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Landslide Monitoring in S.F. Elk River, Humboldt County 2018 Report

Pursuant to Monitoring and Reporting Program (MRP) No. R1-2012-0088

Submitted: July, 24 2018

Prepared By:
Green Diamond Resource Company

1.0 INTRODUCTION

As part of the Landslide Inventory Quality Assurance Project Plan (QAPP) this document represents a summary report of landslide processes within the Elk River drainage. It is further limited to the portions of the drainage owned and managed by Green Diamond Resource Company (GDRCo).

At the time of the development of the WWDR for South Fork Elk River, it was proposed that our landslide sampling would coincide with the acquisition of aerial photographs. Previously, GDRCo would typically purchase aerial photographs every three years, however given the acquisition of LiDAR, orthorectified imagery and publicly available orthorectified imagery provided by the USDA National Agriculture Imagery Program (NAIP), GDRCo delayed purchasing property wide stereo paired aerial photographs for the foreseeable future. Through 2016 orthorectified imagery was provided by the USDA roughly every two years. Unfortunately however, funding for this program has been terminated. Currently, GDRCo is in the process of acquiring aerial orthorectified imagery for 2018, which should allow us to continue this process. Since our last landslide report for GDRCo's ownership of the South Fork Elk River watershed in 2010, GDRCo has acquired the USDA's high resolution orthorectified imagery dated from 2009, 2010, 2012, 2014 and 2016. The following summarizes our findings regarding our review of that imagery. In addition we have also included relevant findings associated with our Preliminary Mass Wasting Assessment Completed in 2016.

2.0 SITE SELECTION

Green Diamond Resource Company's landslide inventory encompasses our entire S.F. Elk ownership, which is about 765 hectares (3 mi^2). Our landslide inventory mapping is not limited to any specific portion of this area. Therefore our review of the 2009, 2010, 2012, 2014 and 2016 NAIP imagery covered all of our S.F. Elk River ownership. For sampling, GDRCo is required to incorporate a random sampling of a minimum of twenty percent of the newly delineated landslides observed from the recently acquired imagery. From the five previously mentioned years of NAIP Imagery, only one landslide was observed.

3.0 DATA COLLECTION AND ANALYSIS ACTIVITIES

For assessment of GDRCo's South Fork Elk river ownership, GDRCo has included landslide data from our Preliminary Mass Wasting Assessment which was submitted to US Fish and Wildlife and National Marine Fisheries in 2016. The GDRCo ownership area within the Elk River drainage is relatively small, therefore we have included landslide data collected from nearby watersheds within the ownership that have similar characteristics and management practices. These watersheds include Jacoby

Creek, Rocky Gulch, Washington Gulch, Fay Slough, Ryan Slough, South Fork Elk River, and Salmon Creek. The watersheds are within GDRCo's ownership in the Humboldt Bay Hydrologic Planning Area (HPA). Similar to the South Fork Elk River ownership, each of these aforementioned areas are largely underlain by earth materials of the Hookton formation or Wildcat group. Additionally, they receive similar management practices and regulatory restrictions as they are bound by the AHCP, our Forest management WDR, our Road Management WDR, and the Consistency Determination by California Department of Fish and Wildlife for Coho.

Previous landslide inventory mapping compiled by Pacific Watershed Associates (PWA) for use in Hart Crower's 2004 Elk River watershed analysis for the Pacific Lumber Company was integrated with GDRCo's landslide database. The compilation of these data included an additional review of aerial photographs dated from 1954, 1966, 1974, 1978, 1984, 1987, 1997, 2000, 2005, 2006 and 2007.

The last WDR Landslide Report that GDRCo submitted in 2010 reported shallow-seated landslides that were observed in aerial photographs from 2007. For this report, we have reviewed NAIP Orthorectified Imagery from 2009, 2010, 2012, 2014, and 2016. From those years, we have only observed one shallow-seated landslide that was visible in imagery from 2012 within the GDRCo ownership of the S.F. Elk River Watershed. No recently active, deep-seated landslides were observed on recent photographs beyond the 1970s in this area. All the landslides that have been compiled from LiDAR interpretation, historic aerial photographs, GDRCo field investigations and the PWA landslide inventory are shown on Figure 1.

