Preliminary report on the proposed Little Sandstone Reservoir Site

by

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The Geological Hazards Section of the Geological Survey of Wyoming was contacted by Winston Boyer of the Boyer Ranch north of Savery in January, 1986, concerning the feasibility of the proposed Little Sandstone Reservoir site. In 1977, Dr. J. David Love of the U.S. Geological Survey responded to a similar inquiry by the Boyers and sent them a letter that addressed a number of his personal concerns about the site. We were primarily asked to respond to those original concerns.

A summary of the original concerns is presented below.

1. Slope movements in the area of the reservoir and dam may adversely affect the amount of sediment present in the waters of the reservoir. The capacity of the reservoir may be affected, and the waters may become turbid.

2. There are faults in the area that were identified as being potentially active by Irving Witkind of the U.S. Geological Survey (U.S. Geological Survey Open File Report 75-279). Seismicity in the area may affect any dam constructed.

3. The dam would be partially constructed on sandstone, and the reservoir would be located over the sandstone. Seepage may occur around the dam

due to the inferred porosity and permeability of the sandstone. The reservoir may lose part of its waters to the adjacent and underlying sandstones.

4. There is potential for the occurrence of selenium in the bedrock, soils and waters in the vicinity of the proposed site.

The Geological Hazards Section of the Geological Survey of Wyoming has searched the literature for pertinent information on the site, studied available aerial photographs of the site and with the Stratigraphy Section of the Geological Survey of Wyoming, conducted a preliminary one day reconnaissance of the area in order to address the concerns presented to it. Weather problems prevented an early access to the site. Our first and only visit to date was on April 30, 1986. As mentioned above both the Geological Hazards and Stratigraphy Sections visited the site.

In the course of interpreting aerial photographs prior to the site visit, we raised an additional concern. Aerial photos indicated that there might be some slope destabilization in the area of the east abutment of the proposed reservoir. Our field investigation stressed this concern as it would have the greatest impact on dam safety. Aspects of the other concerns were also addressed in the field. Our office and field investigations to date are presented below. It must be stressed that this report is only a status report, and cannot be finalized without further investigation.

Slope movements in the study area

There are many types of slope movements in the study area, with each having its own characteristics. We have assigned a very rudimentary and preliminary classification to all slope movements previously identified by Ven Barclay of the U.S. Geological Survey (U.S. Geological Survey Open File Report 76-794), or identified by us on aerial photographs. Not all landslide areas have been examined or observed in the field. Most of our classifications to date are based on the appearance of the slope movement on aerial photography. We also classified some areas as having a destabilization potential. These areas with destabilization potential have not destabilized in the past, but their apparent composition and position on similar slopes to previously destabilized areas warrants concern for the future.

The slope movement types identified in the study area are rock block slide-block glide, soil block glide, rock and soil slump, slump-flow, flow (earthflow or debris laden earthflow) and creep.

With rock block slides-block glides and soil block glides, a detached mass of bedrock or soil moves along a surface of rupture that is planar or gently undulating. The surface of rupture or glide plane is often a bedding plane, a fracture or a contact between weathered bedrock or soils and solid bedrock.

With soil or bedrock slump, a detached mass moves along a surface of rupture that is concave upward. This results in the top of the mass and the units below it tilting backwards into the slope.

A flow is generally defined as a mass movement that exhibits a continuity of motion with a plastic or semifluid behavior resembling that of a viscous fluid. Most of the flows in the study area are composed of earth and debris. An earth flow is a slow to rapid cohesive flow bounded by discrete lateral shear surfaces. They generally have a lobate, hummocky toe and form in moist materials.

Slump-flows are a complex type of slope movement. The upper portion of the movement is a slump. The slump disaggregates in a downslope direction. If moisture is adequate, the disaggregated portion of the slump begins to flow.

Creep is a very slow form of flow. In fact it is so slow that monitoring over long periods of time is usually required to determine if creep is occurring. If there are a series of very small, long and narrow slump blocks on a slope, the cumulative effect of all the slumps is similar to a flow. "Cat steps" on a slope are an indication of this form of creep.

There are two major rock block slide-block glide complexes in the study area. They are relatively deep seated, composed of bedrock and cover large areas (see enclosed map). These large block slides and glides found in the area are of the type that are generally slow moving. A rapid catastrophic movement would be very unusual as both complexes are already encroaching on the opposite valley walls. If they destabilized suddenly, they could not move any appreciable distance.

The most recent signs of block slide activity are near the uppermost scarp of the movements, as would be expected. In general, as one trends upslope on the slide mass, the blocks appear to be younger and not as weathered as those on the lower portions of the slope. In fact, on aerial photographs, the blocks nearest the present valley floor are difficult to delineate.

