

How Practical are Precipitation Shutdown Guidelines?

Paul Marquis

In September of 1994 the Ministry of Forests established "Precipitation Related Operational Shutdown Guidelines."¹ The purpose of these guidelines was to relate soil moisture conditions and landslide potential in an effort to reduce the risk of injuries and fatalities in potentially unstable areas.

The guidelines were developed using historical rainfall data and a theoretical snowmelt model that was originally created by the U.S. Army Corps of Engineers. Although the guidelines apply to all of Vancouver Island and the Lower Mainland, the region was divided into two hydrologic zones in order to account for geographic variability. The wetter hydrologic zone is typified by the west coast of Vancouver Island while its drier counterpart is represented by sites such as Nanaimo.

Designed around a simple input–output model as illustrated in the table in Figure 1, the guidelines require the measurement of precipitation over a fixed period. Operational work is to be suspended in areas with a high or moderate risk of landslides if the soil moisture balance equals or exceeds 100 mm for the wetter hydrologic zone or 55 mm for the drier hydrologic zone. These original shutdown criteria were based on the 2-year return interval for the average annual extreme precipitation event. In other words, on average, one would expect to have to shutdown operations once every two years. While the statistical analysis of precipitation data can establish the return intervals of various events with a known degree of accuracy, the relationship between the average

annual extreme precipitation event and landslide initiation is much more difficult to establish accurately. Although soil moisture is undoubtedly an important factor in landslide initiation, this model treats all moderate and high terrain stability classes as identical and thereby reduces its sensitivity.

The model is further compromised by the fact that it relies upon predicted precipitation. Weather forecasts seldom contain anticipated precipitation totals and when they do they are imprecise, as they tend to give a range of values (e.g. expected accumulations of 30 to 50 mm).

The precipitation data used in the development of the shutdown guidelines was collected by Environment Canada's network of climatological stations. Although there are a large number of stations throughout coastal British Columbia, the vast majority of these sites are located at relatively low elevations. Furthermore, precipitation totals are also influenced by the aspect of the site in relation to the passing storm front.

An example of how the factors of elevation and aspect affect precipitation totals is illustrated by examining three meteorological stations located in the Hesquiat Basin area of the west coast of Vancouver Island (see map, Figure 2). The Estevan Point station, operated by Environment Canada, has an elevation of 7 m. The Hesquiat South installation is situated about 14.5 km northeast of the Estevan Point station at an elevation of 170 m and the Hesquiat North site is approximately 15.1 km north of Estevan Point at an elevation of 700 m.

Both of the Hesquiat sites were established by the Ministry of Forests and consist of a rain gauge and a temperature sensor attached to a datalogger (Figure 3). The distance between these two stations is approximately 5.9 km.

The table in Figure 4 shows the data collected from the

	Wetter Hydrologic Zone	Drier Hydrologic Zone
Actual precipitation in the previous 24 hours	0	13
Allowance for drainage	-50	-30
Current soil moisture balance	0	0
Forecast precipitation for the next 24 hours	150	17
Allowance for drainage	-50	-30
Forecast soil moisture balance	100	0
	Stop work	Continue work

Figure 1. The example for the wetter hydrologic zone uses data collected near the Hesquiat Basin and data used in the drier hydrologic zone were collected in Nanaimo. All data were collected on February 29 and March 1, 2000.

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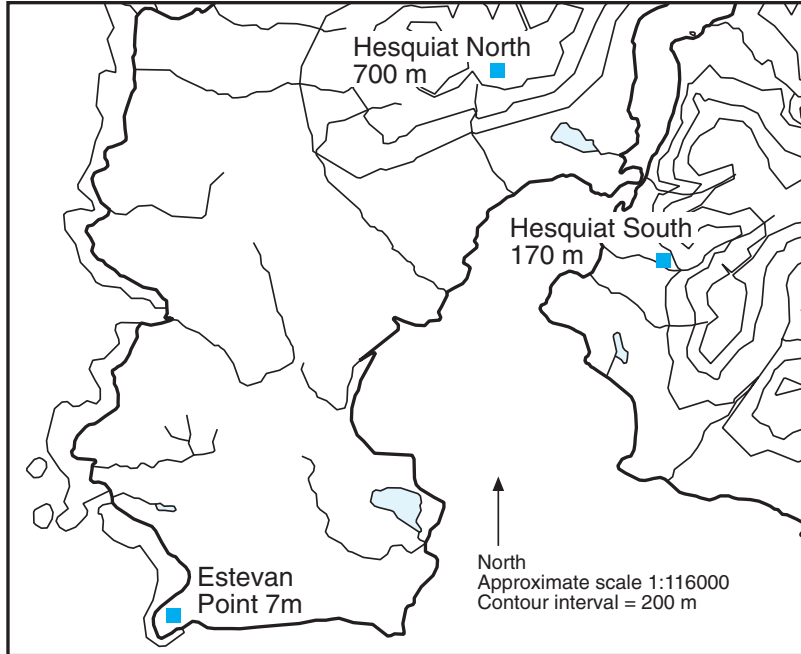


