THURSTON COUNTY
WASHINGTON
SINCE 1852

COUNTY COMMISSIONERS

Cathy Wolfe
District One
Sandra Romero
District Two
Karen Valenzuela
District Three

DEPARTMENT OF RESOURCE STEWARDSHIP

Cliff Moore
Director

MEMORANDUM

Date: March 2, 2009

To: Thurston County Roads and Transportation

From: Mark Biever, L.P.G., L.P.E.G. Water Resources Unit
Nadine Romero, L.P.G., L.P.H.G. Environmental Health

Subject: Rock Candy Mountain Landslide – Kennedy Creek North Fork, January 9, 2009

Purpose

On Friday, January 16, 2009, Thurston County personnel Mark Biever, Ryan Langan and Nadine Romero of The Department Environmental Stewardship and Environmental Health, assisted Roads and Transportation staff on a preliminary landslide assessment of the Rocky Candy Mountain area above State Highway 8 in the Capitol Forest. It was a fact finding mission to evaluate the slide and to determine if additional failures were possible and discuss impacts to Kennedy Creek Road (County Road) at the lower limits of the slide debris. The initial site visit revealed an unexpectedly massive slide of a very complex and violent nature.

On January 23, 2009 a second site visit was conducted by representatives of Washington Department of Natural Resources (DNR), Washington State Department of Transportation (WSDOT), Washington Department of Fish and Wildlife (WDFW), Thurston County and GeoEngineers (private consultant). The purpose of the second site visit was to assess the area in a broad scope and discuss options among the multiple parties involved with landslide in one way or another. The second visit involved walking the failure surface from the midway point of the slide (approx El. 1200 ft) to the head scarp and discuss the potential for future slides and the potential impairment of the highways and businesses. Discussions on improvements to the drainage systems along the County road and State Highway 8 were also topics of discussion among the parties.

Background

This landslide that occurred on January 9, 2009 followed very high rainfall event, known as a "Pineapple Express" because of its tropical origin, from January 6 through January 9 of 2009. A precipitation data collection station at nearby Summit Lake recorded nearly 12 inches of precipitation in the area over two days. The slide was triggered in the upper headwaters of the Kennedy Creek watershed and is located east of a similar landslide that occurred in December 2007. Of particular interest is the County road (Kennedy Creek Road SW) and State Highway 8 which is a major East-West route between Olympia and many Washington coastal communities. Both of these roads have been repeatedly inundated with water and debris in 2007 and 2009

resulting in closures, infrastructure damage and hazard to life and property. The most recognizable incident occurred in December 2007, when a debris torrent destroyed the Ranch House BBQ Restaurant and closed Highway 8 and Kennedy Creek Road for several days. A similar incident occurred again in 2009 narrowly averting the newly renovated Ranch House Restaurant, illustrating the ongoing potential for harm this location poses. The December 2007 landslide was not studied in depth in this investigation but anecdotal evidence suggests it shares many similarities with the 2009 landslide.

Precipitation

The common element between these two events was a three day period of rainfall that approached or exceeded six inches. In fact, the event in January of 2009, the one day total for January 6th was nearly 7 inches. Excessive precipitation over a short period of time is a common catalyst for most landslides in Western Washington. It appears that the 2007 and 2009 landslides were caused by significant precipitation events that immediately preceded the failures. These were intense events that concentrated a lot of water over a short period of time. Both the 2007 and 2009 storms were comparable to the 100 year 24 hour rainfall totals for our area with the 2009 storm delivering approximately 2.5 inches more than the 2007 event. The combination of intense rainfall, steep slopes, and soil-over-bedrock most likely initiated the slides.

Below is a summary of the 2009 and 2007, three-day precipitation events that preceded the slope failures.