Based upon the previous observation, the complete slide masses would most likely destabilize if two conditions were met. First, if a new block were to detach from intact bedrock and slide down onto the existing slide complex, the mass would be loaded, and would have a tendency to increase its rate of movement. Second, if the complete slide complex were to become saturated, the probability of movement would increase. The downdip and downslope portions of the slide complexes are already relatively saturated compared to the updip and upslope portions. If those upper portions were to become saturated, the increased hydrostatic pressure, lubrication of the glide planes and weight of the saturated units may lead to destabilization. If only the lower portions of the large block slide complexes were to become saturated, as when the proposed reservoir waters engulf them, the chance of destabilization of the complete slide mass is not as great. In fact, the chance of complete slide mass destabilization may not be much greater than the existing state if only the lower portions were inundated. The worst case scenario for complete slide mass destabilization would be a damming of either Savery Creek or the Big Sandstone Creek.

The large block slide complex along Savery Creek does have other slope movements associated with it that may react more quickly to increased saturation. As can be seen on the enclosed map, there are a few sizable slump-flows (probably debris laden earthflows) that have formed from both the rubble derived from the block slides and from the block slides themselves. If those flows were to become saturated, they would probably move more readily than the adjacent block slides. The present stability of these flows needs to be determined. In addition, the potential effects on these flows from increased and fluctuating water levels needs to be determined if high water levels will reach them.

The portions of both the block slides and flows derived from the block slides that are immediately adjacent to the proposed reservoir will be subject to numerous smaller scale destabilizations. There are smaller scale slumps and flows already occurring on the toes of the preexisting slides and flows. Those existing smaller scale destabilizations will most likely accelerate if the reservoir waters reach them. This will add to the amount of sediment in the stream and reservoir.

In the study area there are numerous slump-flows that may incorporate bedrock. Some of the larger ones were mentioned previously in connection with the large rock block slides and glides on Savery Creek. The only other one of note is in T.14N., R.89W., Sections 23 and 24. It does not appear to be an immediate threat to the stream or valley although it does have a pond in its upper head bench area. The pond is not filled which indicates that the slide mass may be relatively new.

Most of the other slump-flows are of small scale and do not generally pose a threat. However, many may reactivate if their degree of saturation increases or if they are subject to fluctuating water levels. If the water of the proposed reservoir reactivates them or causes the creation of new ones, extra sediment will be introduced into the reservoir.

There are numerous zones of talus or weathered bedrock that have destabilized in the form of flows, slumps or slump-flows. Most of the movements are shallow and should not be directly affected by the reservoir. However, they will be a continuing source of sediment. As can be seen on the enclosed map, many of the talus and weathered bedrock movements are on north-facing slopes.

There are numerous areas that either show signs of creep or that have potential to creep or to form shallow slumps, slides or flows. Slopes have been lumped into this category if they have orientations, lithologies and degrees of weathering that are similar to slopes that have destabilized. As with the other slope movements described, their degree of destabilization will in part depend upon their relationship to the proposed reservoir waters.

Soil block slides are closely associated with the previously described shallow movements. Areas with soil block slides have been delineated where actually observed. The areas are difficult if not impossible to identify on aerial photos. Their presence on portions of slopes have been used to justify classifying an entire slope as having potential for shallow destabilizations.

Many of the shallow movements described in the two previous paragraphs are controlled by lithology (rock composition). The shallow movements have a tendency to occur in rock units that are less resistant than the prominent sandstones found in the area. This is especially true of the Little and Big Sandstone Creeks. Many of the shallow movements have a tendency to occur on north-facing slopes although they can occur in almost any location. In the northern portion of the study area, many of the shallow movements occur in the lower Haystack Mountain Formation and the Steele Shale.

In addition to the above mentioned slope movement types, there are also many alluvial fans in the area that may destabilize if they become saturated or are subjected to fluctuating water levels. Most of the fans are located on the west valley wall of Savery Creek. The composition and size gradations within the fans are not known. As a result, their true destabilization potential is not known at this time.

In summary, there are many slope movements and slope movement types in the study area. Existing movements as well as areas that may be prone to certain types of movement have been delineated on the enclosed map. Much of the interpretation has come from analysis of aerial photography. Classifications and locations may change when the whole area is examined on the ground.

A concern is how the existing slopes will behave when they become saturated or are subjected to fluctuating water levels if the proposed reservoir is emplaced. There is potential for increasing the sediment load of the reservoir beyond what would be expected from observations of the creeks in the area. Accelerated slumping, flowing and sliding will all contribute to the increased sediment load. It is suggested that an estimate be made of what the increased sediment load may be, and what effect it may have on the capacity of the reservoir.

