Qf1 will be related to the next shorelines in Newark Valley, OIS 0. In this scenario, there are no alluvial fans relating to an OIS 4 age. If alluvial fans are deposited after the shoreline highstand, burying the shorelines, Unit Qf3 is related to OIS 8 or older, Unit Qf2 is related to OIS 6 (and OIS 4?), and Unit Qf1 is related to OIS 2. In this scenario OIS 4 is not represented unless Qf2 actually does represent two ages of alluvial fans. It may be that Unit Qf2 has been incorrectly identified as a deposit of one age, and is actually composed of two (or more) ages of alluvial fans. Because the relation of shorelines and alluvial fans was one of the primary factors in the reconnaissance effort to distinguish fan ages, the lack of shorelines preserved from an OIS 4 lake prohibited the direct relation of any alluvial fans to an OIS 4 shoreline deposit.

Either of the two possibilities presented here, of assigned relative ages of these alluvial fans, could be correct. The first possibility suggests Unit Qf2 would represent OIS 4 and 2. The second possibility suggests Unit Qf2 would represent both OIS 6 and 4. Further investigation of stratigraphy and soil development will help confirm the correlation of alluvial fan ages with shoreline ages and therefore their relation to pluvial lake highstands and paleoclimate conditions. Reconnaissance soils investigations suggest the first relative age assignments presented here seem more likely to be accurate because Unit Qf3 appears to be pedologically correlative to shorelines of OIS 6 age and Unit Qf1 appears to be pedologically correlative to shorelines of OIS 2 age. Alluvial fans most likely represent a time continuum of deposition, but are probably more active during wetter pluvial periods, than during interpluvial periods. Ongoing investigation of stratigraphy and soil development will provide evidence allowing the establishment of the relation of alluvial fans with mapped shorelines of known ages and therefore the relation of fan formation to pluvial lake highstands and Paleoclimate conditions.

Paleowind Direction. Landforms that indicate paleowind direction information, such as sand dunes, spits, and cuspate barriers, were mapped and indicated with arrows denoting interpretations of dominant wind direction at the time of the formation of the landform. The geomorphology of sand dunes has only been explored through air photo and topographic map interpretation at this time. Information from this reconnaissance effort suggests that the sand dunes are often steepest on the north side suggesting many of them may have been formed by winds originating from the south. In addition, there are some sand dunes in Newark Valley that have geomorphology suggestive of formative winds originating from the east and the west. In contrast, shoreline features (i.e., spits, and maybe hornblende. Thin sections of some tufa samples were also made (Redwine, 2003). These samples also are composed of a $CaCO_3$ micritic matrix with grains of micrite cement and have rounded to angular grains. The greatest quantity of angular grains is in the Spencer Hot Springs sample, which also has some silt sized rounded grains. The soil $CaCO_3$ samples have laminations concentrated in the base of the sample, are the densest of all samples collected, and have brecciated grains visible in hand samples. There may be biological material, perhaps some kind of flowering plant or algae in one sample from the Four Corners site (Cold Creek Ranch NW quadrangle) although it is very preliminary in its identification (Miller, personal communication, 2002). In addition, in this sample, there are potentially ooids and fecal pellets from either an earthworm or lacustrine worm (Miller, personal communication, 2002). However, these potential fecal pellets may be interpreted as root casts (Aalto, personal communication, 2002). Because there are no definitive identifying features within samples, field relations were also used to try to help solve the question of depositional origin of the Hacienda Rock. These deposits are ~horizontal and in places are ~9 m (30 ft) thick, and in places are laterally continuous for ~1 km.

The depositional environment of the 'Hacienda' rocks is still unknown. Thin sections suggest they are more similar to spring deposits and lacustrine carbonates than to soil carbonates. Stratigraphic relations also suggest that due to their thickness, they are probably not cemented pedogenic $CaCO_3$ horizons, and because of the lateral extent and horizontality, a spring or lacustrine origin is more likely. The age of these deposits is totally unknown. A best guess from preservation of the 'Hacienda rock' deposit is that it is Pliocene to Pleistocene in age, although it could be much older.

Faulting in Newark Valley

Previous regional mapping (scale 1:250,000, 1° X 2°) (Dohrenwend et al., 1991; Ertec Western Inc., 1981) of faults in Newark Valley resulted in the identification of the location of Pleistocene and potentially Holocene faults. In the present study some additional faults were identified, mapped, and surveyed. These faults offset alluvial fans of three ages in the valley.

Historically, seismicity in this region has been low. There have been several nearby events recorded historically, of magnitude ~3-4 (http://www.seismo.unr.edu/Catalog/catalog-search.html). There was an historical earthquake on April 2, 1875 which is estimated to have had a magnitude of ~5.5. From anecdotal information, the epicenter was placed near Lone Mountain (dePolo and dePolo, 1999). This epicenter is located ~0.8 km west of the playette in which potential moletracks were found (Redwine, 2003). These potential moletracks may be related to this historical earthquake. This region also feels the affects of large earthquakes from more distant sources. For example, on December 21, 1932 there was a M7.2 earthquake near Gabbs, Nevada (~250 km southwest of Newark Valley) that, according to newspaper accounts in the *Elko Daly Free Press*, shook Elko although it did not cause much damage. This 1932 earthquake affected groundwater flow, increasing spring fed discharge from some tributaries into the Humboldt River and decreasing spring discharge substantially in others. There are also personal accounts from Julian Gocoiecea (now deceased) describing a large earthquake in Newark Valley in January of 1932 or 1933 (Redwine, 2003). This event caused Warm Springs (Cold Creek Ranch quadrangle), a strongly producing spring both then and now, to go dry for ~1 month. During this time, Barrel Springs, further south in Newark Valley, a typically low flowing or no flowing spring began flowing extraordinarily strong. These springs returned to their respective 'normal' states after about one month. It seems likely that this was the result of the Gabbs event on December 21, 1933 (Redwine, 2003).

Faults strike in five prominent directions: N40E, N 20E, N 10W, N35W, and N70E (Table 1). Several faults show progressive offset along the same splays of a fault in progressively older geomorphic units (Redwine, 2003). Identifying faults on the western shore of pluvial Lake Newark is problematic because of their interplay with shorelines. One example encountered in Newark Valley is the deposition of alluvial fans onto cuspate shorelines, which are mostly (always?) cemented, thus they hold steep side slopes. A thin covering of fan material on cuspate barriers often results in a landform that looks like a faulted alluvial fan, and can lead to misinterpretation. Far field maximum scarp height and maximum scarp slope of identified faults were measured in a reconnaissance style survey comprised of eye heights and slopes read from a brunton compass (Table 1; Redwine, 2003). A tentative exploration of slip rates was made using these reconnaissance survey data and relative age assignments corresponding to an OIS age correlation. Unit Qf3 is correlated to ~140 ka (OIS 6), unit Qf2 to ~70 ka (OIS 4), and unit Qf1 (OIS 2) with a ~16 ka maximum age. The survey data in combination with these assumed ages result in tentative preliminary slip rates ranging from ~0.04 to ~0.22 mm/yr (Table 1; Redwine, 2003). For comparison, and as an attempt to recognize misidentified faults or erroneous age estimates, beach scarp survey information was also plotted and false "slip rates" calculated. These false "slip rates" range from ~0.4 to 0.8 mm/yr; and are easily distinguishable from slip rates calculated from mapped faults (Redwine, 2003). Surveys with more precise instrumentation as well as additional paleoseismic investigations should be conducted for confirmation, and are planned for future efforts.

Lone Mountain. Surficial geologic maps and topographic surveys including scarp profiles with a Topcon® total station were made to examine the origin of the lineaments in the Lone Mountain location (Silverado Mountain quadrangle). Four backhoe trenches were excavated into the scarp of the western lineament. The Daly Trench was logged and the remaining three trenches (upper, middle, and lower), located just south of the Daly Trench, were sketched and measured, these are presented on the Silverado Mountain 1:24,000 quadrangle and in Redwine (2003).

Surficial geologic maps, topographic surveys, and air photos show constructional beach barriers that are truncated by north-south trending lineaments. Topographic surveys show the western lineament has up to 5 m (17 ft) of vertical variation within its length. Scarp profiles show a general trend of lessening slope gradient to the south. Backhoe trenches (Silverado Mountain quadrangle) show relatively deep water lacustrine sediments alternating with beach gravels that are cut into by unit 8 (Silverado Mountain quadrangle) or BG 3 (Silverado Mountain quadrangle). Unit 8 (Silverado Mountain quadrangle), which is equivalent with BG 3 (Silverado Mountain quadrangle) in all three trenches, is located at 1831 m (6007 ft) and the surface expression is covered by ~245 cm of colluvium. Colluvium has covered the erosional scarp by 2.5 m (~8 feet) along the lineament burying the geomorphology of the erosional shoreline

It is likely that the original geomorphology of these north-south trending lineaments have been modified by lacustrine and, perhaps to a lesser extent, fluvial processes. Some topographic change occurred between the time of deposition of the shoreline at 1836 m (6025 ft) and the time of formation of the erosional shoreline at 1831 m (6007 ft) causing complex cross-cutting relations. The topographic change may simply have been the result of the deposition of shoreline material. It may also be conceivable there may be a fault eastward (basinward) of the present day scarp that behaved like a knick point when the lake level rose again. This would provide a mechanism for the topographic change needed for the lake to change shoreline formation processes (constructional to erosional) and explain why excavation into the modern scarp only reveals an erosional shoreline. To prove this, the area east of the scarp would need to be excavated and examined for offset strata. Unfortunately, the loose nature of the colluvium overlying the scarp and the depth of the erosional shoreline angle suggest that the likelihood of excavating a fault, if it does exist, is minimal. At this point, this theory is entirely conjectural and the most convincing evidence suggests that the lineament is an erosional shoreline.