The precipitation over the 3-day period that was recorded approximately one mile north at the county's Summit Lake precipitation gauging station was as follows:

Precipitation at Summit Lake Gauge

2009	Date	Daily Total (In.)
Tuesday	Jan 6, 2009	2.21
Wednesday	Jan 7, 2009	6.79
Thursday	Jan 8, 2009	0.64
2007		
Sunday	Dec 2, 2007	0.59
Monday	Dec 3, 2007	4.10
Tuesday	Dec 4, 2007	0.34

Location, Topography, and Size of the Landslide

A sharp high elevation ridge or 'divide' meanders along the top of Rock Candy Mountain *west* to *east* and forms a large 'bowl' or basin for Waddell Creek on the south side and a smaller Kennedy Creek basin on the north side. The ridge at an elevation of 1760 feet above mean sea level (msl), sits directly above the 2009 slide and is only a few hundred feet wide and serves as a road for forestry and recreation (Army Road).

Many areas of this road were observed to contain stress fractures and erosional features (as seen on the January 23, 2009 landslide assessment with DNR, WDFW and WSDOT --

photograph). However, a direct relationship of road failure with the 2007 or 2009 landslides was not evident. Concern exists, though, for road maintenance and runoff control in order to not seed future slides and fracture traces at the steeply dipping *soil-bedrock* interface on the ridge. Drainage pipes that are clogged with debris or damaged and not functioning properly can contribute to the erosion and instability problems inherent in rarely maintained forest roads.

The January 9, 2009 landslide begins approximately one hundred feet below the top of North Rim Ridge #1 at an elevation of 1570 feet above mean sea level (msl) and extends to an altitude of around 700 feet above msl. This impressively large landslide is around a ½ mile long and widens from several hundred feet across (at the top) to approximately 1000 feet at its base (terminus of the debris flow). Several topographic benches were observed along the sub-basin which may have partially slowed the slide and stored some of the inertia along with sediment mass from the failure. Towards the top of the landslide the soil-regolith depths may have been as much as 10 to 15 feet deep and as much as 30 feet towards the toe of the slide where slopes decrease to 20 percent. The upper part of the Kennedy Creek sub-basin may has slopes ranging to 70 percent.

It should be noted that the 2009 landslide originated in old growth or second growth forest and did not appear to be affected by logging activities. It is uncertain if that is also true of the 2007 failure. It should also be noted that once the failures began, the forest cover had little affect on the slide masses as they progressed down the hillside. The material gained enough momentum to simply crush the trees and incorporate them into the debris mass (see photos in Appendix 1).

Geology of the Crescent Formation (Black Hills)

The red lateritic-type soils of the landslide appear to be *clayey silts and sands* which rest on a massive[1] weathered basalt. The basalt is the Crescent Formation which is a submarine flow extruded from a divergent plate boundary some 40 to 55 m.y.a. in the Eocene.

These Crescent Basalts are uplifted and partially subducted below North America. However, the Capitol Forest represent basalts uplifted and wrapped around the Olympia Peninsula at steeply dipping angles unable to subduct under North America because of detachment and a 'cold slab' architecture-- where it is unable to sink and be pulled into the deeper asthenosphere for re-melting and volcanic production (Figure A).

At an altitude of approximately 1200 feet above *msl* fresh basalt is exposed below the new stream bed and consists of black-gray *aphanitic* (finely crystalline) igneous texture common to basalts. At first glance, the basalt sequence appears like layers of sedimentary rock, however, such layers are really *unloading joints* in the massive basalt which is more typically seen in granites.

An oxidized reddish-stained basalt directly overlies the black basalt. This exposed basaltic sequence was removed of its weathered regolith consisting mostly of *angular-subangular* blocks and some rounded cobbles in a clayey-silt-sand matrix. Much of the regolith[2] was still saturated

[1] Massive means that the igneous rock body does not have distinctive features such a submarine flow breccia, pillow basalts or columnar jointing patterns from cooling.

[2] The DNR Open File Report 2008-5, "Landslide Reconnaissance Following the December 1-3, 2007 Storm Event" by Isabel Sarikhan and others refers to the 2007 landslides as predominantly debris avalanches which are characterized by 'unconsolidated rock and soil that has moved downslope along a shallow failure plane'. These slides form steep scars and ravel (?) for many years. Debris avalanches 'are most likely to occur on slopes greater than 65% where unconsolidated colluvium overlies shallow bedrock'.

one-week after the slide (although no rainfall had occurred post-slide) and stepping on slumped material was a cautious endeavor.
Several areas of highly compacted glacial till are also exposed at lower elevations along the path of the drainage. The till is a remnant of one of the last continental glaciations that occurred in our region over the past several hundred thousand years. The Black Hills are located at the southwestern extent of the continental ice sheets. The north sloping flanks of the hills in this area are mantled in glacial till which sits immediately over the Crescent Basalts up to about elevation 1300 feet.

