Riverside Recreation: Assessing the Effects of Flow Regulation on the Bars and Benches of the lower Goulburn River

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Key Points

- Regulated flow, including from Inter-Valley Trade (IVT), impacts recreational access to bars and benches along the lower Goulburn River.
- Using lidar and hydraulic models, this study suggests that new operating rules limiting IVT delivery volumes during summer could enhance the availability of these important recreational spaces.
- This research underscores the need for a balanced approach to water management that considers community recreation alongside ecological health and downstream water demands.

Abstract

Low-lying depositional features (bars and benches) along the lower Goulburn River in northern Victoria are highly valued for community recreational activities such as fishing, swimming, and camping. The investigation sought to fill the knowledge gap on how different regulated flow scenarios, including those from Inter-Valley Trade (IVT) operations, impact the accessibility and availability of these important recreational spaces. The investigation utilised a combination of lidar elevation data, aerial imagery, and hydrodynamic models to analyse the inundation patterns of bars and benches under various flow conditions. This approach allowed for a detailed evaluation of how IVT flow magnitude and duration influence the recreational use of bars and benches. Findings indicate that these river features, integral to the river's recreational appeal, are readily impacted by flows within the range of past IVT operations (up to 3000 ML/d). The study highlighted that new operating rule restrictions on IVT delivery volumes could enhance the availability of these recreational spaces during summer, potentially increasing the number of days bars and benches remain predominantly dry and accessible (compared to business as usual). The implications of this work underscore the critical balance between water resource management and the preservation of community-valued recreational spaces. By demonstrating the effects of managed flows on recreational access, the findings contribute to a deeper understanding of sustainable river management practices that can support community recreation while still meeting environmental needs and water demands. The insights from this study offer a valuable perspective for the development of water management strategies that align ecological health with community recreational interests.

Keywords

Flow management; community recreation; Goulburn River; Inter-Valley Trade (IVT); lidar; hydrodynamic modelling

Introduction

Flow regulation in the lower Goulburn River, in northern Victoria, influences the ecological, cultural, and recreational values of the waterway. This study examines how regulated flow regimes, in particular Inter-Valley Trade (IVT) deliveries to meet water demand downstream in the River Murray, affect the recreational use of bars and benches. These features are highly valued public access points for a range of river activities and can be inundated when flows increase. The research focuses on understanding the influence of IVT flow magnitude and timing, and of new operating rules that limit IVT delivery volumes (DELWP, 2022a), on the availability and recreational use of these in-stream features.

Background

The lower Goulburn River is characterised by steep, high banks that prevent access to the water along much of its length, restricting community recreation to select locations, many of which include bars or benches (mostly planar features within the river channel, attached to the riverbank — Figure 1). Bars are coarser grained (sands and gravels), often lower in elevation, and less commonly vegetated. Benches are finer grained (silts and clays), often higher in elevation, and commonly vegetated (Vietz et al., 2004).

During community workshops, stakeholders emphasised the importance of sandbars (and benches) on the lower Goulburn River for recreation, including for families, campers and day visitors using them for swimming and fishing (DELWP, 2022b; Streamology, 2022). This is especially the case for sandy point bars found on many inside bends in this part of the river, because of the easy access they provide to the water (compared to the otherwise steep riverbanks), slow and shallow flows, and relatively warm water.

Being low-lying and in-channel, bars and benches are the main river landforms that are impacted by flows on the scale of IVT deliveries (generally <3,000 ML/d). When river operators increase regulated flows to meet downstream demand for IVT, bars and benches are among the first river features to be inundated, impacting recreational opportunities, especially during summer and holidays.

Figure 1. Example photos of a large sandy point bar (left) and a partially vegetated bench (right).

Approach

Study area

The lower Goulburn River (between Goulburn Weir and the River Murray) was the overall focus of the assessment. Four individual study areas were selected for detailed mapping and inundation analysis (**Error! Reference source not found.**). The four study areas (Moss Road, Darcy's Track, Loch Garry, and McCoy's Bridge) were chosen because rating curves were available at the upstream boundary of each (drawn from a River2D hydrodynamic model).