Moletracks. Trenches across potential moletracks revealed massive silts with no obvious offset, but with measurable fractures. No offset units nor liquefaction pipes were positively identified. These features remain an enigma. A comparison of these "moletracks" with moletracks mapped by John Caskey in Carson Sink from the 1954 Dixie Valley event shows their similarities (Redwine, 2003). The Newark Valley moletracks are better preserved than those formed during the 1954 event. The possibility that the Newark Valley moletracks are related to the 1875 M=5.5 event seems likely because of the fortuitous placement of the epicenter of this event (dePolo and dePolo, 1999; Redwine, 2003). However, the degree of preservation of the Newark Valley moletracks argues that they are younger than, or at least as young as, those formed in 1954. The timing of formation remains unclear because there have been no recorded events, since 1875, with a magnitude of 5.5 or greater. The minimum threshold of surface rupture is M_L of 5.5 and M_S of 6.3 to 6.5 (Bonilla, 1988; dePolo, 1994). Unless surface rupture could be caused by a smaller event, or a large event with an epicenter a great distance away (i.e. Dixie Valley ~200 kms; Gabbs ~250 kms), there is no good candidate event which may have caused the formation of these moletracks unless these features could survive erosional processes since the 1875 event. Weldon et al. (1996) suggest that moletracks are sometimes formed oblique to the trend of the main fault trace, so perhaps the trench sites were not placed across the main fault trace. The lack of observed displacement in the trenches does not completely preclude the possibility of a fault because the material (massive silt) has no marker beds with which to identify displacement with the exception of one green silty clay that may have been displaced by several centimeters. There are fractures with near vertical orientations exposed in the trenches (Redwine, 2003), suggestive of strike-slip faulting. However, these fractures could be related to shrink-swell of clays or freeze-thaw processes. There does not appear to be a functional reason for these features to be anthropogenically generated, but this option has to remain open. The moletrack features remain inconclusive.

Summary of the history of pluvial Lake Newark

Aerial photos (scale: 1:40,000) were used for initial mapping of late Pleistocene and older shorelines. Data obtained from aerial photos were transferred to base maps (USGS 7.5-minute topographic maps, scale 1:24,000). Field verification of aerial photo interpretations and mapping of shorelines followed.

Characteristics of shorelines in Newark Valley. Two categories of lacustrine shoreline features, erosional and depositional, were identified and distinguished while mapping. Erosional shorelines are nearly horizontal wave cut notches cut into hillsides with relatively steep slopes. They are often identifiable on topographic maps as nearly flat tops on bedrock knobs. These features are often accompanied by a beach gravel lag, that, depending, in part, on the age of the feature, may only consist of relatively more rounded and flattened clasts than clasts in colluvium upslope of the shorelines.

Lower gradient topography provides a favorable depositional shoreline environment. These features were field verified by examining geomorphology, surficial characteristics (i.e., clast properties) and, where exposures allowed, stratigraphy. Depositional shorelines can be subdivided into more specific types of shorelines, each describing a specific depositional environment. Some of these types of shorelines have been mapped in Newark Valley, but not all possible distinctions have been made. Depositional shoreline features were given more attention in this study than erosional shoreline features because soil development into these depositional features, along with stratigraphy and fossils within them, offer information regarding timing of formation. Depositional features can also illustrate paleoclimate parameters such as longshore drift direction, a consequence of dominant wind direction.

Regional topography affects initial formation and preservation of shoreline features. If the circumstances are not favorable for formation of fairly large shorelines, the degree of shoreline preservation is less. Detailed investigations of shorelines were concentrated in the more likely locations; however, most of the basin was mapped at some level of field reconnaissance. In the southernmost portion of the basin, south of Highway 50, the basin floor is higher than in the north, resulting in a shallower lake. Here, the basin is no longer confined by the Diamond Mountains, and curves to the southwest around the Pancake Range, towards the Fish Creek Range and (Newark Valley 1:150,000), making the southernmost part of the basin somewhat removed from the main part of the lake basin. These factors decrease the fetch (Redwine, 2003) and wave energy available for construction of shoreline features, resulting in smaller features that are less likely to remain well preserved. In addition, the southern part of the basin floor is wide and is surrounded by gentle slopes dispersing the wave energy, thus decreasing the size of the shoreline features. Even the youngest shorelines are mostly covered by alluvial fans in this region.

In the northern portion of the basin, primarily north of Highway 50, (Newark Valley 1:150,000) there is evidence of more active tectonics, accounting for higher mountain ranges, steeper slopes, and a greater sediment supply than south of Highway 50. These conditions help create larger shoreline features, due both to the sediment available and the greater wave energy produced by the more sudden and extreme base level change. At the northernmost study site, on the Cold Creek Ranch NW quadrangle, and the southern portion of the northern sub-basin, on the Pancake Summit quadrangle, the fetch is the greatest, and large shorelines (primarily baymouth barriers) have been deposited. In addition, older shoreline remnants have been preserved and identified in these same locations. Large cuspate barriers, bars, and barriers are especially prevalent on the western and northwestern shore of Lake Newark in the Diamond Peak, Rattlesnake Mountain, and Christina Peak quadrangles, perhaps due to the large sediment supply from the Diamond Mountains and the steep slopes. Limited exposures reveal some plinthitic (carbonate cemented) shorelines. There are few older shorelines identified in this region. In this environment, shorelines are obscured by faults that closely mimic the geomorphology of the shorelines and often exist in essentially the same locations as the shorelines. In addition, faults displace the shorelines, making the true shoreline elevation difficult to determine. On the eastern and northeastern shore of Lake Newark, in the Cold Creek Ranch, Buck Station, and Buck Mountain West quadrangles there are prominent, plinthitic, cuspate barriers. These plinthitic cuspate barriers may be especially plentiful due to the primarily carbonate bedrock of the southern Ruby Mountains (Hose et. al, 1976; Nutt, 2000) the primary source of sediment and the rock through which surface and subsurface water flows. However, the increase of these plinthitic cuspate barriers may also be apparent as the result of a greater number of exposures in the eastern side than in the western side of the basin. There are few, if any, preserved and identified older depositional shorelines in this area, although there are some high wave cut benches on the West of Beck Pass and Buck Mountain NW quadrangles. The embayment in the Beck Pass NW quadrangle that continues around the basin to the Pancake Summit quadrangle is a location of many segments of older shorelines. Only one site in this region was investigated and mapped in detail for this study.

This study of Newark Valley has identified many shoreline elevations corresponding to at least two, and as many as four, ages of shorelines. Of these four potential age groups of shorelines, the lower two groups are associated with easily identifiable shoreline deposits, and termed younger and older.

Younger shoreline characteristics. In general, the youngest of the age groups of shorelines are thought to correlate to marine oxygen isotope stage (OIS) 2 (~20 to ~13 ka) (Shackleton and Opdyke, 1976) and are considered equivalent to Sehoo age deposits of the Lahontan stratigraphy (Morrison, 1965; 1991). The OIS 2 highstand, at 1845 m (6055 ft), yielded a ^{14}C AMS age of 13,780 $^{+}/-$ 50 ^{14}C yr B.P. These deposits are easily recognized by the youthful appearance of shoreline geomorphology and the abundance of rounded, flattened, and roller beach clasts of varied lithologies on the surface of the features. These deposits have associated soil development with typical Av/Bwk1/Bwk2/2Coxk soil profiles and correlate to a Hydrologic Index value (Mifflin and Wheat, 1979) of 0.29

Shorelines below the highstand elevation (1845 m) have similar geomorphic and surficial characteristics and are assumed to be recessional shorelines associated with that highstand. However, it is possible that some of the lower level shorelines are older shoreline remnants. Mifflin and Wheat (1979), Hubbs and Miller (1948), Snyder et al., (1964), and Reheis (1999a) all had previously identified these shorelines as OIS 2 in age. The detailed surveying of this study modifies the elevation of the highstand slightly from previous studies, ~1.5 m (~5 ft) lower, a minor difference resulting in a small (2-3%) difference in the areal extent of pluvial Lake Newark at that time compared to previous studies.

Older shoreline characteristics. The older group of shorelines may correlate to OIS 6 (~185 to ~135 ka) (Redwine, 2003) and may be time equivalent to the upper Eetza age deposits of the Lahontan stratigraphy (Morrison, 1965; 1991). These deposits have associated soil development with typical Av/Bwk1/Bwk2/2Bkm/2Coxk soil profiles and correspond with Hydrologic Index values (Mifflin and Wheat, 1979) that range from 0.33 to 0.36, and possibly as great as 0.43. The OIS 6 age assignment is supported by soil morphology and soil index calculations (Redwine, 2003). In addition, freshwater snails are exposed in lacustrine stratigraphy of Lone Mountain GP-A that have preliminary amino acid racemization (AAR) ratios tentatively correlative to the Little Valley Alloformation of the Bonneville stratigraphy, thus are suggestive of a middle Pleistocene age (Kaufman, personal communication, 2001).

These older shorelines were initially recognized by discontinuous shoreline geomorphology and the abundance of rounded, flattened, and roller beach clasts of varied lithologies on the surface of the features, and confirmed as the older suite of shorelines using soil development and topographic profiles. Older shorelines occupying the elevations of ~1848 m (6065 ft), ~1850 m (6072 ft), ~1853 m (6080 ft), ~1856 m (6090 ft), ~1860 m (6103 ft), ~1863 m (6113 ft), and ~1866 m (6122 ft) are pedologically and preservationally correlative to each other and most likely represent an OIS 6 lake highstand and associated recessional shorelines (Redwine, 2003). Shorelines at elevations of ~1860 m (6103 ft), ~1863 m (6113 ft), and ~1866 m (6122 ft) lie in the Northern (Cold Creek Ranch NW quadrangle-east) part of the basin, but are affected by faulting complications. Because the sense of motion on the fault and the degree and type of deformation of these shorelines by this fault is not yet understood, these elevations are regarded as potentially representing the OIS 6 age lake. A second northern site (Cold Creek Ranch NW quadrangle- west), thought to be OIS 6 in age, that has only received reconnaissance level attention and has not yet been surveyed, apparently was not affected by faulting. Shorelines in this location are definitely found up to ~1860 m (6103 ft) and most likely exist to ~1874 m (6150 ft). Two wave cut (erosional) shorelines were found in the eastern portion of the basin at 1859 m (6100 ft) and one at 1867m (6125ft). In the southeastern (Pancake Summit quadrangle) part of the basin high shorelines were recognized up to ~1860 m (6103 ft).

Other possible ages of shorelines identified in Newark Valley. Although soil data from OIS 6 shorelines are consistent with each other, preservation differences among these older shoreline deposits suggest that the maximum elevation attained by the OIS 6 age lake may have been 1862 m (6110 ft). Based on soil development, an OIS 8 lake may have reached at least 1848 m (6065 ft), and a pre-OIS 6 age lake may have reached a maximum elevation of at least 1881 m (6170 ft), an elevation 9 m (30 ft) below the potential sill elevation.