Based on the GDRCo property wide landslide assessment, there is a downward trend in landslide occurrence across GDRCo's ownership. This also appears to be true for the S.F. Elk River portion of GDRCo lands. The number of deep- and shallow-seated landslides observed historically through aerial photographs within the S.F. Elk River portion of GDRCo's ownership is shown on Figure 2 and Figure 3, respectively. It should be noted that this takes into account only landslides observed in aerial photographs and orthorectified imagery. It is well known that landslides are commonly masked by overstory canopy and are not always visible in aerial photographs. In fact, based on the GDRCo preliminary Mass Wasting Assessment only 12 percent of the landslides encountered in the field were observed on historical aerial photographs. This can be especially true for larger deep-seated landslides that often move incrementally, leaving only a small area of bare soil to detect that can often be masked by overstory canopy. As a result very few active to historic deep-seated landslides have been detected during our aerial photographic review of the Elk River basin.

One exception to this downward trend was the spike in shallow landslides observed in aerial photographs dated from 1997. This may however be largely attributed to the

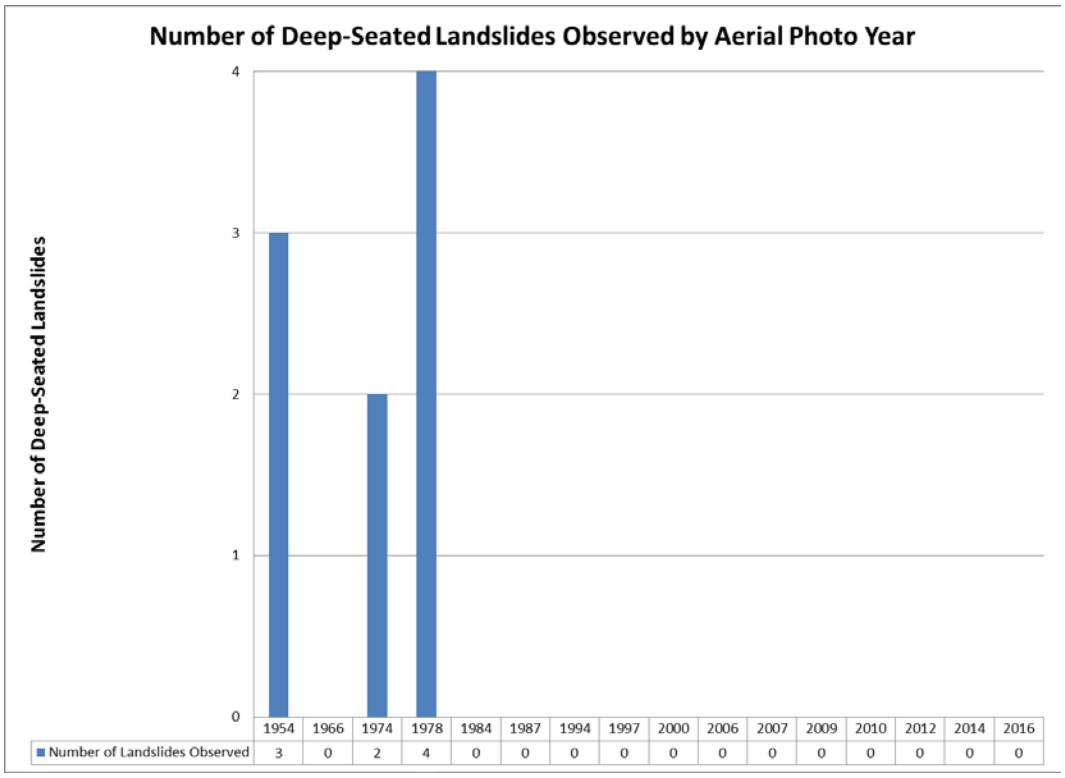


Figure 2 – Deep-seated landslides observed in aerial photograph review within GDRCo Elk River ownership.

