

TECHNICAL MEMORANDUM

Date: August 28, 2018

To: Tom Kneale PEng, Manager – Geotechnical and Materials Engineering
Ministry of Transportation and Infrastructure – Southern Interior Region

Cc: Daniel Hutchins
Interior Roads Ltd.

Re: **Preliminary Observations and Comments**
Texas Creek Road Landslide

1 Introduction and Scope

As requested, Westrek Geotechnical Services Ltd. (Westrek) completed the fieldwork for the assessment of the landside that occurred below the Texas Creek Road and affected a property on Roshard Road within the District of Lillooet. This report is a summary of the observations made on July 31 and August 10, 2018, along with our preliminary assessment of the findings to date. It includes a discussion of the most likely risk mitigation option that is available at this site. This memorandum is provided to the Ministry of Transportation and Infrastructure (MoTI) and Interior Roads Ltd. for a review of the results to date and for communication with stakeholders. Since all the relevant background information has not been collected and reviewed at this time, this memorandum should not be distributed to the broader audience at this time. A more detailed report will be released once all the background information has been reviewed and assessed.

The work was authorized by Tom Kneale PEng on behalf of Interior Roads Ltd. on July 20, 2018.

2 Summary of Observations

The site lies on the south end of a lacustrine terrace on the west side of the Fraser River. The terrace is elevated about 80 m above the Fraser River floodplain. The stream that drains to the landslide site originates within the steep, bedrock-controlled mountainside that rises to the west. Cook's Road crosses the stream several times on the mountainside. The stream flows across a small alluvial fan on the terrace and the Texas Creek Road crosses it and a number of other drainage features, as described below.

Draw 1 (likely the natural stream channel)

- This draw is located directly below the location where the stream meets the Texas Creek Road. This point of the road lies near the apex of the ditch and the majority of the stream is diverted south (see below).
- The culvert for the draw is about 10 m north of the stream and the ditch grade is only about 2% to 4%. A 500 mm diameter corrugated metal pipe (CMP) culvert drains into the draw below (the diameter is uncertain as the inlet is damaged). Flow from the culvert is redirected via a short flume back towards the natural stream draw. The draw was wet at time of assessment.
- Surface runoff infiltrates midway down the draw and it was dry below. The draw gradient is 55%.
- An old trail crosses the draw about 95 m below the road. An old fill slope failure occurred that ran out about 10 m. The scarp was dry at time of assessment, but vegetation suggests the area has ephemeral seepage.
- Seepage emerges near the bottom of the slope about 120 m below the Texas Creek Road. This is about 40 m directly uphill from the house. Channel gradient changes from 65% to 70% uphill to 40% below and the draw is wet.
- Surface runoff continues down to the property where it flows adjacent to the house and the channel has been armoured with cobbles.

Draw 2

- This draw lies below the road about 75 m south of the stream. At this location the Texas Creek Road is retained by “no post” concrete barriers, which suggests that an erosion or landslide event occurred here in the past. There is no culvert above this draw.
- The road fill is cobbly and has a 75% angle. Seepage emerges from beneath the toe of the fill about 25 m below the road shoulder and flows down a short distance into a trapezoidal-shaped draw that has 55% to 60% gradient below that. Seepage infiltrates into the draw a short distance downstream.
- A secondary draw enters the main draw from the south about 50 m from the Texas Creek Road. This draw extends up the slope towards the existing stream culvert (see below). The upper part of the secondary draw has a near-vertical scarp in the clay deposits at the head of the gully (likely an old trail failure).
- A small landslide occurred in the main draw channel just below this junction. There was no seepage when assessed.
- The fan apex is about 140 m from the Texas Creek Road. A small diversion ditch had been constructed to intercept and divert runoff towards a house about 30 m to the north, which lies on the adjacent fan at the outlet of Draw 1. The diversion ditch was dry at the time. A recently installed plastic pipe diverts the runoff out of the diversion ditch a little farther downstream, and it discharges onto the fan surface.

Existing Stream Culvert and Drainage along the Texas Creek Road

The stream is currently diverted about 150 m south to a 500 mm diameter CMP cross-drain culvert. The ditch depth is variable (~0.5 to 1 m) and groundwater seepage emerges from the cut slope along most of this section.