Several large slumps of colluvium/regolith rest at various sizes and altitudes through out the slide. These are likely to continue to move towards the toe of landslide through the next coming storms. The 'hummocky' appearance of the landslide is due to these large slumps resting at various topographic benches in the sub-basin.

Possible Chronology and Failure Mode of the 2009 Landslide

It is likely that some time on Friday, January 9th or Saturday January 10th, 2009 (based on anecdotal evidence) the upper portions of the slope failed in a series of rotational and block collapses. The likely trigger is over-saturation of the zone between the rock and soil. This zone is approximately 15 to 25 feet thick at the top of the slope. It is also possible that surface fractures and buried pipes fed by large amounts of runoff may have contributed to the initial failure although this has not been confirmed on the ground. Observations indicate that the debris flow generated by the slide contained significant amounts of super-saturated material that flowed rapidly downslope after the initial failure in the upper portion of the basin. Evidence of the fluidity of the mass can be seen by the abundance of mud spray, shattered branches, and stripped bark that is found up to 50 feet high on trees in close proximity of the debris path. The abundant dispersal pattern of the mud spray is indicative of high velocity (estimated greater than 25 mph) of the material.

Additionally, looking at the damage pattern caused by the east lobe of the slide suggests that the material had enough kinetic energy, and fluidity to enable it to "slosh" out of the stream channel that generated it, over a small ridge, and through approximately 1500 lineal feet of second growth forest. The width of the east lobe ranges from 300 to 400 feet across at its widest point. The debris shattered and toppled every tree in its path and buried the forest floor in two to six feet of mud and debris. The violent nature of the damage, even to large trees, suggests that the flow material had an impressive amount of energy when it plowed into the forest. The material in this lobe finally came to rest and "deflated" giving up its vast amounts of turbid water into a small tributary. The water then proceded downslope choking DNR road culverts with debris.

The second lobe of this debris flow (West Lobe) remained in its channel of origin and gradually depleted its energy in a much less violent fashion than the east lobe. It ultimately released its water into the Upper Kennedy Creek system that took the brunt of the 2007 debris flow.

The debris-ladened water from this potion of the slide recombined with runoff from the east lobe of the debris flow and continued all the way to State Highway 8. The combined runoff clogged every culvert on its way to Kennedy Creek and overtopped the County road and State Highway 8 resulting in significant maintenance work and a possible redesign of the Highway. Both roads were closed to traffic for several days. A similar occurrence happened in 2007 in which the Ranch House BBQ Restaurant was severely damaged. No injuries were reported in either event.

The violent nature and impressive size of this landslide put it into a category which few multi-modal landslides achieve. The 2009 landslide is among the most dangerous type of landslide because it has the potential to cause severe damage to anything in its path from its origin at the top of the ridge to Highway 8 and Kennedy Creek. It transferred an enormous amount of energy and debris almost two miles from it source in a short period of time. If this slide had occurred in a location where homes or people were situated, there may have been a tragic outcome. Luckily this was not the case and the vast majority of the material and energy was expended upslope of the Highway and County road and only the forest, stream channels, and culverts were affected.

Conclusion

It appears that the large 2009 landslide in the uppermost reaches of the Kennedy Creek watershed will continue to be prone to mass movement due to steep slopes, springs, unvegetated new exposure, thin soil cover over bedrock and till; and new hummocks of unstable colluvium/regolith from the failure. The features created by the 2009 and 2007 failures in this area will likely not reach a stable state for many years. This means that the basins in which these failures occurred will not be suitable for forest harvest or other activities for some time without significant stabilization methods being employed. These areas are particularly prone to additional failures in intense rain storms like we have seen over the past 3 years. All current climate model indications for Western Washington predict and increase in this type of storm activity in the short term and long term. Minimum action steps are to maintain forest-recreation roads and prevent their erosion, refrain from tree removal in the vicinity, conduct in-depth LiDAR studies and consult with DNR expertise in mass wasting and recovery efforts.