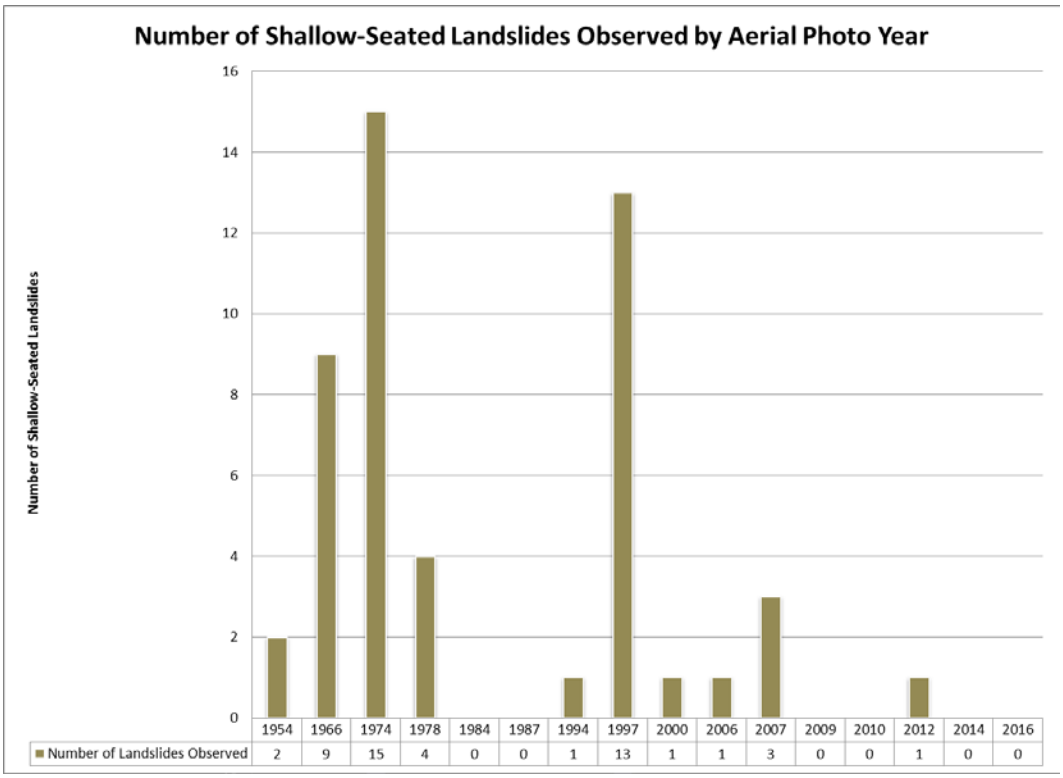


Figure 3 – Shallow landslides observed in aerial photograph review of GDRCo Elk River Ownership.

heavy rain storm events that occurred the winter prior to the 1997 aerial photographs in this region. Intense storms during the 1996-1997 El Nino resulted in between 34 and 50 inches of rain falling from December of 1996 through January of 1997 within Humboldt and Del Norte Counties (Western Regional Climate Center rainfall records for Eureka, Scotia, & Klamath). As a result, elevated landslide occurrence was observed throughout the region, which can be seen on the 1997 aerial photographs that cover these areas.

Sediment delivery estimates

As mentioned above we observed one new landslide from the 2012 photo set. That landslide was surveyed for this report and was observed within the McCloud Creek Sub-basin, in the northern portion of GDRCo's ownership of S.F. Elk River. The slide is located on a moderately steep fill slope of a haul road landing adjacent to a Class III watercourse. Timber was harvested from this slope in 2007 using cable-yarding harvest methods. The road at this site was reconstructed in the mid-1990s from a skid trail that was originally constructed around the mid-1970s using sidecast fillslope construction. The road reconstruction conducted in the 1990s generally appears to have used minor amounts of sidecast fills that only mantled the lower five to ten feet of the fill slope, likely resulting from road grading. A recently constructed water bar was also observed directed toward the corner of the head scarp of the slide. The upper half of the slide contains bare mineral soil and is sparsely vegetated with grasses and shrubs. The lower half contains dense redwood regeneration and several residual redwoods were retained near the stream channel. It appears that a combination of timber harvesting on weakly lithified earth materials, with an over steepened fillslope and road drainage likely contributed to the slope failure. This landslide was estimated in the field to have delivered approximately 20 percent of the total landslide volume to the Class III watercourse. Based on our field measurements, this landslide delivered approximately 550 yd^3 of sediment to the Class III watercourse. It appears that the retention of channel zone trees limited the overall sediment delivery that this slide could have potentially contributed to the Class III watercourse by binding up the earth materials and preventing a torrent of debris. As a result most of the debris still remains on the hillside.

Basin wide sediment delivery rates for the Elk River watershed have been compiled from historic landslide data obtained from PALCO's Watershed analysis. These data were analyzed by Tetra Tech and summarized for the Upper Elk River TMDL (2015). In that report, Tetra Tech calculated sediment delivery rates for 7 historical time periods between 1955 and 2011. Using those data we calculated an average rate for the entire time period in order to compare with rates we have calculated for GDRCo's ownership. Based on the Upper Elk River TMDL (Tetra Tech 2015) we estimated a sediment delivery rate for Tom Gulch and McCloud Creek to be 361 yd^3/mi^2/year for natural and management related shallow landslide sediment for the period of 1955 to 2011.