Runoff from the culvert is conveyed via a shallow ditch to the terrace edge. The landslide initiated at that point in an old trail that crosses the edge of the terrace. The trail fill failure triggered a debris avalanche that ran out onto the floodplain below. A similar but much older trail fill failure was observed a little farther north.

The ditch to the south of the existing stream culvert appears to climb slightly to the south, before dropping again, where it is crossed drained under the Texas Creek road into Draw 3. This section of the ditch was dry when reviewed on July 31, 2018.

Draw 3

This draw has been proposed as an alternative to the existing stream culvert location. It is about 280 m south of the stream and about 130 m south of the existing stream culvert.

- The existing culvert is a 600 mm diameter CMP within a 1.5 m deep ditch.
- The road fill slope below is 80% for 7 m. No seepage was present when reviewed.
- The draw gradient below that is sloped at 50% for the first 20 m. Sidewalls are 10 to 15 m high and sloped at 35%. The draw gradient flattens to 40% to 45% below that and runoff has incised a channel in the draw that is roughly 2.5 m wide and 1 to 2 m deep. No seepage was present when reviewed.
- At about 100 m from the Texas Creek Road, a branch draw joins the main draw from the north. Channel incision in the draw is roughly 5 m wide, 2.5 m deep and has 100% sidewall slopes. A small sidewall failure was observed in this area and the draw gradient steepens to 55%. No seepage was present when reviewed.
- Seepage appears in the main draw at 135 m from the Texas Creek Road. It flows into a small, man-made depression about 15 m long. Flow from the north draw is also diverted into the depression by a man-made berm 1 m high and 10 m long. Seepage infiltrates in the bottom of the depression.
- A dry channel below the depression is crossed by a driveway, about 80 m southeast from the house adjacent to the landslide, and 35 m from a mobile home situated directly across the driveway from the draw. The ditch along the driveway was wet.

3 Preliminary Conclusions and Comments

The landslide hazard associated with the steep slope and draws below the terrace edge and the proximity of houses to the slope toe severely constrains options for drainage off the Texas Creek Road. Given the observed instability, both natural and related to old trails and other development on the steep slope, and given the highly erodible fine-grained deposits that are present, the stream will have to be conveyed down the slope via a flume. This will be a challenging installation considering the slopes involved and the required flume length, and it

will have future maintenance obligations. It will also require a right-of-way that extends down the steep slope and a strategy to convey the runoff across the floodplain.

Aspects to consider for designing and installing a flume in each draw are provided below:

Draw	Positives	Negatives
Draw 1 (likely the natural stream draw)	<ul style="list-style-type: none"> • Shortest ditch length so ditch cleaning less critical. If this draw were to be used, cross-drain the stream where it meets the road rather than diverting it north into the existing culvert. 	<ul style="list-style-type: none"> • Existing scour and previous landslide in the draw • Culvert would not intercept and drain the seepage from the road cut to the south, so one or more other culverts would be needed there. • Would have to consider proximity to house at outlet of Draw 1.
Draw 2	<ul style="list-style-type: none"> • Would collect most seepage along the wet cut slope • No house directly below this draw, but there is one near the Draw 1 outlet to the north. 	<ul style="list-style-type: none"> • Uncertain road fill stability (retained by concrete barriers). • Existing landslides in draw • Would have to consider proximity to house at outlet of Draw 1.
Existing stream drain location	<ul style="list-style-type: none"> • Status quo • Note: could also divert flow into the branch draw that flows into Draw 2 (see above). 	<ul style="list-style-type: none"> • Fine grained sediment in the upper landslide surface will be erodible and marginal for flume support. • House at toe would be proximate to structure, and installation would bisect their yard.
Draw 3	<ul style="list-style-type: none"> • Farthest from most houses • Would drain cut slope seepage along majority of section. 	<ul style="list-style-type: none"> • An elevation survey is needed to establish feasibility. A ditch upgrade may affect the uphill landowner. • Mobile home on floodplain will have to be moved.

The construction of residences so close to the toe the steep unstable slope should not have been permitted without some form of risk mitigation strategy in place. Now that a potential unacceptable risk from landslides to the residences near the slope toe has been identified, a more specific landslide risk analysis should be undertaken by each owner to examine the risk in more detail, and where needed, to determine if any risk mitigation measures can be installed. Typical protection measures might include deflection berms, diversion ditches, or flexible protection fences. It is possible that a cost-effective risk mitigation measure may be not available for the house immediately south of the landslide, given its close proximity of the toe of the steep slope. This house may have to be moved to a safer location.