As a suggestion, if the proposed high water line is plotted on the enclosed map of geologic hazards, areas that will be saturated or subjected to fluctuating water levels can be delineated. Various types of worse case scenarios can then be generated. The scenarios can be created for various depths of material that will move into the reservoir and various periods of time over which it will occur. One of the worst case scenarios should also discuss the effect of the large rock block slide-block glide complexes damming the streams as previously discussed. It is suggested that Stone and Webster Engineering Corporation attempt to generate the scenarios as they have the most complete information on slope and landslide compositions and thicknesses.

Faults and seismicity in the study area

Although our localized reconnaissance of the area did not emphasize faulting, we feel that the work generated by Stone and Webster Engineering Corporation and Ven Barclay of the U.S. Geological Survey is essentially correct. The only modification we have is to extend Barclays fault in T.14N., R.88W., north 1/2 of section 6 into the southern half of section 6. This extension is based upon interpretation of aerial photographs.

There is no apparent evidence indicating that the faults in the area have broken Quaternary or Holocene sediments. Based upon conversations with Stone and Webster Engineering Corporation, we feel that their work is adequate in regards to determining the activity of the faults in the area.

Our office has no record of any epicenters in the immediate vicinity of the proposed dam. In 1977 there was an intensity V, magnitude 4.2 earthquake with an epicenter in T.15N., R.87W. In 1917 there was an intensity IV earthquake reported with an epicenter in the Rawlins area. In 1966 there was a small magnitude and intensity earthquake with an epicenter in T.20N., R.94W. In 1971 there was an intensity V, magnitude 4.4 earthquake with an epicenter south of the area in Colorado. The location of that epicenter was T.9N., R.86W.

The area is considered to be in seismic risk zone 1. Maximum expected intensities in risk zone 1 are between V and VI on the Modified Mercalli Intensity scale. S.T. Algermissen of the U.S. Geological Survey has generated a series of maximum expected horizontal acceleration maps with exceedance periods of 95 years, 475 years and 2,373 years (U.S. Geological Survey Open File Report 82-1033). Although it is difficult to translate horizontal accelerations into intensities, an attempt was made by Pratt, Hustrulid and Stephenson (1978) in "Earthquake Damage To Underground Facilities".

Based upon those two works, the following deductions are drawn about the study area. Statistically, every 95 years there will be an intensity V or less earthquake, every 475 years there will be an intensity V - VI earthquake and every 2,373 years there will be an intensity VI - VII earthquake. Those predictions also apply to the eastern two thirds of Wyoming.

Based upon conversations with Stone and Webster Engineering Corporation, I feel that their analyses are as correct as possible. We plan no further work in this office on seismicity in the area.

Seepage around the Dam and Leakage from the Reservoir into the Bedrock

Concern has been raised concerning seepage of reservoir water around the proposed dam, as it would be located in sandstone. Our impression is that Stone and Webster Engineering Corporation is investigating this possibility. We do not know what degree of seepage is acceptable for dams, and cannot comment further.

Another concern that has been raised is how much of the reservoir waters will "leak" into the surrounding sandstones. Our investigations will not address this issue. Our impression is that Stone and Webster Engineering Corporation is conducting studies that will address this question.

Selenium in the Project Area

Some of the rock units that are exposed in the area have been shown to contain selenium in elevated concentrations in other portions of the State. The Browns Park Formation has supported seleniferous vegetation west of Baggs in the Poison Basin area. Livestock deaths have resulted from selenium poisoning in this area. The Steele Shale and closely related Niobrara Formation have supported seleniferous vegetation in the Shirley Basin. Livestock deaths have also resulted from selenium poisoning in this area.

Little or no selenium data has been collected on the Browns Park Formation and Steele Shale in the study area. We suggest a phased approach to a selenium study in this area. Selenium would most likely be associated with clays in the alluvium and soils. In fact if any was being leached from the bedrock, it should concentrate in the clays. We suggest that the alluvium and soils in the vicinity of the proposed reservoir be sampled to determine if selenium is being concentrated. The water in the alluvium and creeks should also be sampled. If selenium is not found at elevated levels, only a minimal bedrock sampling program should be conducted. If elevated levels of selenium are found in the alluvium or waters of the area, then a detailed study of the bedrock should be conducted in order to determine the source of the selenium.

Examination of East Dam Abutment

During our examination of the aerial photographs of the area, certain lineations were observed on the proposed east dam abutment. The lineations appeared to be similar to those found in shallow slumps. For this reason, most of our field examinations centered in this area.

Close examination of the east abutment revealed no obvious slump scarps although one area was flagged as having a potential for small scale shallow slumps. That area is delineated on the enclosed map. There was only marginal evidence for what could be construed as a highly weathered small scale slump in that area.

We examined the east abutment to determine if portions may be a block glide. Savery Creek is constricted in the abutment area, and a block glide constricting the stream would have explained the unusual configuration.