This location will remain active in the near future and could, in fact, generate additional landslides and debris flows of equal size in the next large or prolonged rain event. The debris that will come from the scarred landscape will provide significant sources of debris that will likely continue to clog culverts within the Kennedy Creek drainage. Kennedy Creek Road and State Highway 8 will continue to be impacted by closures and stormwater infrastructure damage until the current systems are redesigned and rebuilt to handle the increased sediment and debris loading.

The size, type, and violent nature of the slides generated in this drainage basin are of great concern because, although they occur in relatively remote areas, they are very dangerous and could easily injure or kill people that may get in their path. The awesome display of the January 2009 event illustrates a truly violent type of slide that we rarely get a chance to examine and say “no one was injured or killed”. The 2009 landslide was an event that should not be under-estimated or under-appreciated when planning for the future land use and recreation in this portion of the Black Hills.

Attachments and Figures

A photo-overlay LiDAR map is included for topographic and spatial reference (Figure 1). A cross section with representative photographs at each elevation is also attached (Figure 2). A collection of photographs taken between January 7 and January 23, 2009 document the slide from the Headscarp to the debris-choked Kennedy Creek at Highway 8 is attached (Appendix 1) to this memo.

Rock Candy Mountain Landslide - Kennedy Creek Basin - January 2009

Olympia 5 Miles East

N

STATE HWY 8 W/SR 8

HWY 8 W/SR 8

KENNEDY CREEK RD SW

KENNEDY CREEK

SUMMIT LAKE RD NW

HWY 8 W/SR 8

UNK

UNK

CAPITOL FRST

CAPITOL FRST

CAPITOL FRST

CAPITOL FRST

CAPITOL FRST

5 FORKS RD NW

ROCK CANDY MOUNTAIN RD SW

ROCK CANDY MOUNTAIN RD SW

ARMY RD SW

ARMY RD SW

NORTH FORK PORTER CREEK

WADDELL CREEK

2007 Failure (approx limits)

Jan 2009 Failure

Figure 1

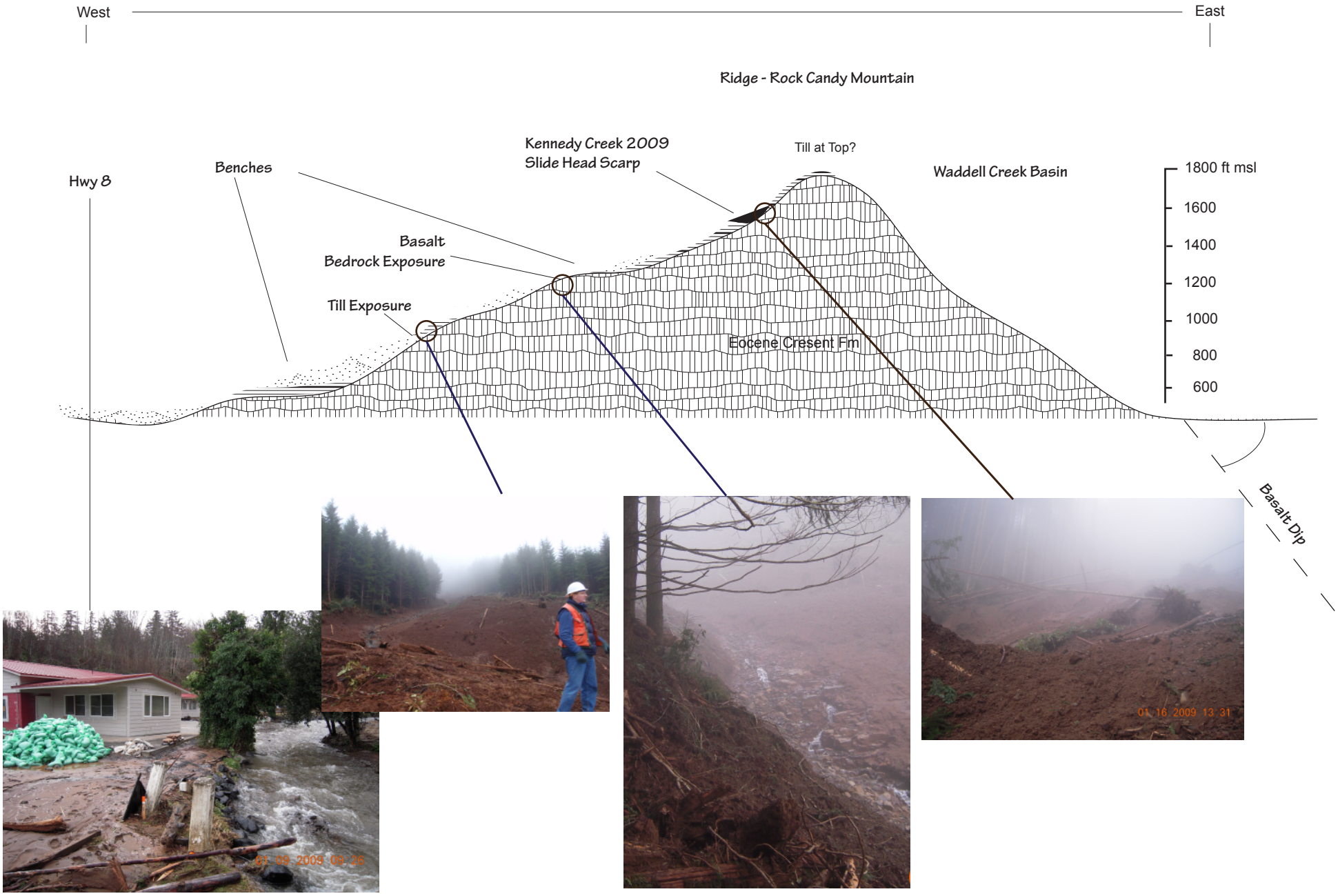