The simplest strategy at this point, both from the short- and long-term perspective, may be to install a new culvert and flume in Draw 2, since there is no home directly below its outlet. The flume would have to extend across the fan to reduce the risk to the house to the north at the outlet of Draw 1. For the short-term, an appropriately sized trench could be excavated across

the fan to convey stream flow or even a small landslide past the house, until the flume can be installed. A detailed site survey and design will be needed for this work. There may be water license issues that have to be addressed.

Westrek will gather and review information such as historical air photos and possibly other records from the District of Lillooet related to the subdivision and issuance of building permits along Roshard Road and Cook's Road. This information will be incorporated into a more detailed report along with more specific engineering recommendations as needed.

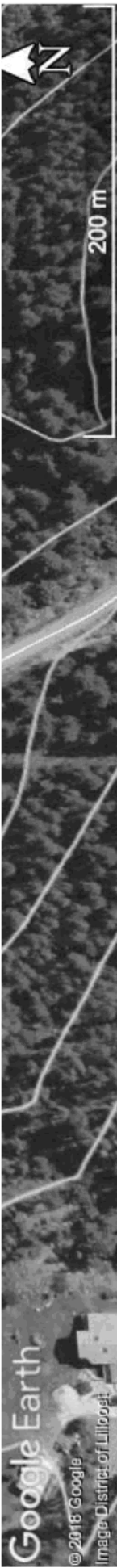
4 Closure

This report has been provided for preliminary review and communication purposes. Please provide any input or points or consideration to the undersigned.

Westrek Geotechnical Services Ltd.



Kevin Turner PEng
Senior Geotechnical Engineer



	TEXAS CREEK ROAD LANDSLIDE LILLOOET, BC		Scale: As shown	FIGURE 1
	Source: Google Earth™, 2005 imagery. Not all houses are shown in this image.		North is to the top	
			Project: 018-163	



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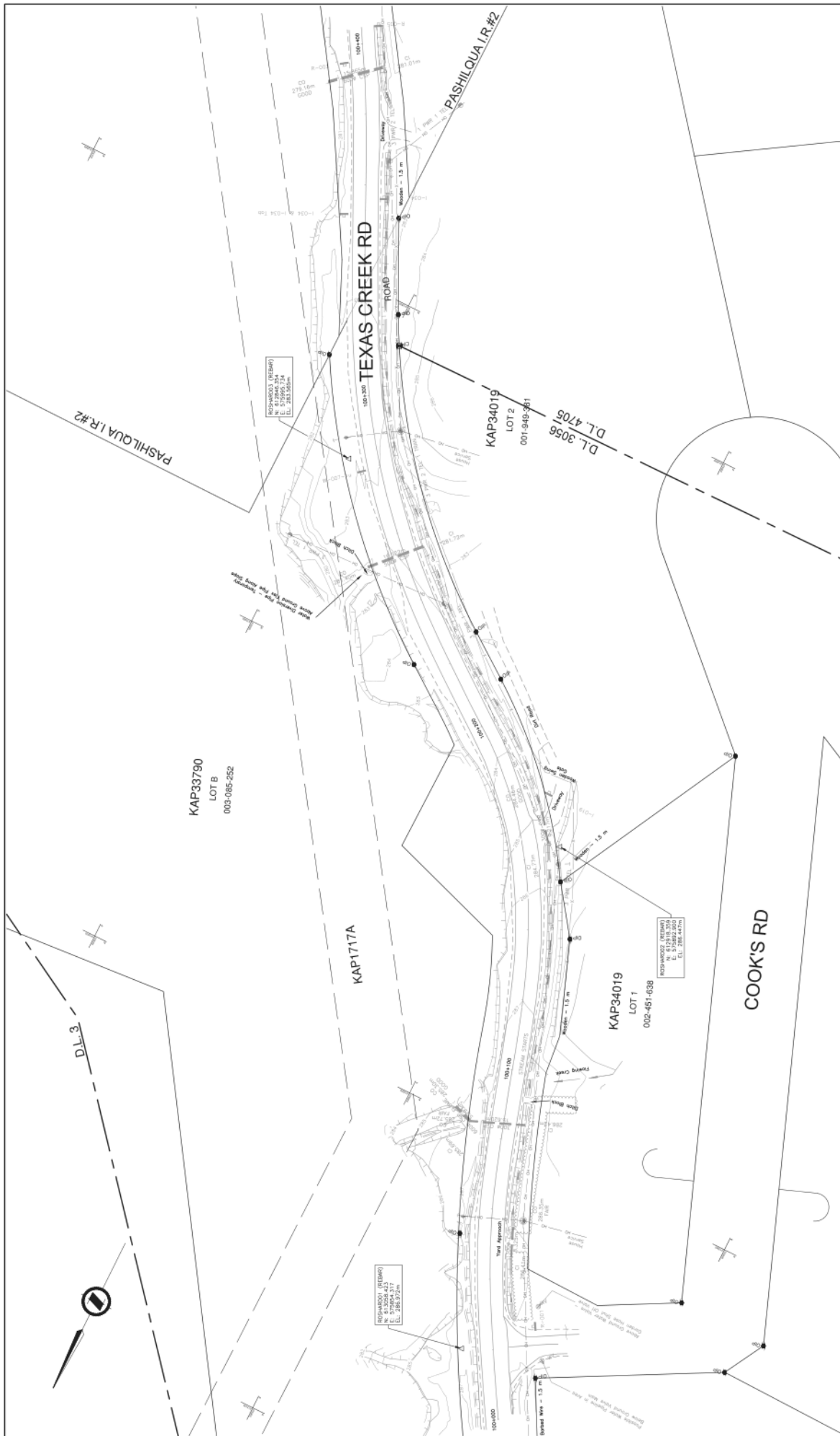
PROJECT NO. ##### PROPOSED ROSHARD SLIDE LILLOOET - TEXAS CREEK ROAD