No conclusive shoreline evidence for a pluvial lake of OIS 4 age was found in the basin. There are ^{14}C ages from freshwater snails within fine-grained lacustrine sediment below the unconformity from LMt.-GP-A gravel pit (Silverado Mountain; Redwine, 2003) suggestive of an OIS 3 age. Although OIS 3 is an unlikely time for a large pluvial lake, and AAR estimates from the same deposit indicate that the ^{14}C ages are minimum ages, the possibility that the deposit dates to OIS 3 is not ruled out. There is also one preliminary Cl-36 modeled age suggestive of an ~30ka shoreline (Kurth, 2003). However, this age estimate is contrary to associated soil data and elevation data collected for the rest of Lake Newark and, thus, is the details of this interpretation are still being considered.

Potential overflow of Lake Newark and oldest shoreline characteristics. The oldest shoreline features, or potential shoreline features, lack strong geomorphologic evidence that can be easily seen on aerial photographs, topographic maps, or in the field. These potential shorelines are identifiable, primarily, as erosional benches around the basin resembling wave cut platforms and there is often an associated increase in depositional material at what would be the shoreline angle. These locations are sometimes, but not always complemented by the presence of a higher percentage of rounded, flattened, and/or roller clasts than is found above this elevation. In many positions around the basin this degree of evidence could be found at ~1890 m (6200 ft), similar in elevation to the two potential overflow outlets of pluvial Lake Newark and the modern day sill threshold.

Sandstone rollers and flattened and rounded gravels are frequently found in these locations in greater concentrations than are found at higher elevations. However, much of the bedrock on the west side of Newark Valley is sandstone, which tends to round easily, as demonstrated by the presence of rounded sandstone pebbles in channels within canyons where the transport distance was likely not far. This suggests that the presence of rounded sandstone gravels at high elevations is not enough evidence alone to prove the presence of a high shoreline. In the northwest part of the basin rounded basalts were found at 1890 m (6200 ft). These lithologies also appear to round easily and were found in areas and at elevations where the rounded shape did not necessarily indicate much, if any, transport by water. There are some locations where the rounded stones are not derived from local bedrock. In the north (Cold Creek Ranch NW quadrangle), rounded and flat quartz rich siltstone pebbles not derived from the local bedrock were found at 1890 $^{+}/-6$ m (6200 $^{+}/-20$ ft). The low hill on which these pebbles were found is primarily composed of Tertiary volcanics and Mississippian Diamond Peak Formation (Hose et al., 1976). The Diamond Peak Formation does have rounded chert and quartzite pebbles incorporated into it, but not quartz rich siltstone. One rounded and flat clast of this lithology was also found at 1881 m (6170 ft) at the Pancake site at P4 location (Pancake Summit Photogeologic Map), where several rounded sandstone and limestone gravels were also found. A backhoe pit was excavated at P4, where these pebbles were found, which exposed clast supported, subrounded to rounded gravels mostly blown apart by gypsum accumulation. Underlying the gravels is a gently dipping (~5 degrees basinward) erosional surface cut into firm, lacustrine clays, identified from ostracodes (Forester, personal communication, 2003) as Pleistocene in age. This deposit also contains abundant reworked Paleozoic fossils (Forester, personal communication, 2003). This site is located at 1880 m (6170 ft), ~10 m (30 ft) below the overflow sill elevation. This is a common elevation of the many potential very old shorelines, which helps to lend credibility to the interpretation that locations of rounded and flattened clasts of exotic lithologies are shorelines. Sites of field assessment of shoreline features at this elevation are mapped and are identified with their location.

Concrete evidence for the possibility that pluvial Lake Newark, at some time, rose high enough to overflow through Huntington Valley and into the Southern Humboldt River, thus temporarily becoming a part of the Lahontan Basin is limited. However there is suggestive indirect evidence that pluvial Lake Newark did overflow. In the northernmost part of the basin (Cold Creek Ranch NW quadrangle), the two potential overflow channels flowing north from the western and eastern potential sill locations are wide, shallow, and presently occupied by underfit drainages. Their geomorphology suggests that any overflow was most likely intermittent rather than continuous or catastrophic. The gentle morphology of these channels at and near the sill, where not obscured by young sediments, suggests that the maximum lake level would not have been much higher than the overflow level or the discharge would have likely been great enough to incise through the fine material present in the sills. The eastern potential overflow channel quickly becomes large downstream, with large stream terraces on its right bank (Cold Creek Ranch NW quadrangle), indicating incision and a much larger discharge compared with modern day. This eastern channel continues through Huntington Valley and, in the modern day drainage arrangement, only receives drainage from a low hill in the northernmost part of the drainage divide (Cold Creek Ranch NW quadrangle). The western potential sill is presently lower than the eastern potential sill by 1.5-3 m (5–10 ft) (Cold Creek Ranch NW quadrangle). This sill has a channel very much like the one associated with the western potential overflow to the north of the sill. The similarity of the northern channels in both the western and eastern potential overflow sites, and the similarity in elevation, suggests they may have both served as lake overflow channels at some time.

Hubbs and Miller (1948) and Hubbs et al., (1974) suggest that the distribution of related fish species offer evidence that Newark was a part of the Lahontan Drainage system, which supports the idea that Lake Newark did overflow to the north. A species of chub, *Gila bicolor newarkensis*, is found in many springs along the west side of Newark Valley, north of Highway 50. This species is most similar to the species of chub found in the Humboldt River to the north of Newark Valley, *Gila bicolor obesa*, that is characteristic of the Lahontan hydrographic system. South of Highway 50, in Fish Creek Valley, a southern arm of pluvial Lake Newark, another species of chub, *Gila bicolor euchila*, lives in Fish Creek. The differentiation of fish species between Newark and Fish Creek Valleys suggests there has been long isolation between these fish populations (Hubbs and Miller, 1948 and Hubbs et al., 1974). The amount of differentiation between fish species in Newark Valley and the Humboldt River compared with differentiation between fish species in Diamond Valley (east of Newark Valley) and the Humboldt River suggests that Newark Valley has been isolated from the Lahontan hydrographic system longer than Diamond Valley (Hubbs et al., 1974). Lake Diamond overflowed into the Humboldt River, most recently in OIS 2 time (Mifflin and Wheat, 1979; Tackman, 1993).

A hand dug soil pit into the eastern sill in the northern end of Newark Valley revealed a deposit rich in silts and clays with infrequent rounded stones. This soil is formed in either arroyo sediments, loess, lacustrine deposits, or reworked loess and/or lacustrine deposits. This soil is far more developed than any other soil described in fine-grained materials in Newark Valley (Redwine, 2003). However, comparisons of soil properties and soil indexing methods group this soil with the older of the two suite of shorelines correlated with OIS 6 (Redwine, 2003). The age of this sill deposit is probably best understood from its relation to alluvial fans of Qf3 age (Cold Creek Ranch NW quadrangle) which are equivalent to or older than the age of the overlying shorelines, best correlated with OIS 6 (Redwine, 2003), making the sill older than OIS 6.

The oldest of the four potential age groups of shorelines is associated with the elevation of the sill, indicating a potential overflow of pluvial Lake Newark that would temporarily allow Lake Newark to become a part of the Lahontan Drainage Basin. As discussed previously, there has not been any concrete evidence of a shoreline at this elevation or of the implied overflow yet identified. However, the geomorphology of the potential overflow channels, the presence of gravel lags at similar elevations to the sills, and relations of fish populations of Newark Valley with those of the Lahontan Basin (Hubbs and Miller, 1948; Hubbs et al., 1974) are highly suggestive that pluvial Lake Newark did overflow at some time. The timing of this potential overflow is poorly constrained. Based on soil development of the deposit in the sill and relations of the sill with mapped alluvial fans, the timing of an overflow would most likely be much older than OIS 6, perhaps correlative with a large climatic deviation such as that documented during OIS 16. This lake level would be associated with a Hydrologic Index (Mifflin and Wheat, 1979) of at least 0.47.

Additional shoreline soil data. In an effort to understand soil development in Newark Valley as well as ages of Quaternary deposits, fifteen backhoe trenches were excavated into shorelines in the Cold Creek Ranch NW quadrangle site, Pancake Summit quadrangle site, and the Silverado Mountain site. Ten soil pits that were dug by hand into shoreline deposits, and two natural exposures provided an additional twelve descriptions in the four primary study areas. In addition, eight exposures, hand dug and natural, were described in alluvial fill deposits near the potential sills in an attempt to understand the timing of potential overflow. One soil pit was hand dug in the center of the basin to examine soil development in the most recent lacustrine sediments (Newark Valley 1:150,000). Field descriptions of soil development were described using nomenclature described by the Soil Survey Staff (1975) and Birkeland (1999), whereas carbonate stage development was described according to Machette (1985). Of these 36 soil profiles described (Redwine, 2003) laboratory analyses including particle size, organic matter content, pH, and calcium carbonate ($CaCO_3$) % were performed on 18 profiles. In addition, either all or some portion of all soil profiles have been analyzed for bulk density (Redwine, 2003).

In addition, soil indices were calculated for use as a relative age indicator. Soil development can be used as a proxy for time passed since deposition of the parent material in which the soil is developed. Carbonate stage development within soil profiles is particularly useful in the semi-arid setting of the Great Basin. Several soil indices have yielded semi-quantitative age estimations for the geomorphic surfaces in this study. In this way, relative ages of deposits can be determined, correlations between ages can be made, and approximate age estimations can be made by correlation with nearby regions where soil development has been calibrated with numerical age constraints. Three types of soil profile indices were calculated for soils in Newark Valley: (1) the Profile Development Index (PDI) (Harden, 1982; Harden and Taylor, 1983; Birkeland, 1999); (2) the secondary carbonate accumulation index (Cs) (Machette, 1985; Machette et al., 1997); and, (3) four different clay indices (Birkeland, 1999). In addition to the soils described on shorelines, one soil (Lake) was described in the middle of the basin from the playa floor, and one soil (Sill) was described in the eastern sill. All of these descriptions were used in index calculations. In addition, some index calculations were completed on what has been termed for this study the Hacienda soils. Hacienda soils consist of fine sands, silts, and clays and occupy drainages within the potential overflow channels of pluvial Lake Newark. These are alluvial sediments, but with such a high silt content that I hypothesized they likely have been heavily influenced either by eolian input, or by reworked lacustrine sediments of a higher lake level. Detailed soil descriptions, laboratory data, and analyses are in Redwine (2003).