As the inundation assessment relies on extrapolating flow-water level relationships from existing rating curves at fixed locations, the analysis was constrained to reaches extending 10-20 km downstream from the rating curve sites. The length of each study area varies due to the presence of tributaries and non-uniform location of known recreation sites that were important to capture in the analysis. Even without major tributaries or offtakes within each study area, extrapolating a rating curve relationship beyond the location at which it applies inevitably creates uncertainty that increases with distance. Therefore, the results should be treated as best estimates, given the available data.

Figure 2. Map of the lower Goulburn River showing the extent of the four study areas

Analysis method

The key datasets used to complete the assessment of inundation for bars and benches are listed in Table 1, with the method used to complete the assessment summarised in Figure 3. For detailed explanation of the methods used, refer to Streamology (2022).

Table 1. Datasets used in the desktop analysis of bar and bench inundation.

Dataset	Description/Purpose	Source
Lidar Digital Elevation Model	Lidar elevation data captured across various dates in early 2010, during low flows. Used for mapping bars and benches and estimating baseline water surface elevations.	DELWP/GBCMA
Aerial imagery	2009 aerial imagery covering the Lower Goulburn River. Resolution 30 cm. Used to aid in identifying and categorizing bars and benches, and for 3D visualisations of inundation.	GBCMA
Rating curves	River2D rating curves for four study sites describing water level-flow relationship from 300 ML/d up to 12,000 ML/d. Used to estimate water surface elevations for different flows across each study area.	CEWO Long Term Intervention Monitoring Project
Recorded hydrographs	Goulburn River flows for Murchison, Shepparton and McCoy's Bridge gauges. Used for estimating bar and bench inundation in response to actual recorded flows in different IVT seasons.	DELWP/GBCMA
Simulated hydrographs	Simulated Goulburn River flows for 'idealised' conditions laid out in the interim operating rule. Used for comparing the bar and bench inundation in recent years to what would be expected under the operating rule.	DELWP/GBCMA