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KEY MAP
NOT TO SCALE

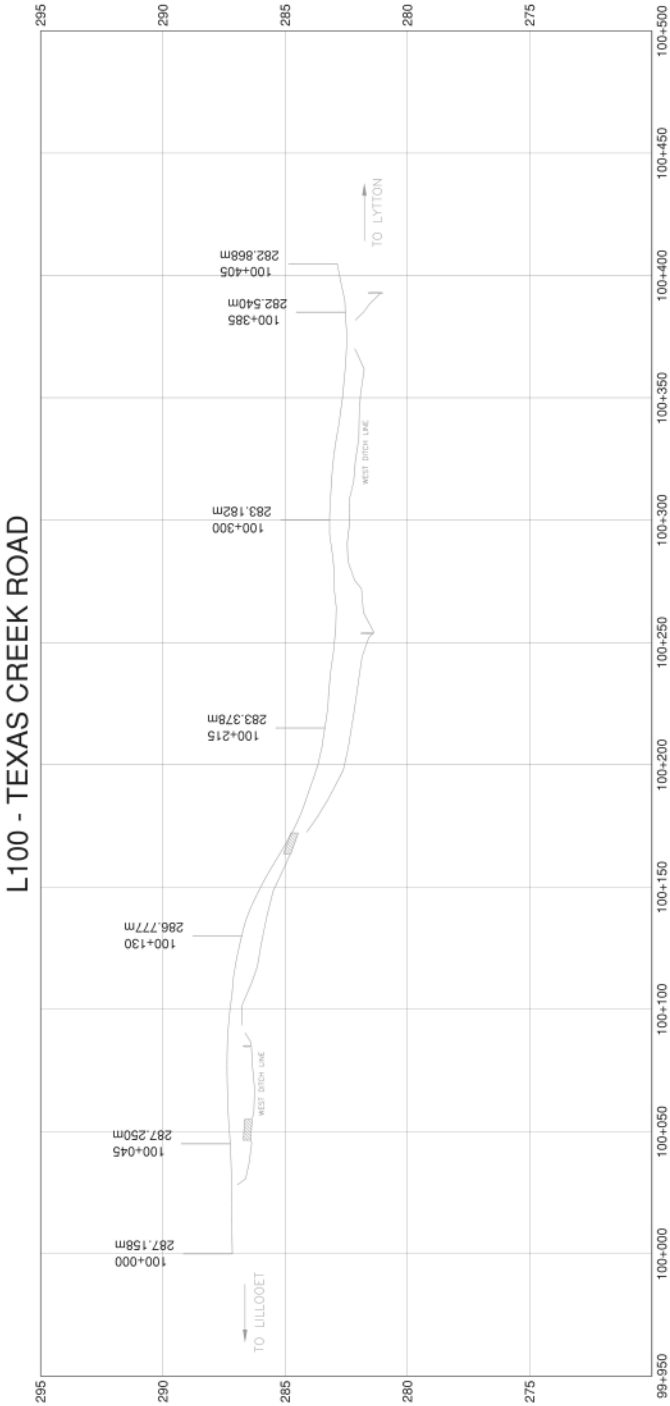