Numerical ages of shorelines. To augment estimates of shoreline ages based on geomorphology, preservation, and soil development, ^{14}C AMS numerical age analyses and amino acid racemization (AAR) age estimates were used where possible. These techniques provided for additional age estimates of the two suites of shorelines. Snail shells were collected from Warm Springs Gravel Pit (WSGP), site 70300-3b (Cold Creek Ranch NW quadrangle), and Lone Mountain Gravel Pite (Lmt. GP), site GP1 (Silverado Mountain quadrangle) for ^{14}C AMS and AAR analyses. Tufa was collected from three gravel pits near Lone Mountain and the Diamond Peak Gravel Pit (DPGP) (Diamond Peak quadrangle) for ^{14}C AMS analyses. ^{14}C AMS analyses were performed by Beta Analytic and the USGS. AAR analyses used procedures outlined in Kaufman and Manley (1998) and were conducted by Darrell Kaufman and Ben Laabs of Northern Arizona University (NAU). To provide context for these age estimations, stratigraphic sections were described from which the materials were sampled (Redwine, 2003). Thin sections were made from some tufa samples to examine the material they are composed of and the degree of alteration of the tufa (Redwine, 2003).

Summary of the history of Pluvial Lake Newark and some regional context. These soil and geomorphic investigations in combination with numerical ages allowed for some interpretation of pluvial Lake Newark's lacustral history. Numerical ages and stratigraphic correlations were used to construct a lake level curve (Redwine, 2003). Pluvial Lake Newark stood relatively high from at least 14,480 $^{+}$/- 40 ^{14}C yr B.P. to at least 13,025 $^{+}$/- 40 ^{14}C yr B.P. during the latest lake cycle. Tufa within Lone Mountain-GP-B (Silverado Mountain quadrangle) records a lake at 14,480 $^{+}$/- 40 ^{14}C yr B.P., followed by a relatively quick transgression to near highstand elevations at 14, 450 $^{+}$/- 60 ^{14}C yr B.P., after which there was a gradual rise in lake level until the maximum, Sehoo equivalent, OIS 2 highstand was attained at 13,780^{+}/-50 ^{14}C yr B.P. Following the highstand was a quick and major recession prior to ~13,690 $^{+}$/- 40 ^{14}C yr B.P., and then a relatively stable lake level persisted until at least 13,025 $^{+}$/- 40 ^{14}C yr B.P after which the desiccation record is unknown (Redwine, 2003).

In some sub-basins of the Lahontan Basin shorelines older and higher than those representing OIS 6 (Reheis, 1999a; Reheis et al., 2002; Reheis, 2003) have been recognized. Subtle indications from field observations suggest that similar high shorelines are likely present in Newark Valley, although timing information is indefinite. To the east, deep water sediments correlated to OIS 6 have been found in the Bonneville basin. However, older lakes with shorelines higher than that of the Bonneville strandline (OIS 2 age) in the Bonneville basin have not been reported. The implication is that either Lake Bonneville does not have the same hydrologic history as Lake Lahontan, or the older high shoreline deposits have not yet been recognized in the Bonneville basin. It is not known if the paleoclimate effects of OIS 6 were different between the Lahontan and Bonneville basins, in part because the Bonneville lake history is complicated by the diversion of the Bear River into the Bonneville basin between OIS 4 and OIS 2, thus the change in volume of water due to paleoclimatic differences can not be quantified (Jarrett and Malde, 1987; Bouchard et al., 1998). In the Lahontan basin (Kurth et al., 2001; 2002; Reheis et al., 2003) and in Newark Valley, the OIS 6 lake was higher than the OIS 2 lake. In the Lahontan basin (Kurth et al., 2002; Kurth, 2003) and in Newark Valley

(Redwine, 2003) any lakes that existed during OIS 4 time appear smaller than, or similar in elevation to, the lakes during OIS 2 time. Likewise, in the Bonneville basin, the OIS 4 lake appears smaller than the lake during OIS 2 (Kaufman, 2003; Oviatt and McCoy, 1988). The similarities between the pluvial histories of the Lahontan basin and Newark Valley, in combination with the proximity of Newark Valley to the Bonneville basin, suggest the apparent differences in hydrologic histories between the Lahontan and Bonneville basins are due to reasons other than differences in paleoclimate.

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LEGEND

Qal	Quaternary modern alluvium. Active channels and drainages younger than or equivalent to Qf1. Often Qal is mapped together with Qf1.
Qf1 / Qf1a	Quaternary alluvial fan, youngest. Characterized by a dark gray color on air photos, minimal dissection with gullies generally from 1 to 2 meters deep, slopes from 4 to 8 degrees, a lower topographic position than Qf2, Qf3, and Qf4, occasional bar and swale topography, and overlie shorelines of marine oxygen isotope stage 2 (13,780 +/- 50 radiocarbon years) age. There are no formal soil descriptions; however, outcrops exhibit a maximum carbonate stage of I to I+. Some alluvial fans of unit Qf1 potentially have patterned ground, possibly indicative of permafrost conditions. Fans too high in elevation to interact with shorelines are distinguished by an 'a', Qf1a, and are correlative with Qf1 from surficial properties and appearance in air photos.
Qac	Quaternary abandoned channel; lies above the modern day alluvial channel (unit Qal) and appears to be recently abandoned.
Qalt	Quaternary alluvium, terrace deposits. Identified on air photos and reconnaissance level field checking as stream terraces above modern alluvium.
Qal1	Quaternary alluvium. Mostly arroyo deposits characterized by a relatively lighter color in air photos (off white to light gray) than Qal2. Soil description generally show sandy loam to silt loam with either weak or no Bt horizons, 2.5YR to 10YR colors, and no clay skins. PDI values for these deposits suggest they are latest Pleistocene to Holocene in age. These deposits overlie deposits of Qal2 age in some places.
Qal2	Quaternary alluvium. Mostly arroyo deposits characterized by a relatively darker color in air photos (medium gray) than Qal1. Soil descriptions generally show silt loam to clay loam with 10YR colors, some clay skins, and Bt horizons. PDI values suggest a late Pleistocene age for these deposits.
Qmb	Quaternary playa deposits with marsh and spring deposits. Primarily composed of silts and clays, located in the middle of the basin, distinguished by many springs and ponded water (marshy areas) and a spotty appearance, suggesting a sandy covering. Primarily identified on air photos with some reconnaissance level field checking.
Qma	Quaternary playa deposits with marsh and spring deposits. Primarily composed of silts and clays, located in the middle of the basin distinguished by considerably more springs and ponded water (marshy) areas than Qmb. Primarily identified on air photos with some reconnaissance level field checking.
Qi	Quaternary undiferentiated. Composed of remobilized Qsly beach deposits and of intact beach deposits and alluvial deposits changing at an unmappable scale. Marine oxygen isotope stage 2 (13780+/- 50 radiocarbon years) and younger.

Qed Quaternary eolian sand dunes. Unit Qed is composed of sand dunes on and around the playa surface. This unit was primarily identified and mapped from a spotty white to gray color in air photos and a lunate or cuspate shape; reconnaisance level field checking in some areas.

Qp Quaternary playa deposits. Composed of silts, clays, fine sands, and salts. One 1-meter deep soil pit exposed silty clay loam to silty clay, with up to 56% clay, some stage I carbonate development (36 to 41% calcium carbonate), and a PDI suggestive of marine oxygen isotope stage 2 age. Includes 'playette' deposits within cuspate barriers, where they occur at a mappable size. Primarily identified and mapped from the white color on air photos and a flat surface.

Qps Quaternary playa deposits with a sandy covering. Composed of silts, clays, fine sands, and salts. Primarily mapped from a white color with a spotty appearance and its flat surface.

Qsp Quaternary spit. Shoreline features formed from longshore currents. Identifiable on air photos by the distinct geomorphology of a relatively wide feature at the point of connection with the edge of the basin that narrows and bends into the basin in the direction of the longshore current. Generally composed of fine gravels to clay sized particles. Primarily identified from air photos and reconnaissance level field checking.

Qsps Quaternary spit with a sandy covering. Identifiable in air photos as areas adjoining a spit, but with a spotty appearance suggesting a higher component of sand and no distinct geomorphology.

Qsly Quaternary beach barriers young. Composed of distinct, individual beach barriers correlated by elevation, preservation, and soil development to marine oxygen isotope stage 2 (13,780 +/- 50 radiocarbon years). Identified by a cigar shaped morphology and mapped from a combination of air photo, field reconnaissance, and detailed field mapping. More individual beach barriers exist than are mapped. Only large and/or easily distinguishable beach barriers or beach barriers in areas of detailed study were mapped.

Qslyu Quaternary shoreline deposits young, undifferentiated. Includes shoreline deposits of all types; bay barriers, cuspate barriers, back barrier lagunal deposits, surface and underlying playette deposits. Deposits correlated by elevation, preservation and soil development to marine oxygen isotope stage 2 (13,780 +/- 50 radiocarbon years) highstand and associated recessional shorelines. Identified in air photos by a concentric, bathtub-ring shape and continuous nature. Field checked in many, but not all locations. Seven soil descriptions show characteristic soil profiles Av/Bwk1/Bwk2/Bwk3/2Ck, with an eolian cap 20-50 cm thick and maximum carbonate stage development of stage I+. Three soil descriptions show profiles with Av/Ck with an eolian cap 5-15cm thick and up to carbonate stage I development.

Qf1,2u Quaternary alluvial fans of both Qf1 and Qf2 relative ages, undifferentiated.

Qf2 / Qf2a — Quaternary alluvial fan, intermediate aged. Characterized by a medium gray color on air photos and moderate dissection, with gullies from 3 to 5 meters, slopes from 5 to 7 degrees; and generally occupies a lower topographic position than Qf3 and Qf4. Qf2 overlies shoreline deposits correlated to marine oxygen isotope stage 6 age and is often truncated and sometimes overlain by shoreline deposits of marine oxygen isotope stage 2 age. Fans too high to interact with shorelines are distinguished by an 'a'. Qf2a is correlated with Qf2 from surficial properties and appearance in air photos.

Qslo — Quaternary shorelines, old. Distinct individual beach barriers correlative by elevation, preservation, and soil development to marine oxygen isotope stage 6. Identified by distinct, cigar shaped morphology from a combination of air photo, field reconnaissance, and detailed field mapping. More individual beach barriers exist than are mapped. Only easily distinguishable barriers or barriers in areas of detailed study were identified.

Qslou — Quaternary beach barriers old, undifferentiated. Includes shorelines deposits of all types; bay barriers, cuspate barriers, back barrier lagunal deposits, surface and underlying playette deposits, etc. Deposits are correlative by elevation, preservation, and soil development to marine oxygen isotope stage 6 (~140ka). Identifiable in air photos by a concentric, bathtub-ring shape and discontinuous nature. Field checked in many locations. Fifteen soil descriptions of this unit show characteristic soil development of Av/Bwk1/Bwk2/Bwk3/2Bkm/Ck, with an eolian cap 20-50 cm thick and maximum carbonate stage development of stage III to IV.