The long term landslide sediment deliver rate calculated from shallow landslides across GDRCo's entire California ownership was estimated to be 237 yd^3/mi^2/year (GDRCo 2016). Within the Humboldt Bay HPA – which, as previously mentioned, includes our Elk River ownership as well as other similar areas within the ownership- we have estimated a landslide sediment delivery rate of 102 yd^3/mi^2/year. The sediment delivery rate for the Humboldt Bay HPA was the second lowest rate we observed within an HPA for the GDRCo ownership.

Discussion

The estimates of sediment delivery rates obtained from the TMDL differ significantly from our field-derived sediment delivery estimates of landslides in this area. Our sediment delivery estimates are derived from a more extensive field-based review of landslides (which is discussed in our S.F. Elk Landslide Monitoring S.O.P.). The overall shallow landslide sediment delivery rates that we have calculated for the S.F. Elk River watershed are less than a third of those calculated and reported for the same areas reported in the TMDL. In part, this difference is likely due to the level of detail in data collection as the TMDL field data relies on ocular estimations of delivery and our estimates are based on calculations from topographic profiles and field developed cross sections of both the source area and remaining slide debris. Ocular estimations can result in widely varied estimations and typically result in an overestimate of volume. Also, GDRCo only owns a small portion of Tom Gulch, the majority of that basin is owned by Humboldt Redwood Company (HRC). That portion of the basin is characterized by steeper stream gradients and more incised drainages. A report by SHN consulting engineers and geologists (Simpson 2013) similarly describes this basin as being more deeply-incised than adjacent basins in the area. Also, since it is underlain by the soft sediments of the Wildcat group, these deeply incised streams result in areas that are more susceptible to landsliding. The GDRCo portion of Tom Gulch is located at the top of the basin where streams are not as incised. In this area we did not observe higher than normal shallow streamside landsliding. As for McCloud creek, the SHN report also saw low erosion rates for that area. Based on these observations we would expect to see a lower rate of sediment delivery associated with shallow streamside landslides within the GDRCo portion of the ownership when compared to the basin as a whole.

As shown in Figures 2 and 3, there is a downward trend in the number of landslides observed over time. This is also true for sediment delivery rates across the ownership which we observed in our Preliminary Mass Wasting Assessment. Decadal rates are not available at the HPA level due to a lack of data within those smaller areas. Regardless, based on our observations, it is our judgement that these declining rates are consistent across the ownership. The evolution of timber harvesting over time, which includes regulatory changes as well as self-imposed changes in management practices, is likely the best explanation for this downward trend. Early logging practices in this region took place around the turn of the century and again in the

1960s and 1970s. Each era involved intense ground-based harvesting that involved clear cutting of the basin followed by broadcast burning. At the turn of the century streams were heavily impacted by railroad construction which was often situated within or immediately adjacent to a watercourse. Also side-cast road construction was the common practice for road construction in the 1960's and 1970's which contributed to significant sediment delivery as well as landsliding. Road building practices began to change on Green Diamond lands in the early 1980s which reduced and eventually eliminated side-cast road construction. This change in road building practice greatly reduces the potential for road-related landsliding.

Canopy retention areas such as Riparian Management Zones and Habitat Retention Areas were established as part of the Forest Practice Act of 1973 and continued to evolve over time with the implementation of the Watercourse and Lake Protection Zone rules in 1983, the Threatened and Impaired (T&I) Watershed rules in 2000, and the Anadromous Salmonid Protection (ASP) rule package in 2010. Our first WDR in 2006 also added protections including addressing road related sediment sources. In 2007, Green Diamond Resource Co. implemented the Aquatic Habitat Conservation Plan (AHCP). This added retention of channel zone trees in order to maintain streambank stability in previously unprotected Class III watercourses. It also added additional retention to areas prone to landsliding within headwall swales and Steep Streamside Slopes (SSS). Later, in 2014 the SSS zone slope threshold and widths of the retention zones were modified to more closely represent localized landsliding. These modifications were the result of the data collected and analyzed during the GDRCo SSS Delineation Project. Additionally, the Forest Management WDR approved and implemented in 2012 included further revisions and enhancements to our Elk River management plan. Over the years, each of these changes has resulted in continually increasing tree retention in the most sensitive areas of the landscape and has gradually reduced the number of streamside landslides and sediment delivered to watercourses over time.