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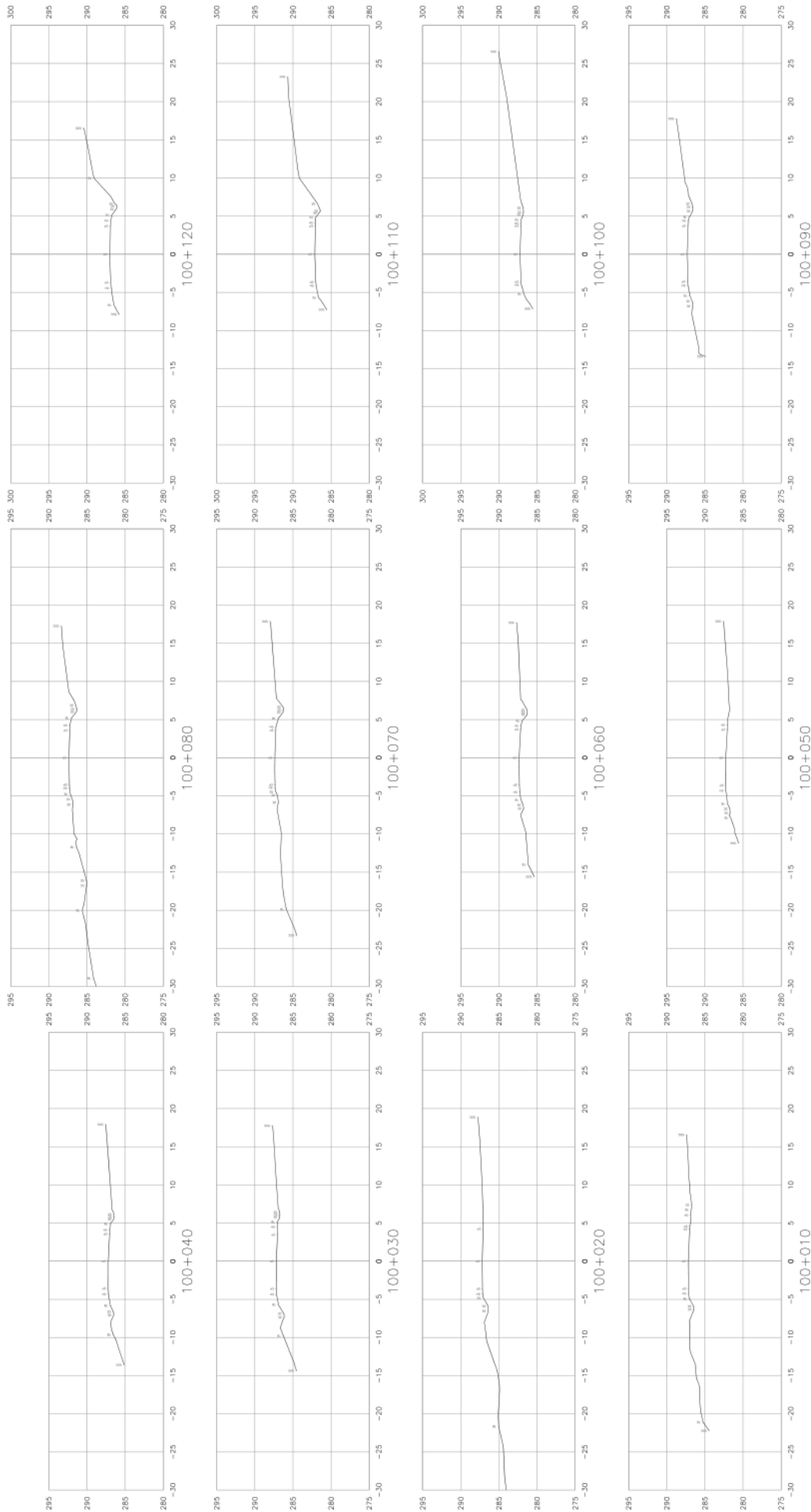
