NL WATER RESOURCES MANAGEMENT DIVISION

WSP 2022 HURRICANE SEASON FLOOD ALERT SYSTEM

END-OF-SEASON REPORT

2022-06-01 TO 2022-12-31

MARCH 02, 2023

CONFIDENTIAL

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IMPORTANT NOTICE

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1 FLOOD ALERTS SUMMARY

The WSP Hurricane Season Flood Alert System (HSFAS) Product is the combination of professionally trained meteorologists applying their full knowledge of atmospheric science to Newfoundland and Labrador's weather patterns and combining these patterns with existing trends, known observations, and weather prediction models. Examining maximum precipitation predictions from many different dynamic models, allows forecasters to produce a better forecast of the maximum precipitation potential, based on the strength of different models in handling the atmospheric physics of differing weather patterns.

From June 2022 to December 2022, 39 alerts were issued in total. There were two missed alerts (i.e., the case when observations from a station triggered an alert that had not been issued). Note that some communities had two alerts issued in one day. The second of the alerts were issued with an afternoon update forecast.

Table 1 Summary of Flood Alerts

	Site location	Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
1	Burgeo (BURGEO NL)	6-18-2022	69.0	105.1
2	Burgeo (BURGEO NL)	6-18-2022	69.0	115.1
3	Burgeo (BURGEO NL)	6-19-2022	80.9	146.6
4	Burgeo (BURGEO NL)	6-19-2022	86.5	10.3
5	Wabush (WABUSH)	7-11-2022	46.3	50.3
6	Churchill Falls	7-11-2022	75.9	113.3
7	Wabush (WABUSH)	7-11-2022	46.4	60.0
8	Churchill Falls	7-11-2022	55.6	86.1
9	Happy Valley-Goose Bay (GOOSE A)	7-11-2022	46.8	63.6
10	Churchill Falls	7-12-2022	45.6	51.6
11	Churchill Falls	7-12-2022	65.1	74.8
12	Wabush (WABUSH)	7-17-2022	53.7	60.4
13	Wabush (WABUSH)	7-17-2022	53.7	62.8
14	Happy Valley-Goose Bay (GOOSE A)	7-18-2022	54.4	61.7
15	Happy Valley-Goose Bay (GOOSE A)	7-18-2022	54.7	61.7
16	Battle Harbour	8-17-2022	53.4	54.9
17	Wabush (WABUSH)	9-12-2022	52.6	78.2
18	Wabush (WABUSH)	9-12-2022	56.5	95.1
19	Churchill Falls	9-12-2022	39.8	59.8
20	Wabush (WABUSH)	9-13-2022	63.5	97.8
21	Churchill Falls	9-13-2022	33.7	56.8
22	Wabush (WABUSH)	9-13-2022	67.5	101.4
23	Churchill Falls	9-13-2022	33.7	56.8
24	Mary's Harbour	9-13-2022	61.2	68.6
25	Battle Harbour	9-13-2022	51.2	59.4
26	Wabush (WABUSH)	9-14-2022	67.5	108.0
27	Wabush (WABUSH)	9-14-2022	65.0	105.0
28	Wabush (WABUSH)	9-15-2022	33.0	55.0
29	Corner Brook	10-15-2022	54.8	66.1
30	Burgeo (BURGEO NL)	10-15-2022	87.3	103.2
31	Deer Lake, Steady Brook	10-15-2022	60.6	69.6

	Site location	Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
32	Corner Brook	10-15-2022	54.8	66.1
33	Burgeo (BURGEO NL)	10-15-2022	57.3	103.2
34	Deer Lake, Steady Brook	10-15-2022	60.6	68.6
35	Burgeo (BURGEO NL)	10-16-2022	85.3	108.8
36	Deer Lake, Steady Brook	10-16-2022	55.8	64.7
37	Corner Brook	10-16-2022	55.7	58.1
38	Deer Lake, Steady Brook	10-16-2022	74.8	77.5
39	Deer Lake, Steady Brook	11-24-2022	58.3	65.9
Legend (WRMD or EC Exceeded flood limit)				
Exceeded 12-Hourly 20-yr flood limit				
Exceeded 12-Hourly 100-yr flood limit				
Exceeded 24-Hourly 20-yr flood limit				
Exceeded 24-Hourly 100-yr flood limit				

The 2022 season was less active than the 2021 season (39 vs 56 alerts). The alerts were generally associated with 3 significant rain events in the season. Two rain events were in Labrador, one in July and one in September and another rain event in western Newfoundland in October. Two alerts were missed, one for eastern Newfoundland in September and another for Labrador in July.