Harvesting itself has also changed significantly with the common practice of cable yarding on steeper slopes. Current cable yarding operations typically achieve full suspension significantly reducing the chance of bare soil being exposed to erosion processes due to yarding. Ground-based shovel yarding utilizes track-mounted machines that operate on top of the slash without the need for cutting skid trails. This evolution in ground-based yarding began around the year 2004 on GDRCo lands. Each of these changes contributed to the reduction in the amount of bare soil exposed compared with historical ground-based operations. Both changes in management practices have resulted in reduced ground disturbance in recent times and have contributed to the reduction of landslide occurrence in the area.

Most recent decadal erosion rates associated with shallow landsliding are down more than 90 percent across the GDRCo ownership when compared with historical highs in

the 1970's. The implementation of the T&I rules and the transition to shovel logging in the early 2000's could likely represent the beginning of the most significant changes in modern logging era. From that point forward, shallow landslide sediment delivery rates are at an all-time low of 50 $yd^3/mi^2/yr$. As previously mentioned the long term sediment delivery rates for the Humboldt Bay HPA are significantly less than the property wide average. Our recent review of aerial photographs in the area supports this declining trend having observed only one relatively small landslide within the South Fork Elk portion of the GDRCo ownership since our previous report in 2010, eight years ago. Subsequently, we would expect that the most recent decadal sediment delivery rates for the Humboldt Bay HPA, which includes the Elk River portion of our ownership to be even lower than the long term sediment delivery rates we have estimated for the ownership.

4.0 PROBLEMS ENCOUNTERED AND RESOLUTION

One of the problems encountered was during the compilation of previously mapped landslides within the S.F. Elk River watershed and involved mapping projection errors from using the older landslide inventory from PWA, which were used in the Hart Crowser 2004 Watershed Analysis as well as the Upper Elk River TMDL. We attempted to verify the locations from the aerial photographs on file at GDRCo, but several of the aerial photographs from 1966 and 1974, that shown historical landslides, could not be located. Therefore some location interpretation and extrapolation had to be conducted using the existing PWA data in conjunction with GDRCo LiDAR and aerial photographs from 1978 in order to properly locate those landslides and integrate them into our database. In addition, some of the landslides mapped by PWA were determined to be a part of isolated movements of larger deep-seated landslides. Sediment delivery rates of deep-seated landslides have not been calculated on GDRCo's ownership, although, this data will be compiled at a later date as part of GDRCo's Mass Wasting Assessment.

5.0 SUMMARY OF MONITORING ACTIVITIES

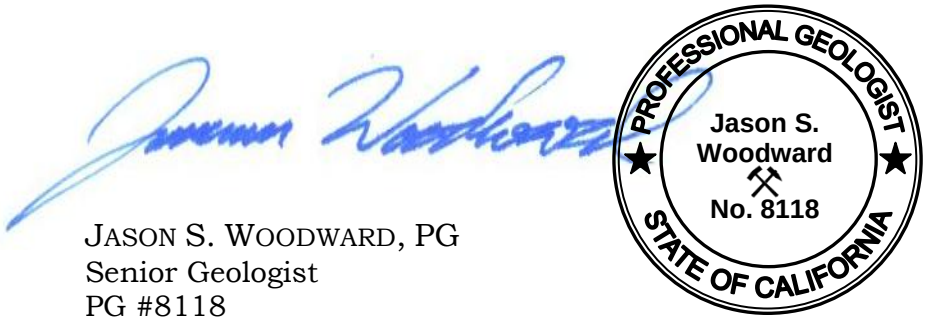
Our most recent landslide monitoring included a review of the orthorectified imagery from 2005, 2006, 2009, 2010, 2012, 2014 and 2016. The review of aerial imagery was followed by field reconnaissance. Compared with historical data, there appears to be a downward trend in observable landslides within the GDRCo portion of the S.F. Elk River drainage. This downward trend is supported by our recent monitoring where only one new landslide was observed on the aerial imagery within the GDRCo portion of the S.F. Elk River drainage during this time period. As previously mentioned the one landslide we did observed delivered 503 yd^3 which was roughly 20 percent of the total volume of the landslide.