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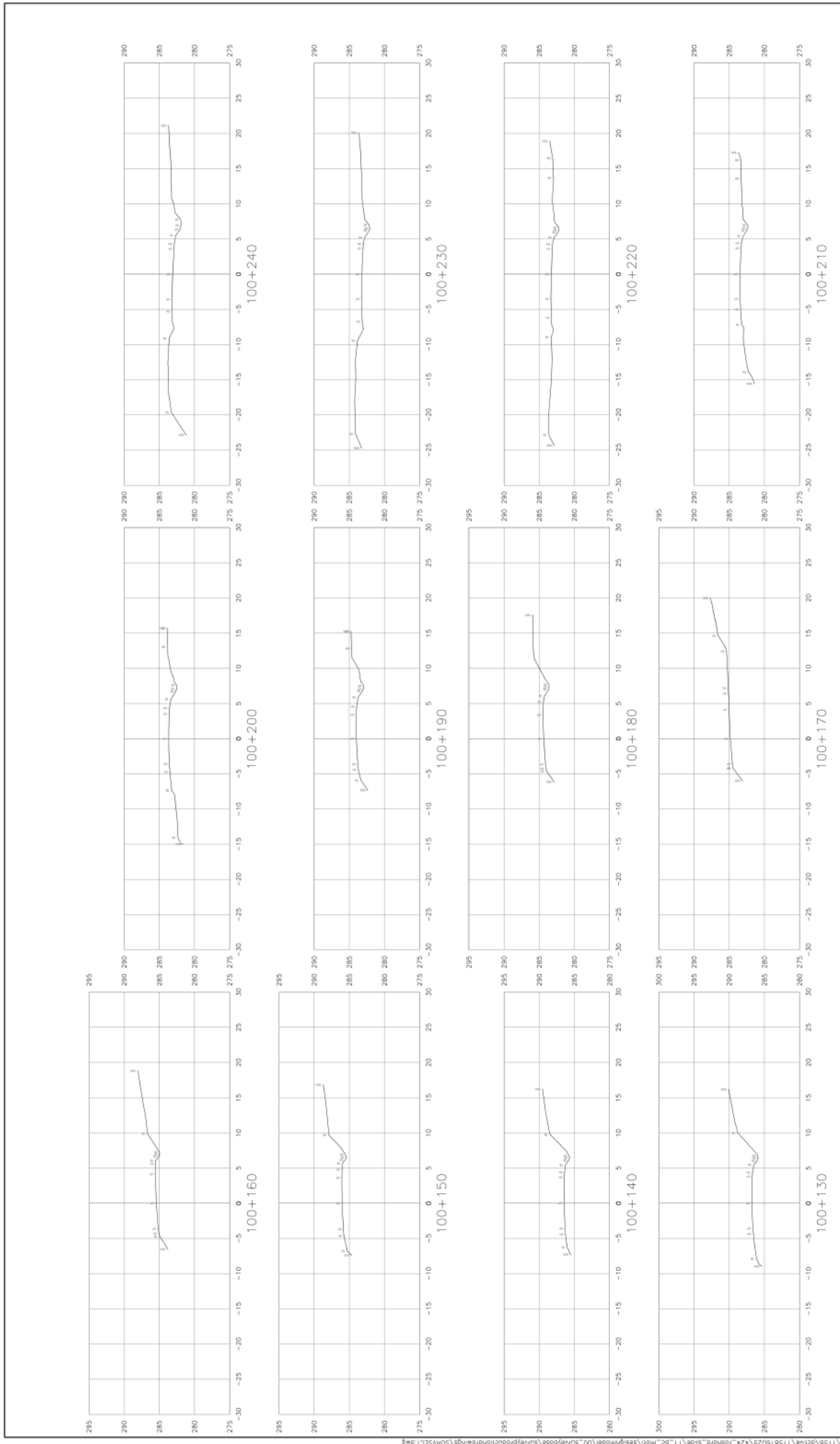