Figure 2 - January 9, 2009 Landslide - Kennedy Creek Uppermost Basin - Rock Candy Mountain

Photos by M. Biever and Depiction by N. Romero, 2/11/09

Appendix 1: Rock Candy Mountain Landslide and Debris Flow – January 2009
Upper Kennedy Creek Basin: Olympia, Washington

January 2009 Landslide Head Scarp in mature forest. Approximate El.1600'

January 2009 - Upper portion of the slide (1400 – 1500'). Blocks and debris piles

Appendix 1: Rock Candy Mountain Landslide and Debris Flow – January 2009
Upper Kennedy Creek Basin: Olympia, Washington

January 2009 - Middle Portion of the slide (1100 -1300'). Increasing velocity splinters trees. Begins the debris flow stage near this elevation.

January 2009 - Middle Portion of the slide (900-1200') Looking upslope the path of the slide debris is apparent and the transition to debris flow/torrent has occurred. The forest has been leveled in the path of the debris

Appendix 1: Rock Candy Mountain Landslide and Debris Flow – January 2009
Upper Kennedy Creek Basin: Olympia, Washington

January 2009 - Lower Portion of slide. This stage (~ El. 900') the movement is rapidly flowing debris. Two Lobes diverge from the parent channel. East Lobe (right of tree island) jumps a small hill and slams into forest. Velocity is very high at this point. Debris travels over 1500 feet into forest destroying everything in its path. West Lobe remains in the parent channel.

Appendix 1: Rock Candy Mountain Landslide and Debris Flow – January 2009
Upper Kennedy Creek Basin: Olympia, Washington

January 2009 – Divergence of the two lobes of the debris flow. Channel on the left is the channel of origin.

January 2009 – East Lobe of the debris flow. Rapidly moving debris plowed through the existing forest before coming to rest 1500 feet from the location this photo was taken.

January 2009 – Kennedy Creek at the Ranch House BBQ restaurant. The Thurston County Kennedy Creek Road is the roadway in the forefront. State Highway 8 is the roadway in the far background. Both roadways were closed for two days for debris removal and water over the roadway.