Qf2,3u — Quaternary alluvial fans of both Qf3 and Qf2 relative ages ,undifferentiated.

Qf3 / Qf3a — Quaternary alluvial fan, old. Characterized by a light gray to off-white color in air photos, dissection up to 15 m deep, with slopes from 7 to 15 degrees, and a high topographic position. Soils have not been described, but preliminary examination of outcrops suggest soils developed into unit Qf3 are characterized by stage III to IV $CaCO_3$ development. Qf3 been eroded and buried by shorelines most likely correlative to marine oxygen isotope stage 6. Where Qf3 is too high in the basin to interact with shorelines, or the interaction is unclear, it is distinguished by an 'a'. Qf3a is correlated with Qf3 from surficial properties and appearance in air photos.

Qsi — Quaternary silts and clays with very few rounded clasts. Arroyo, eolian, spring, or lacustrine in origin. PDI calculations suggest the soil developed into this deposit is correlative to marine oxygen isotope stage 6.

Qc — Unit Qc is colluvium of all ages characterized by steep slopes covered with angular talus composed of boulder to gravel sized material.

Qf4 — Quaternary alluvial fan, oldest. Characterized by a light gray to off-white color in air photos, dissection 10 -20+ m, a high topographic position, discontinuity, and poor preservation. May be similar or equivalent in age to fans identified as Qf3. Qf4 has been eroded and buried by and shorelines likely correlative with marine oxygen isotope stage 6 .

Qfu	Quaternary alluvial fans undifferentiated by age.
Qfh,u	Quaternary alluvial fans undifferentiated by age and Quaternary (?) "Hacienda rock", undifferentiated.
Qh	Quaternary (?) "Hacienda rock". Appears in air photos either as flat bedrock with white edges, or as fan morphology with many white spots. Composed of rounded to angular silt sized plagioclase, quartz, glass, mica, and carbonate mud in a micritic carbonate matrix. Has many root tubes and locally contains sparse ooids and/or fecal pellets within the deposits. Up to 12 m (40 ft) thick and is horizontal in all mapped sites. The origin of this deposit(s) is poorly understood. May be groundwater discharge, spring, lacustrine, or some combination in origins. In part, the carbonate matrix has been partially remobilized and appears pedologic in origin. The age of this deposit is poorly constrained and is estimated to be within the Pliocene to Mid Pleistocene range.
Lu	Limestone undifferentiated. Limestone not identified, but likely Mississippian Joana limestone (Hose and Blake, 1970; Hose et. al., 1976; Nutt, 2002) which underlies the Mississippian Diamond Peak.
Mdp	Mississippian Diamond Peak (Hose and Blake, 1970; Hose et. al., 1976; Nutt, 2002).
Bu	Bedrock undifferentiated. Bedrock was mostly not mapped for this study
- - - - - - - -	Crests of beach barriers of shorelines of marine oxygen isotope stage 2 age and associated recessional shorelines.
— · · — · ·	Crests of beach barriers of shorelines correlative with marine oxygen isotope stage 6.
··· ··· ··· ··· ··· ·	Unidentifed lineament, may be shoreline or fault.
(green line)	Lineaments in areas of shoreline influence which are suspected of being a fault, but lacking detailed field investigations or positive field evidence.
(red line)	Fault, solid where positively located, dashed where approximately located, dotted where buried. Adjacent number (e.g. N35W) is fault strike.
? ⇄ ?	Preliminary evidence, channels incised into alluvial fans apparently laterally offset, suggest there may be a lateral component of motion along this fault.
⊘	Locations investigated at or near 1889 m (~6200 ft), the potential overflow elevation, with no field evidence of shoreline/lacustrine depostits.
●	Locations investigated near 1880 m (~6200 ft), the potential overflow level, with evidence suggesting shoreline/lacustrine deposits, either a significant increase in rounded, flattened gravels relative to those above this topographic position, or wavecut bedrock.
Ⓣ	Tufa locations.
◎	Fossil location.

^{14}C Location of radiocarbon sample.

AAR Location of amino acid racemization sample.

* Location where "Hacienda rock" has been found.

Arrow denotes interpretation of dominant longshore current direction at the time of deposition of the adjacent lacustrine feature; interpreted from geomorphology or from mapping of beach gravels of unique lithologies.

Arrow denotes interpretation of dominant wind direction as demonstrated from the adjacent sand dune.

Location of soil description of a hand dug soil pit or natural exposure (see Table 1).

Location of a backhoe trench (seeTable 1).

Field locality and number (see Table 1).

GP Gravel Pit.

Springs

Double sided arrows denote a low saddle in the drainage divide.

References:

Hose, R.K., and Blake, M.C., Jr., 1970, Geologic map of White Pine County, Nevada: U.S. Geological Survey Open-File Report 70-166, 1:150,000.

Hose, R.K., Blake, M.C., Jr., and Smith, R.M., 1976, Geology and mineral resources of White Pine County, Nevada: Nevada Bureau of Mines and Geology Bulletin 85, 105 p., 1:250,000.

Nutt, Constance J., 2002, Geologic Map of the Alligator Ridge Area, Including the Buck Mountain East and Mooney Basin Summit Quadrangles and Parts of the Sunshine Well NE and Long Valley Slough Quadrangles, White Pine County, Nevada, U.S. Department of the Interior, U.S. Geological Survey, Geologic Investigations Series I-2691, scale 1:24,000.

Morrison, R.B., 1991, Quaternary stratigraphic, hydrologic, and climatic history of the Great Basin, with emphasis on Lakes Lahontan, Bonneville, and Tecopa, in Morisson, R.B., ed., Quaternary nonglacial geology; Conterminous U.S.: Geological Society of America, The Geology of North America, Boulder, Colorado, p. 283-320.

Redwine, Joanna L.,2003, The Quaternary pluvial history and paleoclimateimplications of Newark Valley, east-central Nevada; derived from mapping and interpretation of surficial units and geomorphic features, [unpublished MS thesis], Humboldt State University, Arcata, California, 358 p.

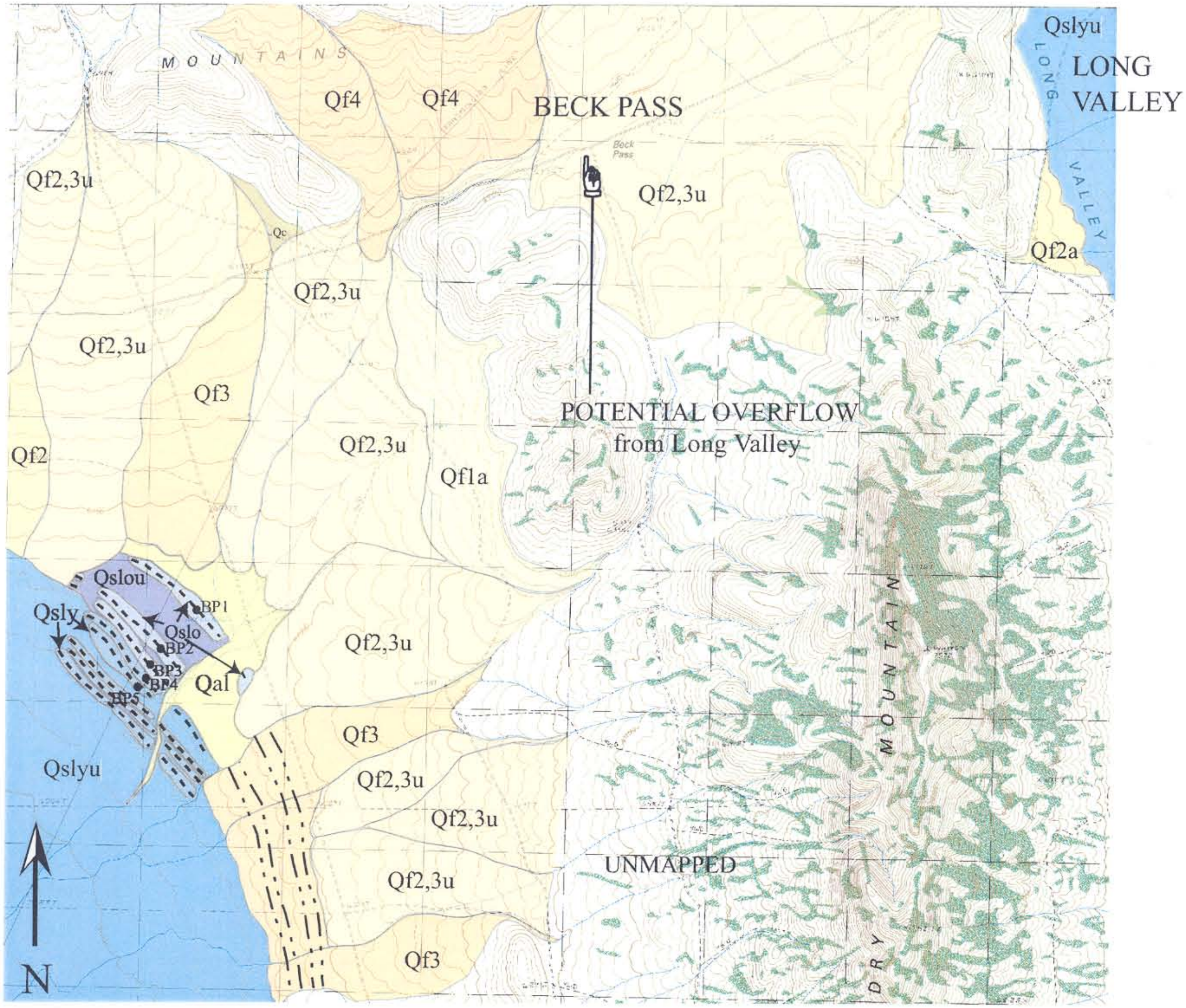
Table 1-Site numbers and field data from Preliminary Geologic Maps of Surficial Geology of the Quaternary Units of Newark Valley, Nevada.