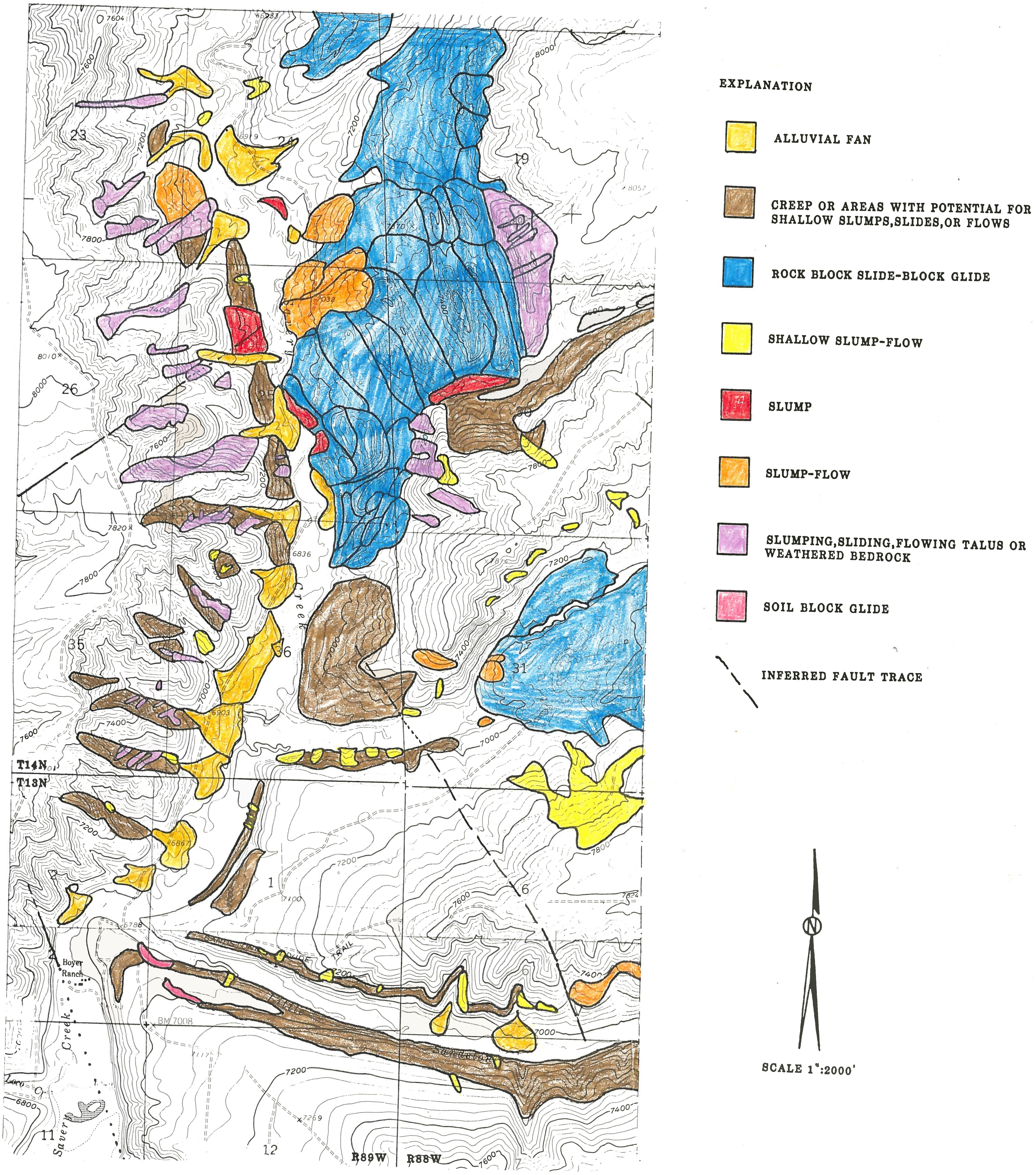
No surficial evidence was found to support the block glide theory. Most exposed bedrock in the area appeared to be continuous, without separations large enough to explain the present land configuration. At present we do not have an explanation as to why the stream is constricted. Further investigation from our office will hopefully answer the question.

Conclusions

There are a few points that deserve further attention in regards to the feasibility of a reservoir in the area.

1. There are numerous small and large scale slope movements in the area. How will they be affected if their degree of saturation is increased or if they are subjected to fluctuating water levels? Will the increased amounts of sediment that are introduced into the reservoir from the destabilization of the existing movements or from the creation of new ones greatly affect the capacity of the reservoir? Are there any existing techniques that can be used to address the previous two questions?

2. A selenium occurrence and availability study of the area is needed. Suggestions for a phased approach to this study are presented in the text.



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