Figure 2. The Hesquiatic Basin is located approximately 50 km northwest of Tofino on Vancouver Island.

three stations following a precipitation event in May of 1998. Some of the disparity in the daily rainfall totals between the Hesquiatic sites and Estevan Point are due to the different collection methods. The precipitation at Estevan Point is measured with a manual gauge and although it is read twice a day the real values collected are not



Figure 3. This is a photo of the equipment installed at the two Ministry of Forests sites in the Hesquiatic Basin. To ensure the accuracy of the data, the installations are periodically replaced with spare units and brought back to the office where the sensors are calibrated.

coincident with the actual date as the precipitation that falls overnight occurs on two different days. Environment Canada therefore manipulated the data to obtain an estimate of the daily precipitation. For this reason, the storm totals at the bottom of the table are a more accurate indicator of the ratio of precipitation received at each site.

Most of the storms along the west coast of Vancouver Island progress from the northwest to the southeast. The Hesquiatic North site is located on the downwind side of the ridge (i.e. it has a southerly aspect) and therefore receives less precipitation than the Hesquiatic South site which has a more westerly aspect. The Estevan Point site is more open and therefore the precipitation is not markedly influenced by orographic effects. For the May 1998 storm, the Hesquiatic South site received almost twice the precipitation (194%) of the Estevan Point station, although they are less than 15 km apart.

An example of the effects of elevation on precipitation can be seen by examining the results of a storm that covered the Hesquiatic Basin area in December of 1998. The data collected for this event is listed in Figure 5.

For this particular storm, the effects of elevation can be seen by comparing the daily totals for the two Hesquiatic sites. The apparent one day delay in precipitation for the Hesquiatic North site is explained by examining the temperature recorded at this station. On December 14, the average daily temperature was 1.7°C below freezing, indicating that the precipitation was accumulating at this station in the form of snow. As the temperature rose on the 15th to an average of 2.5°C, the snow began to melt. By the 16th, the temperature had risen to 4.1°C and the rain gauge was measuring both snow melt and rain. This is a good illustration of how rain on snow events can generate higher soil moisture levels.

It is interesting to note that neither of the storms cited above would have resulted in the suspension of operation work according to the current guidelines. That is not to say

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Date	Estevan Point	Hesquiat North	Hesquiat South	Average
21 May 98	2	3	3	3
22 May 98	13	10	14	12
23 May 98	44	33	66	48
24 May 98	11	35	45	30
25 May 98	1	4	5	3
26 May 98	18	4	4	9
27 May 98	1	39	34	25
28 May 98	0	6	4	3
Total	90	134	175	133
% of average	68%	101%	132%	

Figure 4. Rainfall measurements in millimeters collected at the three meteorological stations in the Hesquiat Basin.

that the current guidelines never result in a work shutdown. For example, in February 1999, the measurements taken from the Hesquiat South station indicate that this site received a total of 1337 mm of precipitation. Applying the current guidelines to these data would have resulted in work being suspended for 14 of the 28 days that month.

Cessation of work due to precipitation in the drier hydrologic zones, however, is much less common. For example, during the past three years (1997 to 2000) there have been no instances in which the implementation of the precipitation shutdown guidelines would have stopped operational work in the area around Sandspit on the Queen Charlotte Islands. In fact, examination of the intensity-duration-frequency data compiled by Environment Canada for the Sandspit airport indicate that the current guidelines would only result in a work shutdown about once every 25 years! Is this realistic?