Site #	Quadrangle	Scale	what	[a]Unit Faulted	Estimated Age (years)	fan slope (degrees)	Feature Measured	Scarp Height (meters)	Scarp Slope (degrees)	potential lateral offset (meters)	direction of offset	strike of fault	slip rate (mm/yr)
62801-1	Cold Creek Ranch NW	1:48,000	soil description	[a]NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H1-H2	Cold Creek Ranch NW	1:48,000	soil description	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H3-H6	Cold Creek Ranch NW	1:12,000	soil description	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N1-N7	Cold Creek Ranch NW	1:12,000	soil description	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CP-4	Christina Peak	1:24,000	beach gravels at 1853 m (6080 ft) on Qf2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CP-7	Christina Peak	1:24,000	fault? and shoreline	Qf3 & Qf1	140,000	[b]ND	fault?	ND	ND	possible offset	right	N15E	ND
CP-8	Christina Peak	1:24,000	fault? and shoreline	Qf3	140,000	ND	fault?/[c]sl	yes	ND	14	right	N15E	ND
CP-10	Christina Peak	1:24,000	Qf3 description	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CP-11	Christina Peak	1:24,000	fault or beach scarp measurements	Qf3	140,000	ND	fault	0.1-0.5m	ND	meters	right	ND	0.001-.0004
CP-12	Christina Peak	1:24,000	scarp measurements	Qf3	140,000	ND	fault	yes	ND	12	right	N65E	ND
CP-13	Christina Peak	1:24,000	scarp measurements	Qf3	140,000	ND	fault	yes	ND	24	right	N65E	ND
CP-14	Christina Peak	1:24,000	scarp measurements	Qf3	140,000	ND	fault	yes	ND	yes	right	N10E	ND
CP-15	Christina Peak	1:24,000	scarp measurements	Qf2	70,000	ND	fault	3	ND	no	NA	N10E	0.04
CP-16	Christina Peak	1:24,000	scarp measurements	Qf3	140,000	ND	fault	10	ND	[d]NA	NA	N25E	0.07
CP-17	Christina Peak	1:24,000	scarp measurements	Qi	16,000	ND	sl	1	ND	NA	NA	ND	0.06
CP-18	Christina Peak	1:24,000	scarp measurements	Qi	16,000	ND	fault?/sl	2	ND	NA	NA	N10-20E	0.13
CP-19	Christina Peak	1:24,000	scarp measurements	Qf3	140,000	ND	fault	20	15	NA	NA	~N	0.14
CP-22	Christina Peak	1:24,000	scarp measurements	Qf3	140,000	ND	fault	20-26	20	NA	NA	N40E	0.14-0.19
CP-23	Christina Peak	1:24,000	scarp measurements	Qf2	70,000	ND	fault	13	19	NA	NA	N40E	0.19
CP-24	Christina Peak	1:24,000	location of beach	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CP-25	Christina Peak	1:24,000	scarp measurements	Qsly	16,000	ND	beach	8	ND	NA	NA	NA	0.50
CP-26	Christina Peak	1:24,000	location of beach	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
70200-10b	Rattlesnake Mountain	1:150,000	scarp measurements	Qi	16,000	ND	fault?/sl	5	ND	NA	NA	ND	0.29
70200-10b	Rattlesnake Mountain	1:150,000	scarp measurements	Qi	16,000	ND	fault?/sl	7	ND	NA	NA	ND	0.41
70200-10b	Rattlesnake Mountain	1:150,000	scarp measurements	Qi	16,000	ND	fault?/sl	8	ND	NA	NA	ND	0.48
70200-10b	Rattlesnake Mountain	1:150,000	scarp measurements	Qi	16,000	ND	fault?/sl	7	ND	NA	NA	ND	0.41
70200-10b	Rattlesnake Mountain	1:150,000	scarp measurements	Qf2	70,000	ND	fault?/sl	15	ND	NA	NA	N42W	0.22
70200-10b	Rattlesnake Mountain	1:150,000	scarp measurements	Qf2	70,000	ND	fault?/sl	15	ND	9?	?	N37W	0.21
101701-1	Diamond Peak	1:12,000	scarp measurements	Qsly	16,000	ND	beach	6-8	10	NA	NA	ND	0.39-0.52
101701-2	Diamond Peak	1:12,000	scarp measurements	QF2on3	70,000	ND	fault	7	11.5	NA	NA	N35W	0.10
101701-4	Diamond Peak	1:12,000	scarp measurements	Qf3	140,000	ND	fault	12	12	NA	NA	ND	0.09
101701-5	Diamond Peak	1:12,000	scarp measurements	QF2on3	70,000	5	fault?/sl	12	15	NA	NA	N35W	0.17
101701-6	Diamond Peak	1:12,000	scarp measurements	Qf3	140,000	7	fault?/sl	17	12	NA	NA	N7W	0.12
101701-7	Diamond Peak	1:12,000	scarp measurements	Qsly	16,000	ND	beach	12	17	NA	NA	ND	0.77
101701-9a	Diamond Peak	1:12,000	scarp measurements	Qf3	140,000	15	fault	26	26	NA	NA	N35W	0.19
101701-9b	Diamond Peak	1:12,000	scarp measurements	Qf3	140,000	10	fault	31	26	NA	NA	N40W	0.22
101701-9c	Diamond Peak	1:12,000	scarp measurements	Qf3	140,000	17	fault	26	26	NA	NA	ND	0.19
101701-9d	Diamond Peak	1:12,000	scarp measurements	Qf3	140,000	8	fault	20	24	NA	NA	ND	0.14
101701-9e	Diamond Peak	1:12,000	scarp measurements	Qf2	70,000	11	fault	9	16	NA	NA	N37W	0.13
101701-10	Diamond Peak	1:24,000	scarp measurements	Qf2	70,000	ND	fault	3	13	NA	NA	N15W	0.04
101701-11	Diamond Peak	1:24,000	scarp measurements	Qf3	70,000	ND	fault	8	20	NA	NA	N15E	0.11
101701-12	Diamond Peak	1:24,000	scarp measurements	Qf3	70,000	ND	fault	15	20	NA	NA	N15E	0.22
70200-2	Diamond Peak	1:24,000	stratigraphy and age control	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
71500-3	Silverado Mountain	1:48,000	stratigraphy and age control	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Daily Trench	Silverado Mountain	1:12,000	stratigraphy and age control	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Upper, middle, and lower trenches	Silverado Mountain	1:12,000	stratigraphy	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LMt 1-6	Silverado Mountain	1:12,000	soil descriptions	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GP 1,2, &3	Silverado Mountain	1:12,000	stratigraphy and age control	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WSGP (70300-3)	Mooney Basin	1:48,000	soil description, stratigraphy, and age control	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
P1-P7	Pancake Summit-Photogeologic Map	1:40,000	soil descriptions	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes. [a]-Not Applicable. [b]-No data available. [c]-shoreline.

For additional information, see Redwine (2003).

Preliminary Surficial Geologic Map of the Quaternary Units of Part of the Beck Pass 7.5 Minute Quadrangle.



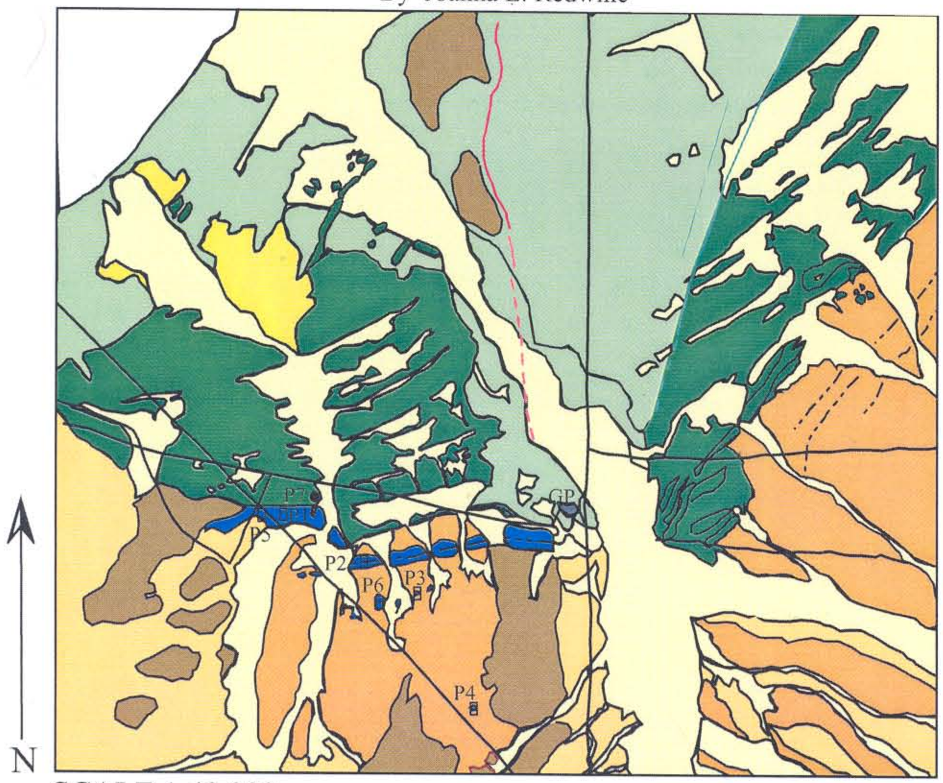
0 KM 1 2 3
0 MILE 1 2

SCALE 1:48,000
CI= 40 ft.

By Joanna L. Redwine

Photogeologic Map of the Surficial Geology of Part of the Pancake Summit 7.5 Minute Quadrangle.