Table 2 Monthly Analysis of Flood Alerts

Month	Total Alerts	12-hourly 20-yr alerts	12-hourly 100-yr alerts	24-hourly 20-yr alerts	24-hourly 100-yr alerts	Env. Can. & WRMD Obs.
June	4	1	0	2	1	0
July	11	8	3	0	0	1
August	1	1	0	0	0	0
September	12	2	5	4	1	1
October	10	9	1	0	0	0
November	1	1	0	0	0	0
December	0	0	0	0	0	0
Total:	39	22	9	6	2	0

The geographical spread of the alerts this season was focused on western and southern Newfoundland and Labrador. Most alerts (62%, Fig. 1) were issued for Labrador.

Table 3 Regional Analysis of Flood Alerts

Community	Region	Total Number of Alerts
Wabush	Labrador	11
Churchill Falls	Labrador	7
Happy Valley-Goose Bay	Labrador	3
Battle Harbour	Labrador	2
Mary's Harbour	Labrador	1
Corner Brook	Western	3
Deer Lake, Steady Brook	Western	5

Community	Region	Total Number of Alerts
Burgeo	Southern	7

From a geographic perspective:

- Eight (8) alerts were issued for the Western region
- Zero (0) alerts were issued for the Eastern Region
- Zero (0) alerts were issued for the Central Region
- Seven (7) alerts were raised for the Southern Region
- Twenty-four (24) alerts were issued for Labrador

There was a significant concentration of rainfall alerts for western Labrador, given a relatively persistent storm track and a favourable pattern for excessive rainfall. Rainfall was well below normal in coastal Labrador and central Newfoundland. Rainfall was slightly below normal in eastern Newfoundland. The Atlantic Hurricane Season was active yet again in Atlantic Canada, with severe storm surge and wave damage in Channel-Port aux Basques with Post-tropical Fiona and the St. John's Waterford Bridge flooding from the remnants of Hurricane Earl, both in September.

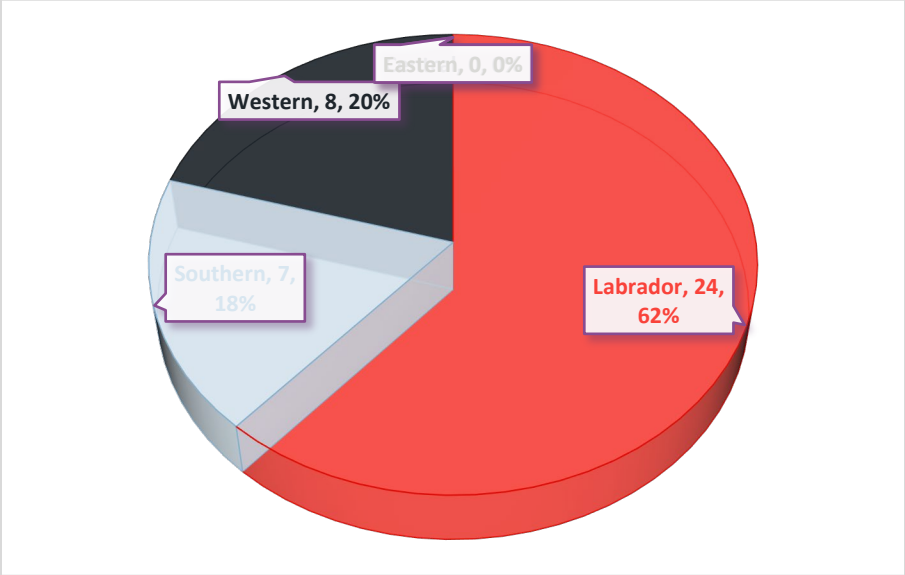

Figure 1. Alerts by Region

2 VERIFICATION OF ALERTS

The flood alerts were verified using three data sources/methods to compare with the forecasted values. These data sources include: ECCC rain gauge data, WRMD rain gauge data, and qualitative community-based reports. However, there remains some significant challenges with verification. Rainfall has very high spatial variability, meaning that stations only a few kilometres apart may record vastly different values. Nearby gauge comparison is a limited verification method due to the intense variability of precipitation over the changing terrain and within small (meso-) scale atmospheric features. Specifically, we find many of the heavy rain events forecasted in Burgeo will fall over the higher terrain north of the town while the town reports lower totals.