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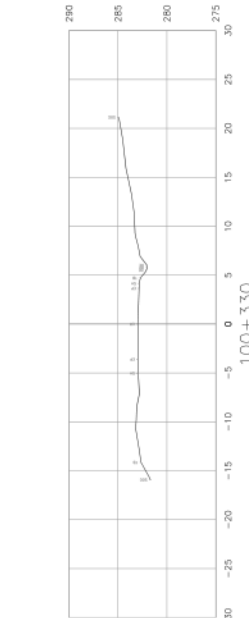
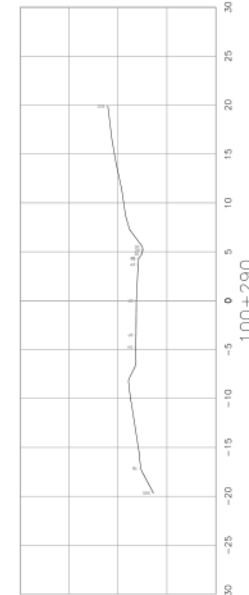
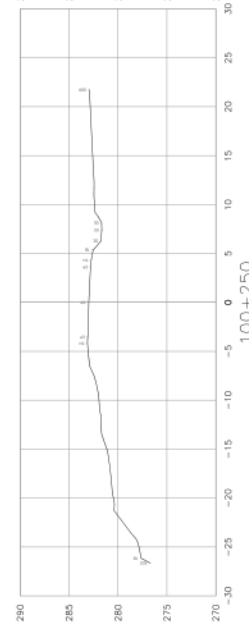
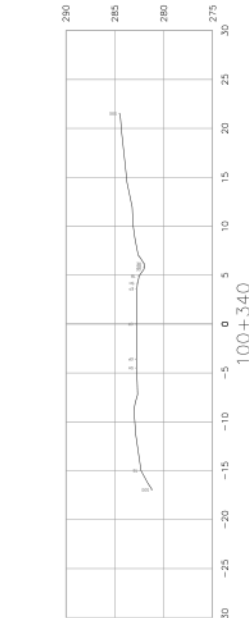
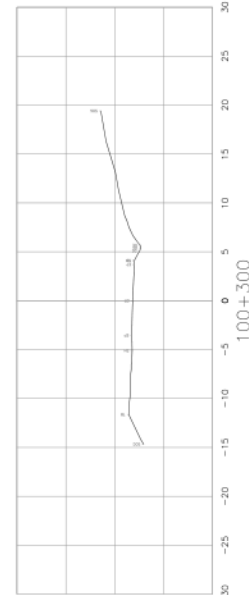
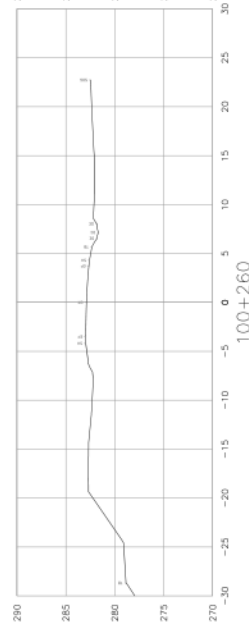
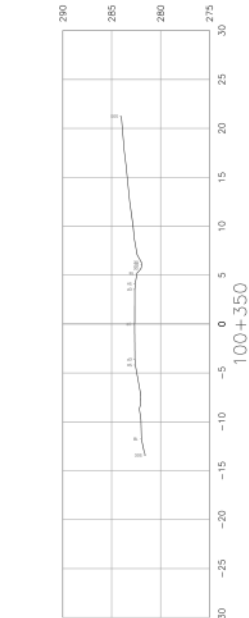
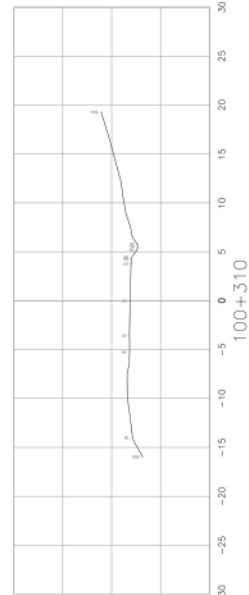
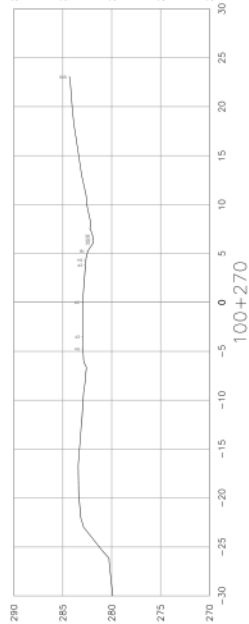