By Joanna L. Redwine



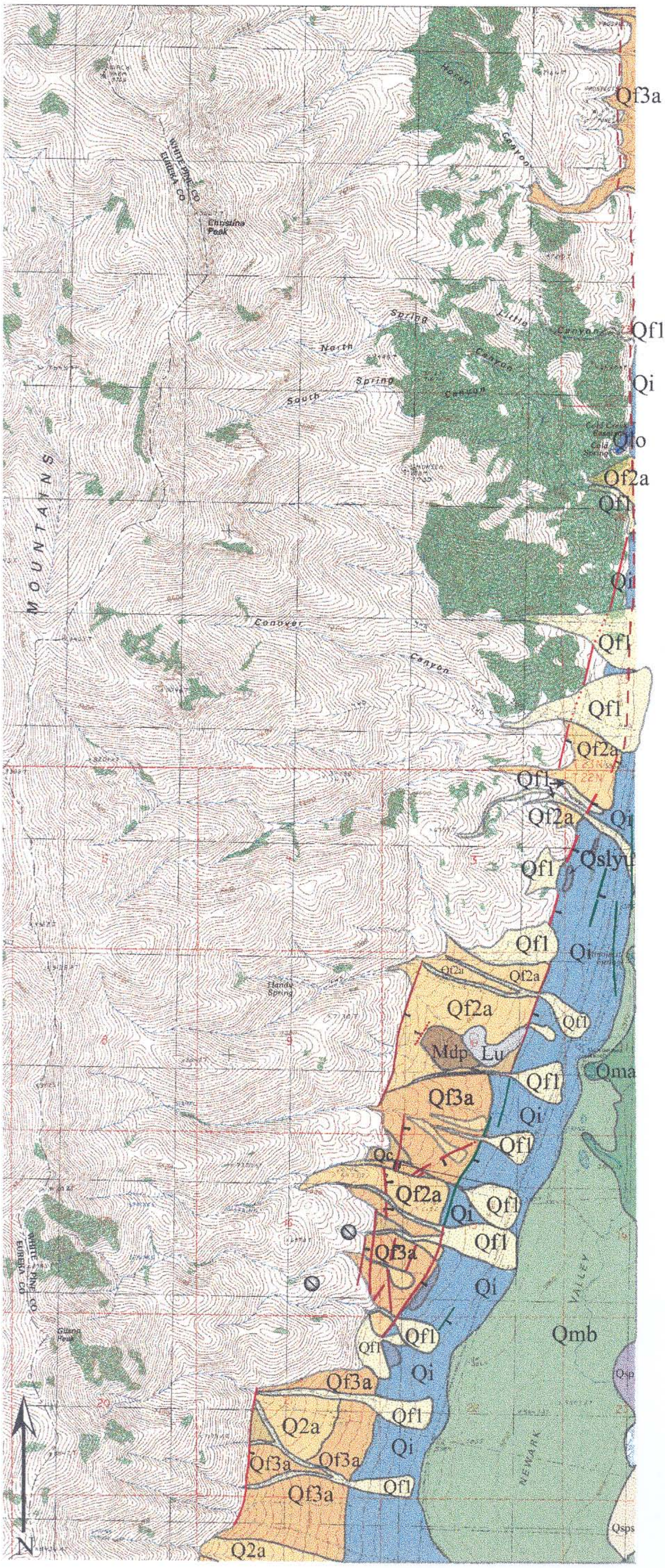
SCALE 1:40,000

Legend

- Qlp — Lacustrine playa deposits younger than or equivalent to ~13,780 ^{14}C yr B.P.
- Qf1b — Alluvium and fan deposits younger than Qf1a.
- Qf1a — Alluvium and fan deposits younger than latest Pleistocene shorelines <~13,780 ^{14}C yr B.P.
- Qle — Eroded lacustrine shoreline features associated with Qsly.
- Qsly — Latest Pleistocene lacustrine shoreline deposits younger than or equivalent to ~13,780 ^{14}C yr B.P.
- Qf2 — Alluvial fan deposits older than ~13,780 ^{14}C yr B.P. and younger than shorelines correlative to marine oxygen isotope stage 6.
- Qslo — Older lacustrine shoreline deposits correlative to marine oxygen isotope stage 6.
- Qf3 — Alluvial fan deposits older than Qslo.
- Mdp — Mississippian Diamond Peak formation. Conglomerate and sandstone facies.
- (blue line) — Undefined lineament.
- (red line) — Fault. Solid where observed, dashed where approximated.
- (dash-dot line) — Shoreline barrier crest of Qslo age.
- (solid line) — Shoreline barrier outlines of Qsly age.
- P# — Station number corresponding with soil descriptions (Table 1).
- ▯ — Backhoe Pit.
- ● — Hand dug soil pit.

Preliminary Surficial Geologic of the Quaternary Units of Part of the Christina Peak 7.5 Minute Quadrangle.

By Joanna L. Redwine



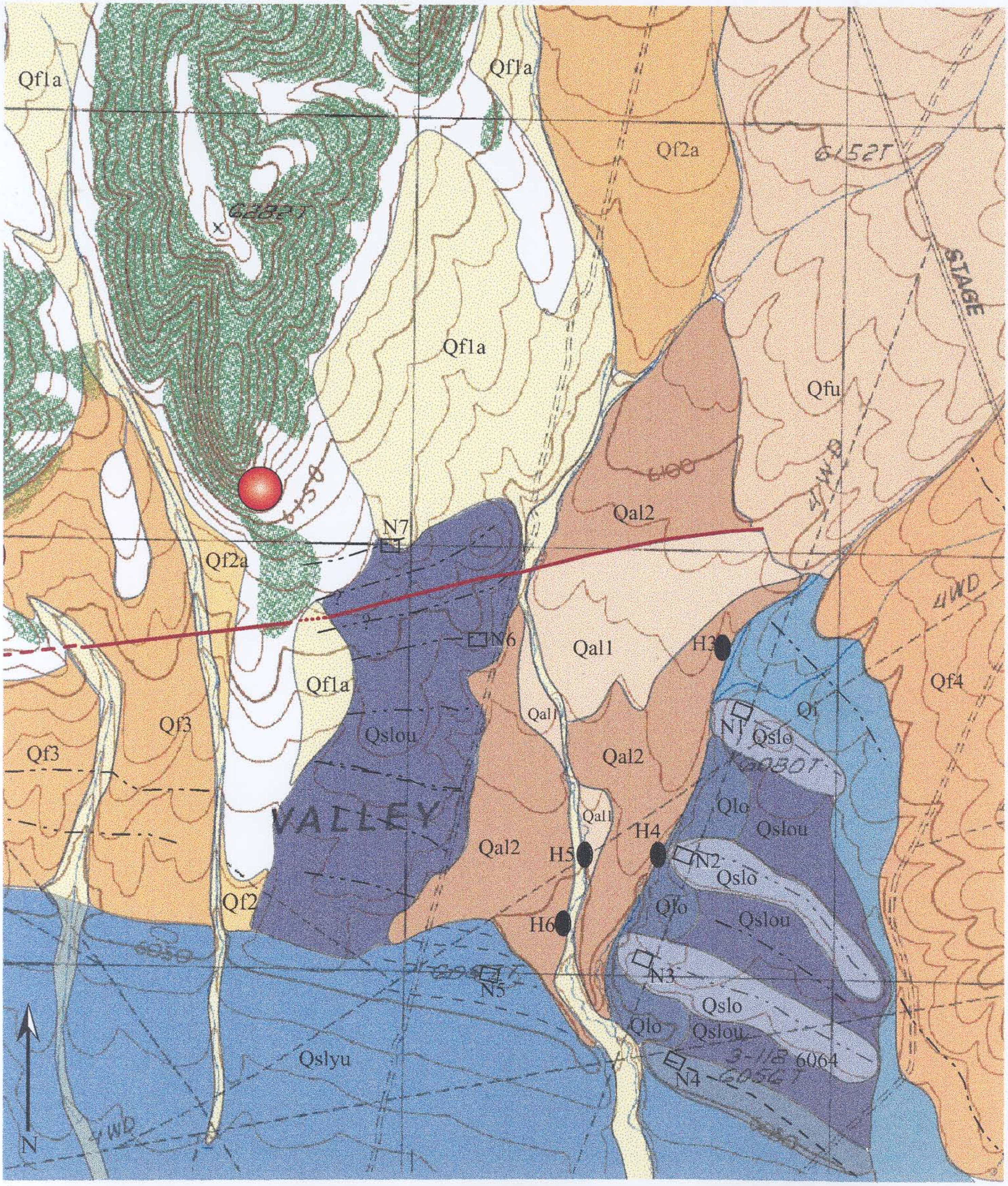
0 1 2 KM 3
0 1 MILE 2

SCALE 1:48,000
CI=40 Ft.

6000 0301 (

Preliminary Surficial Geologic Map of the Quaternary Units of part of the Cold Creek Ranch NW 7.5 Minute Quadrangle.

By Joanna L. Redwine



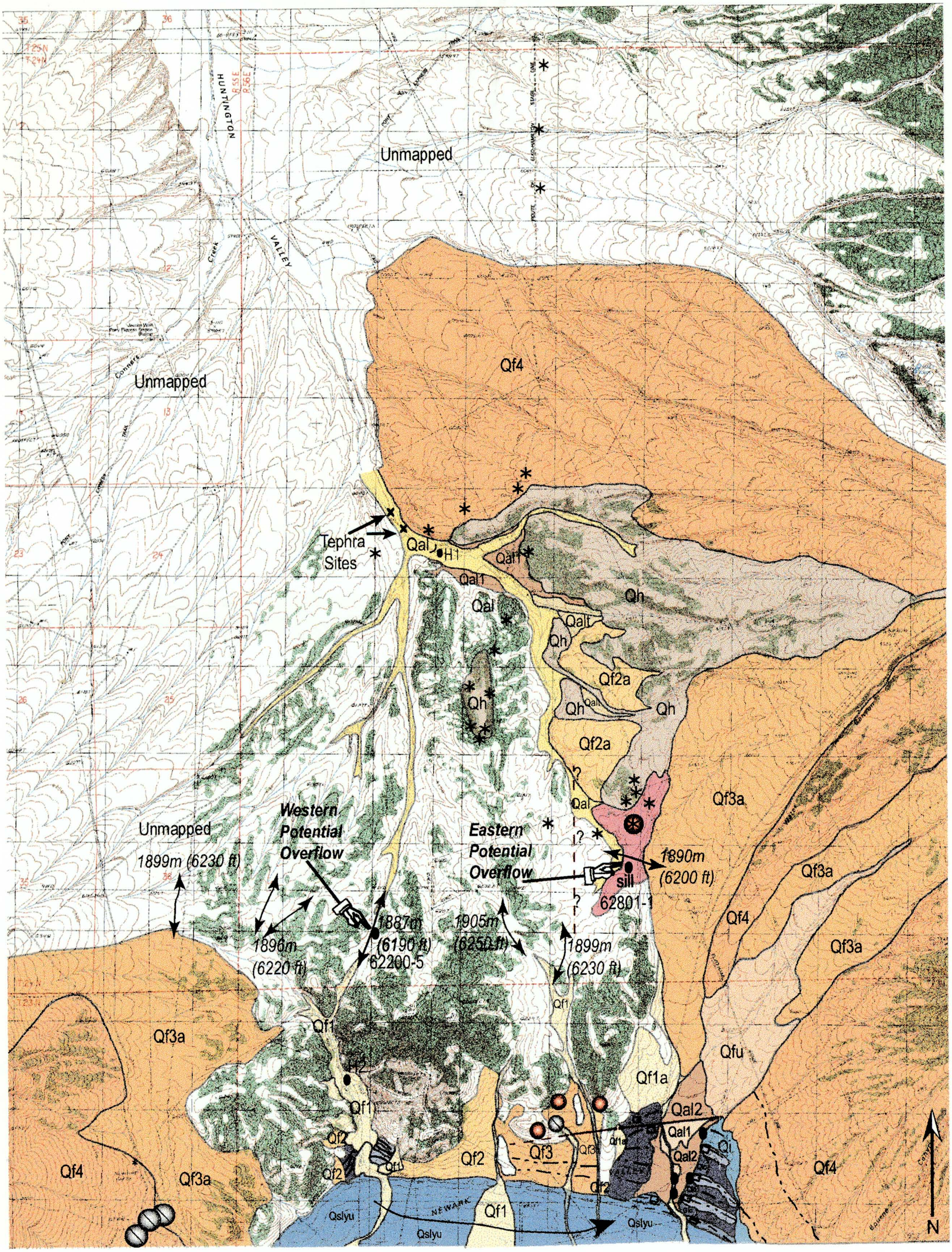
0 1

KM

SCALE 1:12,000

CI=10 ft.