On September 22nd, 1999, I was in the Sandspit area examining some recent road deactivation. As is commonly the case in the Charlottes, it was raining. In fact, it was raining more intensely than usual. A road building crew was working in the same area and by

Date	Estevan Point	Hesquiat North	Hesquiat South	Average	Hesquiat North Average Temp.
13 Dec 98	6	11	9	9	-0.3
14 Dec 98	54	1	82	46	-1.7
15 Dec 98	6	65	85	52	2.5
16 Dec 98	17	105	52	58	4.1
17 Dec 98	0	7	0	2	-0.9
Total	83	189	228	167	
% of average	62%	142%	171%		

Figure 5. Rainfall measurements in millimeters collected at the three meteorological stations in the Hesquiat Basin. The average daily temperatures for the Hesquiat South and Estevan Point sites never fell below freezing.

late morning they decided that the amount of precipitation that had fallen was sufficient to stop work for the day. This was obviously the right decision as culvert installation and ditching could not be accomplished effectively. However, review of the meteorological record for Sandspit, which is located approximately 9 km to the northeast of the work site, indicated that only 20.8 mm of rain fell that day.

This real life example also highlights another problem associated with the current guidelines: they were developed exclusively to address safety considerations. In fact there are at least two other valid reasons to stop work as a result of excessive precipitation. As noted above, work should stop when it is no longer effective to continue. For example, the compaction of a road bed cannot be conducted to the appropriate standard under saturated conditions. In addition, work should be halted when it threatens environmental resources such as fish. The generation and export of sediment should be a primary consideration in all projects.

So what is all this telling us about the current precipitation shutdown guidelines? Their effectiveness is questionable, as you can probably deduce from the above examples. On the whole the current guidelines:

- do not adequately account for differences in terrain stability,
- do not account sufficiently for variation in precipitation patterns,
- rely on predicted data,
- are difficult to implement (e.g. the collection of data to input into the snowmelt model),
- do not address environmental and work quality issues, and
- are probably set too high for the drier hydrologic zone.

Fortunately, the Workers' Compensation Board requirement that deals with weather-related hazards is not as rigid as the current precipitation shutdown guidelines. Section 27.17 of the Occupational Health and Safety Regulations simply states, "Where weather conditions create hazards to workers, additional precautions must be taken as necessary for the safe conduct of the work."

Although models such as the current precipitation shutdown guidelines can provide valuable insight into the relationships between variables, they are poor tools for making decisions where natural systems are concerned. A more pragmatic approach to the

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problem should combine analytical measures, such as the collection of precipitation data, with the inherent flexibility associated with human judgement. In short, the current precipitation shutdown guidelines are an oversimplification of a complex natural system. Therefore, more often than not, the application of these guidelines results in less than optimum outcome.

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¹ Ministry of Forests Memorandum from the Assistant Deputy Minister to all Regional Managers dated September 19, 1994. ▲



Technical Tip

Rock Climbing, Fly Fishing, and LWD Anchors

Mike Parker

One of the perks of fisheries work is finding scenic spots in Mother Nature's playground for our outdoor activities. I have found some great pools through which to drift a fly, along with the odd rock climbing wall where a stream has endlessly battled against a limestone cliff trying to erode it away. Strangely enough, these two activities popped into my caffeine-stimulated brain while reading an article by Rick Rodman on the use of Manta Ray Anchors in a recent issue of *Streamline* (Vol. 5 No. 2). He mused about the potential reasoning behind a cable failure, the only one he had had in the two years his structures had been in the Little Slokan River.

Rick's cable failure had been immediately below the clamp that fastened a loop around the log he had anchored. I have seen the same failure before on other projects, and a connection popped into my mind between this and a similar failure described in a book I had once read on rock climbing anchors. Its relevance to LWD Anchors was immediately apparent to me.

I have always attempted to draw the anchor cable as tightly as possible around a log, and this practice

seems to be the rule on most projects I have seen. First, this helps to keep the cable from sliding along or off the log when it had not been run through a drilled hole in the log. Second, it made for a neater appearance. Aesthetics is always important when the public may see your work. Unfortunately, this practice apparently produces a weaker anchoring system than a larger, loose loop might.

The applicable reference to failure in rock climbing anchors came from a book by John Long, a longtime professional rock climber whose articles I have read over the years. He recently produced a book entitled *More Climbing Anchors* (1996) as part of the *How to Rock Climb* series that has existed for many years. When it is your life on the end of the line and not a piece of LWD, I guess you think a bit more about your anchors. As explained in the book and diagrammed in Figure 1, it is actually possible to create a cumulative strain greater than the actual force being applied. By tightly wrapping a log with a cable such that the angle of the cable at the loop is greater than about 40°, a "load multiplication" occurs at the point of your cable clamp. Therefore, some cable failures may be avoided