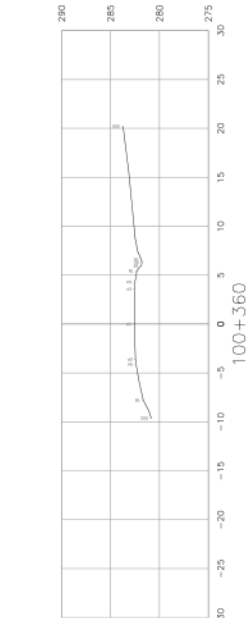
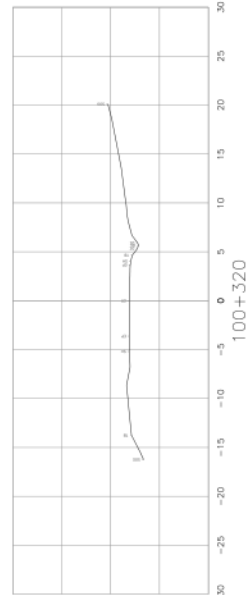
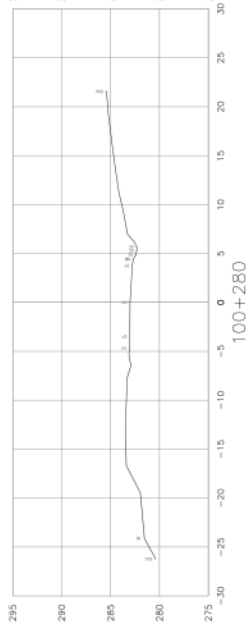
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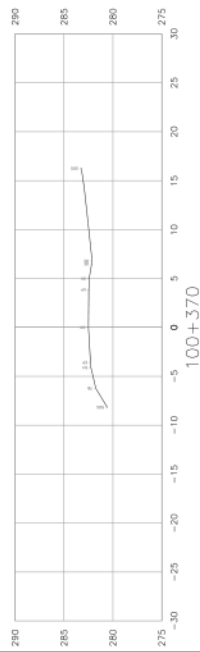
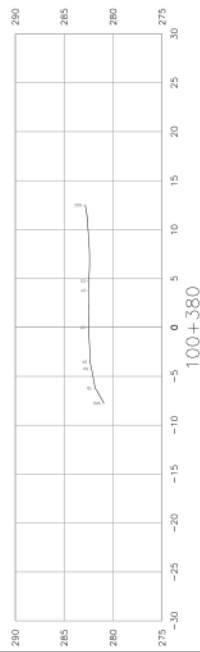
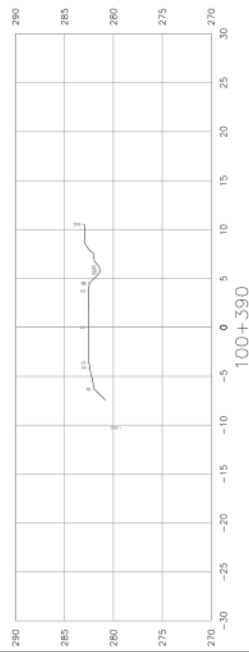
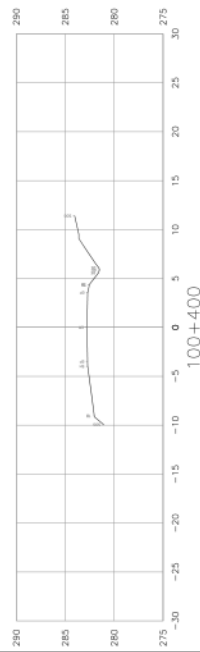
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