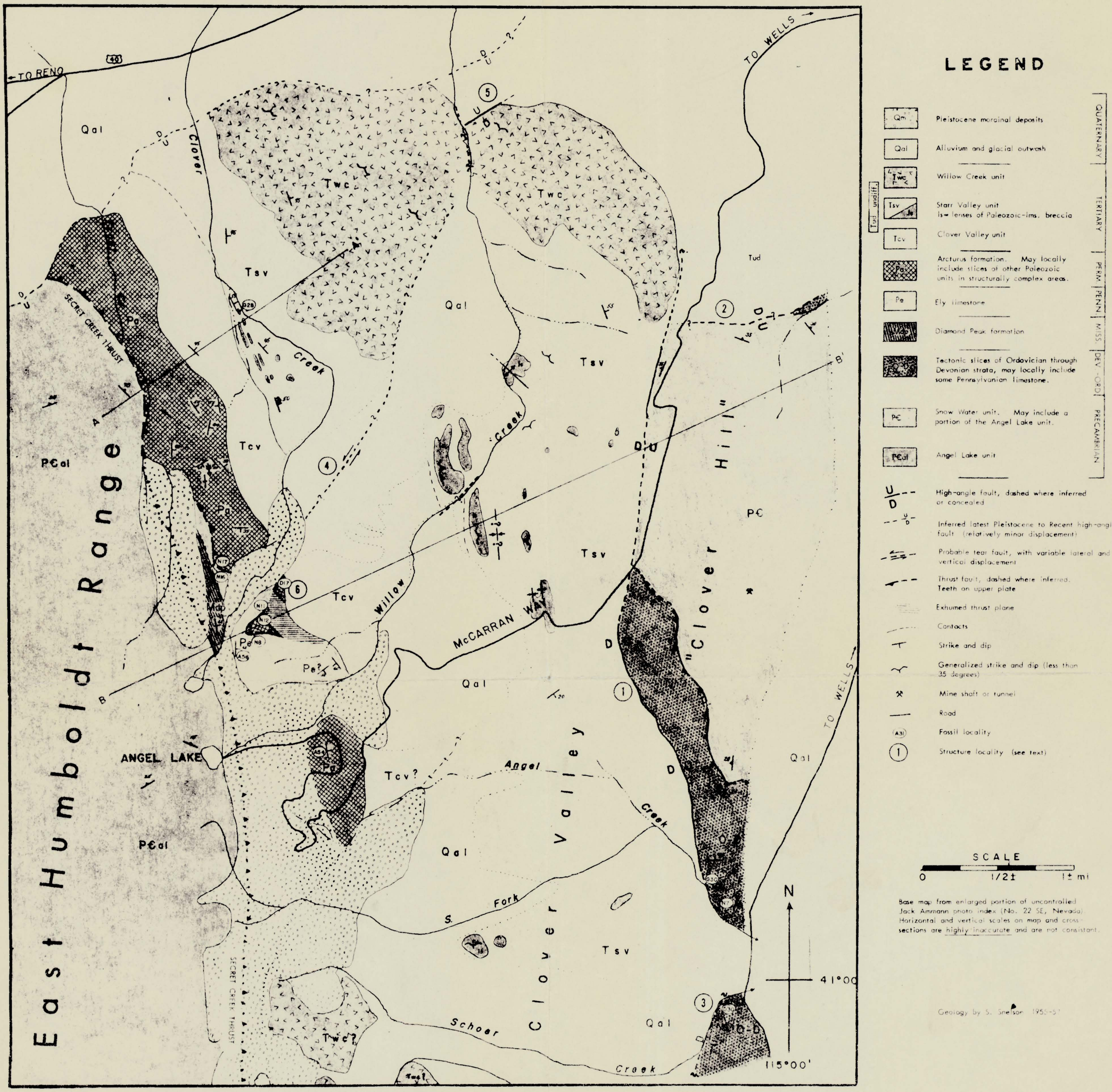
Preliminary Surficial Geologic Map of the Quaternary Units of part of the Cold Creek Ranch NW 7.5 Minute Quadrangle.



0 KM 1
0 MILE 1

SCALE 1:48,000
CI=10 ft.

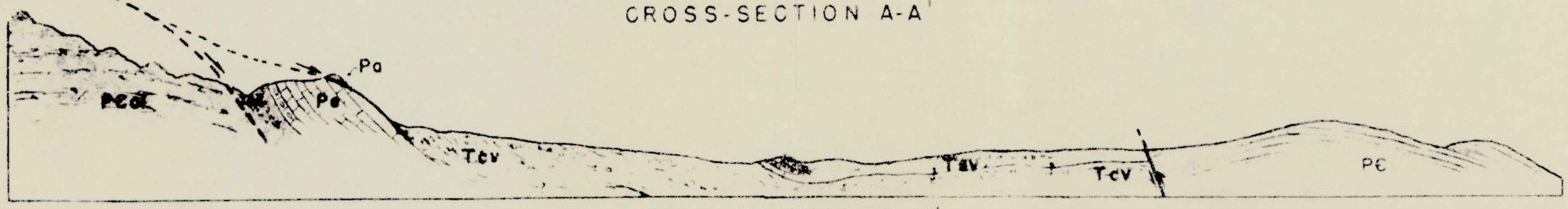
5220
60000304



MAP NO. 1

GEOLOGIC MAP of the CLOVER VALLEY AREA

CROSS-SECTION A-A'

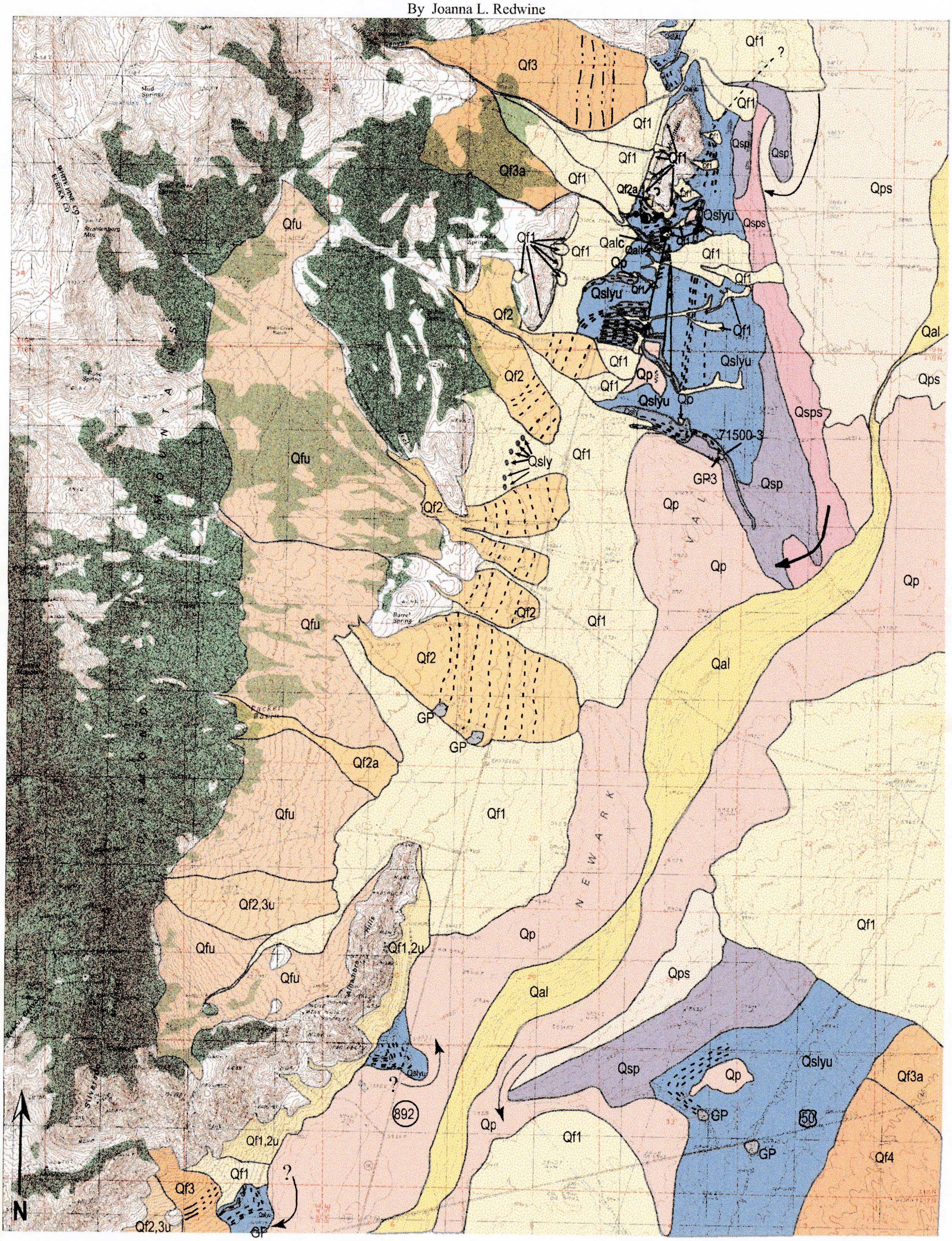


CROSS-SECTION B-B'

6000 0301 (0170)

Preliminary Surficial Geology of the Quaternary Units of the Silverado Mountain 7.5 Minute Quadrangle.

By Joanna L. Redwine



0 KM 1 2 3
0 MILE 1 2

SCALE 1:.48,000
CI = 40 ft.