6.0 SUMMARY OF TRAINING & CERTIFICATION

Our geologic technicians are continually collecting landslide data in the field. Training of new staff geologists includes several weeks of field work with the oversight of trained staff geologists in addition to a licensed professional geologist. During our field training individuals learn to identify landslide features such as ground cracks, scarps, back-tilted stumps, skewed trees, hummocky topography, as well as develop cross sections of landslides, which are used to determine landslide erosion and sediment delivery volumes. The two staff geologists who conducted the recent surveys have a combined 12 years of landslide surveying experience.

We have completed our work in accordance with generally accepted professional geology and forest geology practices for the nature and conditions of the work done in the same, or in similar, localities at the time the work was performed. Should you have any questions about this work, feel free to contact us at any time.

Respectfully submitted,
GREEN DIAMOND RESOURCE CO, GEOLOGY DIVISION



JASON S. WOODWARD, PG
Senior Geologist
PG #8118

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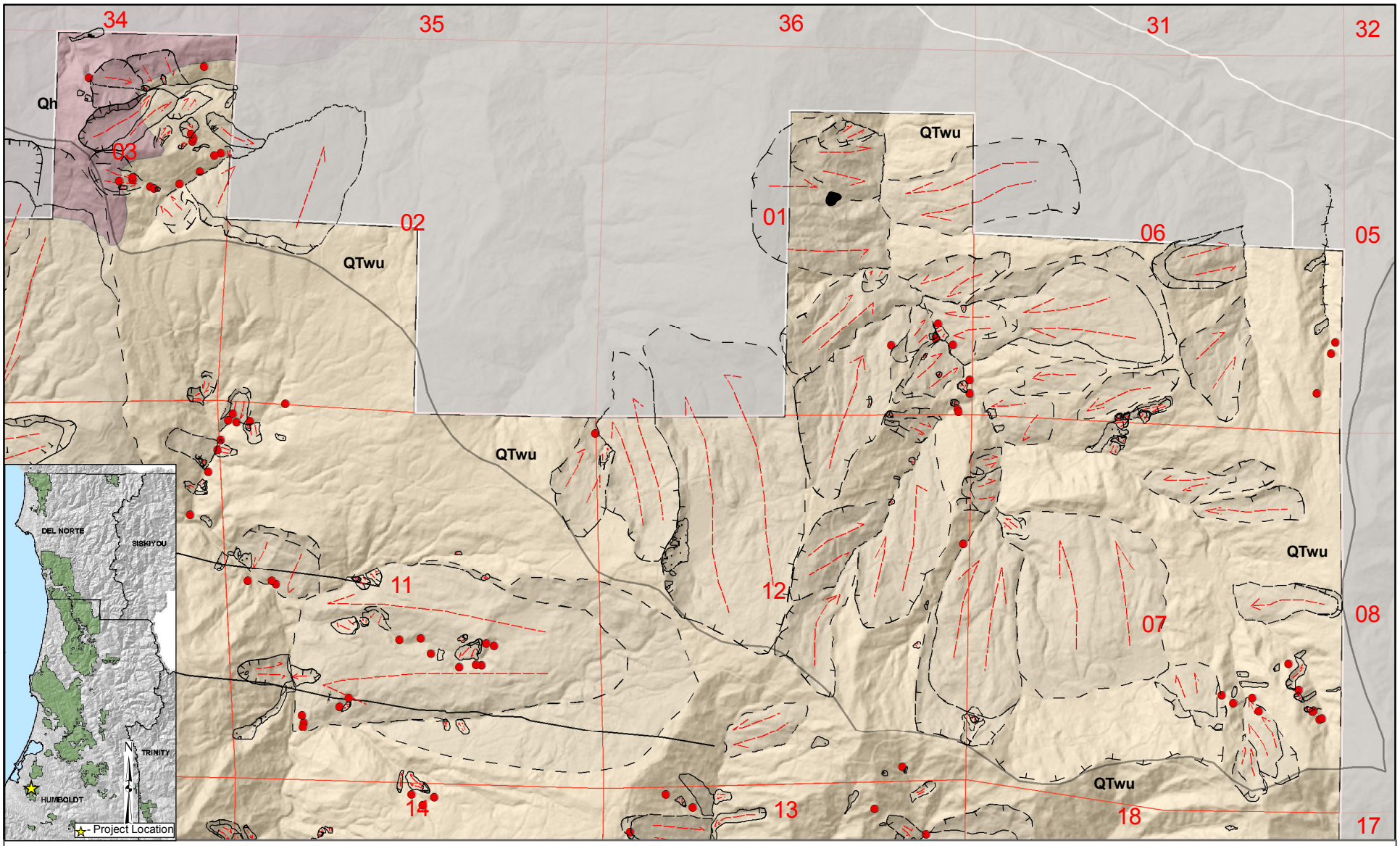
FIGURES

1 Geologic and Geomorphic Map of GDRCo's S.F. Elk River ownership

APPENDICES

A Copies of field data and sketch.
B Photo of 2012 Landslide.