Also, due to the risk involved with missed alerts, the implemented forecasting approach represents a worst-case scenario. The forecast is essentially the highest possible rainfall based on the current conditions instead of the most likely scenario rainfall. Every season, by design, there are many alerts issued that are not required. As such, any issued alert will generally overestimate what is observed, creating alerts that will not verify. The system was designed to avoid missing an alert, as the consequence for missed alerts is very serious for the people and resources involved.

2.1 COMMUNITY BASED FLOOD REPORTS

WSP works with Fire & Emergency Services – NL (FES-NL) whenever there are reports of flooding that may not have been forecasted. The concept was to create a qualitative field verification measurement that could further validate the statistical methods. Following a forecasted flood event, the intention was for local officials to classify the event as having no, minor, or catastrophic flooding, and these eyewitness reports would be noted on the verification. In the absence of community accounts, local newspapers and social media were scanned to verify the alerts qualitatively.

The most significant flooding event through the season was non-alerted as the remnants of Hurricane Earl tracked southeast of Newfoundland. Basement flooding and road closures were reported via media as the Waterford River overflowed its banks. Old Petty Harbour Road and Mooney Crescent Roads were heavily damaged, and three people had to be rescued, one of which was trapped in a car and the other two in a house in Mount Pearl. The 20-year flood limit was exceeded at the St. John's West Climate Station, with 92.8 mm recorded on September 11th. Given that the St. John's Airport (YYT) recorded it's greatest 3-day rainfall in over 70 years, that wouldn't have raised an alert due to the extended event duration; it could be worth discussing alerts for longer duration heavy rainfall events.

2.2 POTENTIAL MISSED ALERTS

In addition to the eastern Newfoundland rainfall already discussed, a heavy rain event occurred in Mary's Harbour, Labrador, on July 20th, with 128.6 mm recorded. The 24-h 100-year limit of 92 mm was more than exceeded. This rain event was courtesy of a strong low over the Strait of Bell Isle. Thunderstorms were observed over the eastern Gulf of St. Lawrence early in the morning. While these thunderstorms did not track over southeast Labrador, the

marginally unstable atmosphere and convective rainfall may have contributed to more rain than forecasted by the models and the WSP forecasters. Models have more difficulty predicting precipitation amounts in areas of showers and thunderstorms compared to larger areas of light or moderate rainfall. No reports of flooding were received.

Table 4 Potential Missed Alerts

Community	Nearby Flood Report	Issue Date	12-hour Precip Forecast	24-hour Precip Forecast	EC Observed	WRMD Observed	Conclusion
Mary's Harbour	N/A	7-19-2022	38 mm	41 mm	7-20-2022 128.6 mm	N/A	24-h 100-year limit exceeded (92 mm). No reports of flooding were received.
St. John's (Goulds and Waterford River)	Waterford River Flooding	9-10-2022	43 mm	61 mm	9-11-2022 80.6 mm 172.4 mm (3-day total)*	N/A	Neither Outer Cove nor Goulds and Waterford River limits were exceeded.
Mt. Pearl	Waterford River Flooding	9-10-2022	43 mm	61 mm	9-11-2022 92.8 mm 195.1 mm (3-day total)	N/A	24-h 20-year limit exceeded (91 mm)
Mary's Harbour	N/A	9-21-2022	35 mm	42 mm	9-24-2022 67.0 mm 85.5 mm (2-day total)	N/A	Near 24-h 20-year limit (71 mm)

*Greatest 3-day rainfall total recorded at YYT (1942-2023)

2.3 CLIMATE NORMALS

Airport reports of rainfall across NL were examined to determine how the 2022 HSFAS season compared to the climatological normals. The 2022 months are colour-coded in red if they were substantially above normal and blue if they were substantially below normal.

Table 5 Monthly Rainfall Totals (in millimetres) compared to climate normals

Location	Jun 2022	Jun Norm	Jul 2022	Jul Norm	Aug 2022	Aug Norm	Sep 2022	Sep Norm	Oct 2022	Oct Norm	Nov 2022	Nov Norm	Dec 2022	Dec Norm
St. John's	79.6	97.5	71.1	91.6	148.9	100.0	225.5	129.6	62.9	153.7	144.5	124.8	116.5	102.9
Gander	39.6	85.7	Trace *	95.4	63.3	104.2	57.1	114.7	28.4	102.3	31.3*	75.2	56.8	48.9

Location	Jun 2022	Jun Norm	Jul 2022	Jul Norm	Aug 2022	Aug Norm	Sep 2022	Sep Norm	Oct 2022	Oct Norm	Nov 2022	Nov Norm	Dec 2022	Dec Norm
Deer Lake	83.2	87.8	116.7	95.1	82.2	109.6	82.8*	99.9	21.2	84.9	36.6	60.2	25.8	27.6
Goose Bay	68.8	90.0	169.0	121.3	71.6	99.3	134.6	90.6	29.2	63.3	13.9	22.7	2.6	6.6
Notes: * Note that data was missing at the site for one or more days														

2.4 SUMMARY

June saw above normal rainfall in southeast coastal Labrador, the Burin Peninsula, and the central-south coast. Below normal precipitation was observed through much of the rest of the province. July was wetter than normal across western Labrador and western Newfoundland and drier than normal in northern Labrador. Much of the province was drier than normal in August except St. John's, which was wetter than normal. September was wetter than normal in western Labrador, southwest Newfoundland, and the Avalon Peninsula. Much of the elevated rainfall in southwest Newfoundland and western Labrador was courtesy of Post-tropical Fiona, while much of the elevated rainfall for the Avalon Peninsula was courtesy of the remnants of Hurricane Earl. October was much drier than normal across the whole province. November was wetter than normal across much of central and eastern Newfoundland (the Gander total (Table 5) was influenced by the missing data). Labrador was drier than normal. December was wetter than normal in western Labrador. Less precipitation than normal was observed in southeast Labrador and central and eastern Newfoundland (rainfall was closer to normal, but snowfall was well below normal).

3 LESSONS LEARNED

The geographic spread of alerts and flooding events from this season were unique compared to previous seasons. As individual seasons continue to depart further from climate normals, customized alerting services such as this become more critical. Record-breaking dry or wet spells emphasize the growing importance of nowcasting and advanced weather monitoring on a very local scale.

Flooding is a complex phenomenon and can occur with amounts significantly less than the 20-year or 100-year thresholds and vice versa – no flooding may occur with amounts significantly higher than those. The HSFAS product, along with the services provided by WRMD, such as water level monitoring and reporting, are key components that work well together to help provide advance warnings to communities to better prepare for potential flooding.

Validation and incremental improvements to the HSFAS service is aided by having a network of observations. While a product such as the ECCC Canadian Precipitation Analysis (CaPA) would help, this still represents a precipitation model which could vary significantly from true observations. As we have indicated in the past, the best solution would be to fill the gaps in the available monitoring networks. Using only the ECCC and WRMD gauge data limits our ability to verify the forecasts in some areas. Many communities require additional measurements, access, and/or studies. Without adequate instrumentation for measuring precipitation, it can be almost impossible to know for certain in high terrain areas whether the forecasted precipitation was accurate. Attempts have been made to fill these gaps through community-based flood reports and the use of local media sources to try to collaborate sparse gauge data.

4 CONCLUSION

It would be beneficial to pursue additional improvements to the data sources:

1. Additional rain gauges could be installed, particularly in the regions that generated significant alerts.
2. Flood Risk Mapping Studies could be considered for the communities that triggered alerts based on Intensity-Duration-Frequency (IDF) curves.
3. Consider longer duration alerting for longer duration events (48-h and 72-h)

5 CLOSURE

We trust that this report meets your needs. Please do not hesitate to contact the undersigned if you have any questions or comments regarding the hurricane season outlook.

Yours sincerely,

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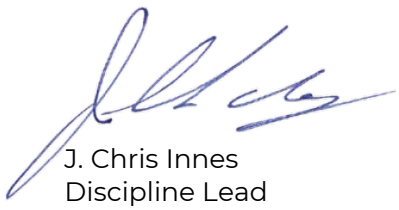

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