GREEN DIAMOND RESOURCE COMPANY

FIGURE 1 , GEOLOGIC AND GEOMORPHIC SITE INDEX MAP
South Fork Elk River WWDR 2017 Landslide Report
MRP No R1-2008-092

T3N, R1W & T3N, R1E

0 2,000
Feet

EXPLANATION

Earth Materials

Qh - Hookton Formation

QTwu - Wildcat Group undifferentiated

Property Boundary, non-GDRCo Property shaded in grey

Approximate Watershed Boundary

Symbols

Earthflow - Arrow indicates direction of movement solid where active to historic, dashed where dormant

Rotational/translational Landslide - Arrows show direction of movement solid where active to historic, dashed where dormant.

Landslide too small to map w/ torrent track

Debris slide (Recently mapped slide in bold)

Scarp - Solid where historic to active, dashed where dormant

Appendix A Field Data

Elk River WWDR Landslide Survey

PKey ______ ~~Steep Streamside Slope Assessment Form~~ Digitized ___

Name(s) S. Kirkman, A. Fehrenbach Location McCloud Creek, SF Elk River off R SA 2551

Date 10/11/17 GDRCo Num 14-0504 ~~Sub~~Unit # A LSID 1

UTM Top / Bot (NAD 83) X 404589 Forensics

Y 4503058 (Road) - Crk Erosion - (Harvest) - Bedrock

Accy. (ft) ______ Meas. Count ______ (AHCP) Feature Type

(SSL) DSL / IG / HS

LS Type: DF/(DS)/EF/R/T/RS/RF

Material (slide debris): Rock - (Earth(20%-80% <2mm/med sand)) - Debris(20-80%>2mm)

Bedrock: QTwu

Type:	Mode:	Activity:	Certainty:	failure surface
(Slide)	Rotation	(Active (last annual cycle))	(D) P Q	GW SW (ML) MH Bedding
Flow	(Translation)	Dormant Historic	Watercourse Class	GP SP CL CH Jointing
Fall	Block	Dormant Young	I / II-1 / II-2 / (III)	GM SM OL OH Fractured
Topple	Wedge	Dormant Mature		GC SC PT
Composite	Compound			

Delivery: (Y) / N / Indirect

Deliv. Loc.: (Active Channel) / CMZ / FP / Mid slope

Delivery Est.: 20 %

Dimensions (d=displaced mass r=rupture)

Ld: 123'	Lr: 157'	Skid Road Assoc. Y / N	Ave Slope Inclination (%)
Wd: 100'	Wr: 105'	Truck Road Assoc (Y) / N	Source/Debris: 32° 63% / 38% 21°
Dd: 8'	Dr: 8'	RR Assoc. Y / N	Ave slp Clino/x-sec 32° 63% / (53%) 28°
		Cut (Fill) Pulled X-ing	Toe-Water 0%
Lt (toe to crown): orig. 160'		Curvature	Above slide ~~to SSS~~ 0%
Dwat (from crown): 157'		(CC) CV - CP - P	

VA (upper tuta veneer of debris) Ld 35' Wd 74' Dd 2'

~~Dsss to crown~~ ______

Ls w/in SSS? Y/(N) Post Harv. Slide? (Y) / N Was ~~SSS~~ Harvested? (Y) / N Was Retention Met? Y/N N/A

Comments (Veg. cover, erosion, Forensics, seeps): Slide occurred off the edge of the fill slope of the SA-2551 road. Road was decommissioned in 2009/2010. A waterbar drains into the upper-right-lateral scarp corner. Recent reactivation is evident in the upper-left-lateral scarp/corner. Scarp vegetated w/ grass and some bare soil is exposed. Sub-merch and channel trees appear to have been retained on slide slope. Few trees tilted on slide, stumps tilted and split, some regen/stumps straight.

Site Sketch (Scale 1" ≈ ______) *map proximity of; stumps, gullies, roads, yarding corridors.

Stream channel at toe is choked out w/ slide debris and LWD from broken trees/branches, etc.

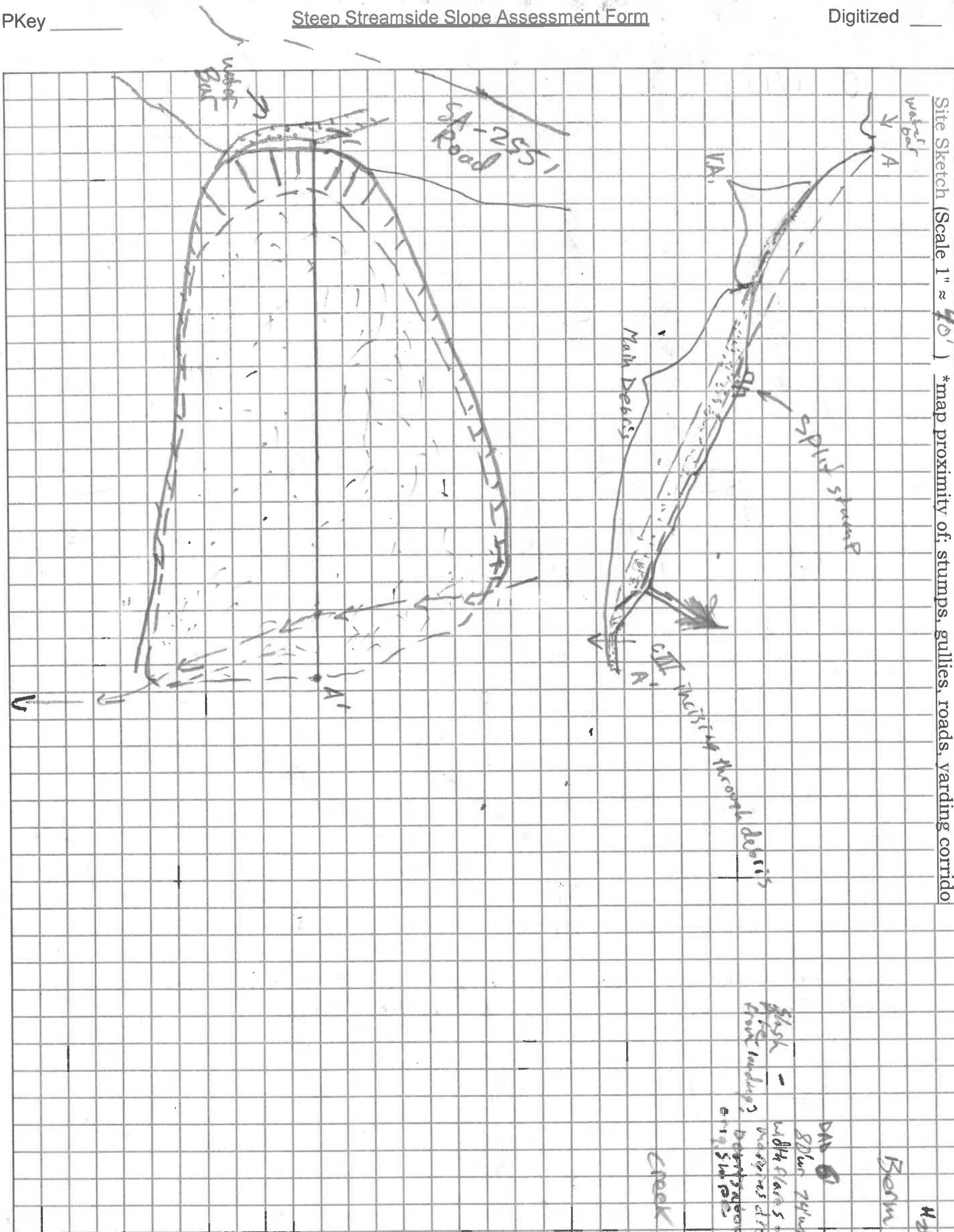
Dist | slope

PKey ________

Steep Streamside Slope Assessment Form

Digitized ___

Site Sketch (Scale 1" ≈ 40') *map proximity of: stumps, gullies, roads, yarding corrido



Dist	Slope
3'	0°
31'	49°
21'	29°
27'	9°
33'	26°
18'	22°
18'	23°
16'	37°
12'	—

Appendix B

Photo of 2012 landslide