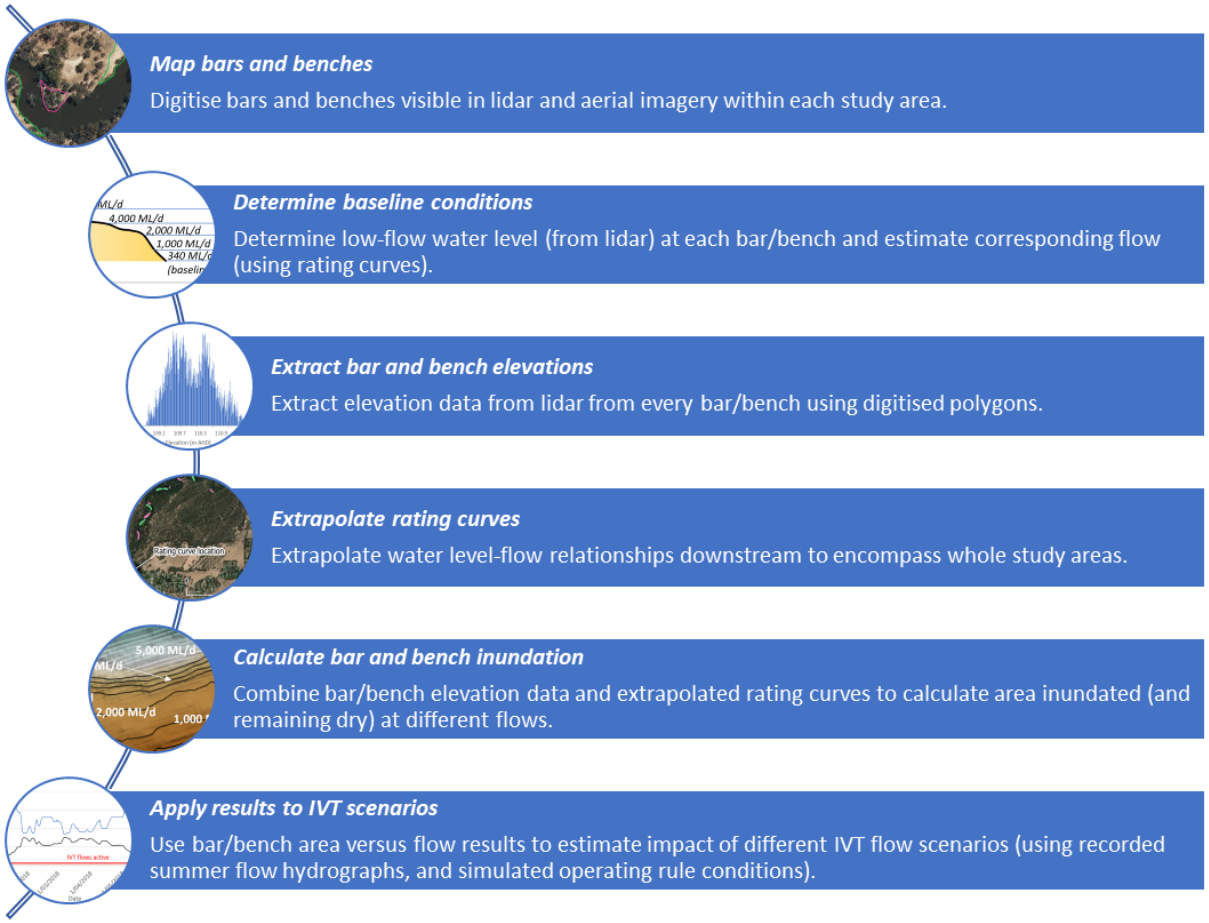


Figure 3. Flow diagram summarising the analysis approach used to assess bar and bench inundation.

Findings

Bars and benches mapped

A total of 112 bars and benches were mapped across the four study areas, representing a total low-flow baseline area (the area above water in the lidar data, captured during low flow) of 207,143 m². A breakdown of the mapping results is provided in Table 2.

Table 2. Summary of mapping results for the four areas. Bar and bench areas are for a 700 ML/d baseline condition.

	Moss Road	Darcy's Track	Loch Garry	McCoy's Bridge
Length of river mapped	20.9 km	8.1 km	12.6 km	10.9 km
Bars mapped	28	13	4	7
Benches mapped	20	11	12	17
Total features mapped	48	24	16	24
Total area all features	117,055 m²	20,976 m²	11,511 m²	39,098 m²
Average area per feature	2,439 m²	874 m²	719 m²	1,629 m²

Flow-area relationships

When bar and bench elevations and areas are combined with extrapolated water level-flow rating curves, the result is a new curve that depicts the relationship between flow and the percentage of bar/bench area remaining above the water (compared to a low-flow baseline area). This is depicted in Figure 4, along with several key flow values related to the IVT operating rules which limit the volume and timing of IVT flow that can occur over summer and autumn (DELWP, 2022a). A uniform low-flow value of 700 ML/d was used to calculate a consistent baseline area for each feature so that the different study sites could be compared as consistently as possible (correcting for different flows during each lidar capture).

Key insights available in Figure 4 include:

- The more upstream the study area, the more rapid the initial decline in available bar/bench area, with Moss Road experiencing the most rapid decline, followed by Darcy's Track, then Loch Garry and McCoy's Bridge. This indicates that bars and benches in upstream reaches are more sensitive to the impacts of increasing flow.
- Sandy point bars, as well as being particularly valued locations for recreation, are commonly lower in elevation and gradient than benches, meaning they are more sensitive to increasing water levels. This is why Moss Road sites show a more rapid reduction in area, because it has a relatively high number of sandy point bars.
- By 800 ML/d, the flow at which stakeholders reported that recreational sites begin to be noticeably inundated (Streamology, 2022), there is 85–95 % of area remaining dry.
- Typical monthly average flows under the new IVT operating rules (1,100 ML/d) reduce the dry area to 70 % at Moss Road, and around 85-90 % for the other study areas.
- A pulse of 3,000 ML/d (three of which are allowed per summer under the operating rules) reduces the available area at Moss Road and Darcy's Track to around 25-30 %, compared with 50 % at Loch Garry and 65 % at McCoy's Bridge.

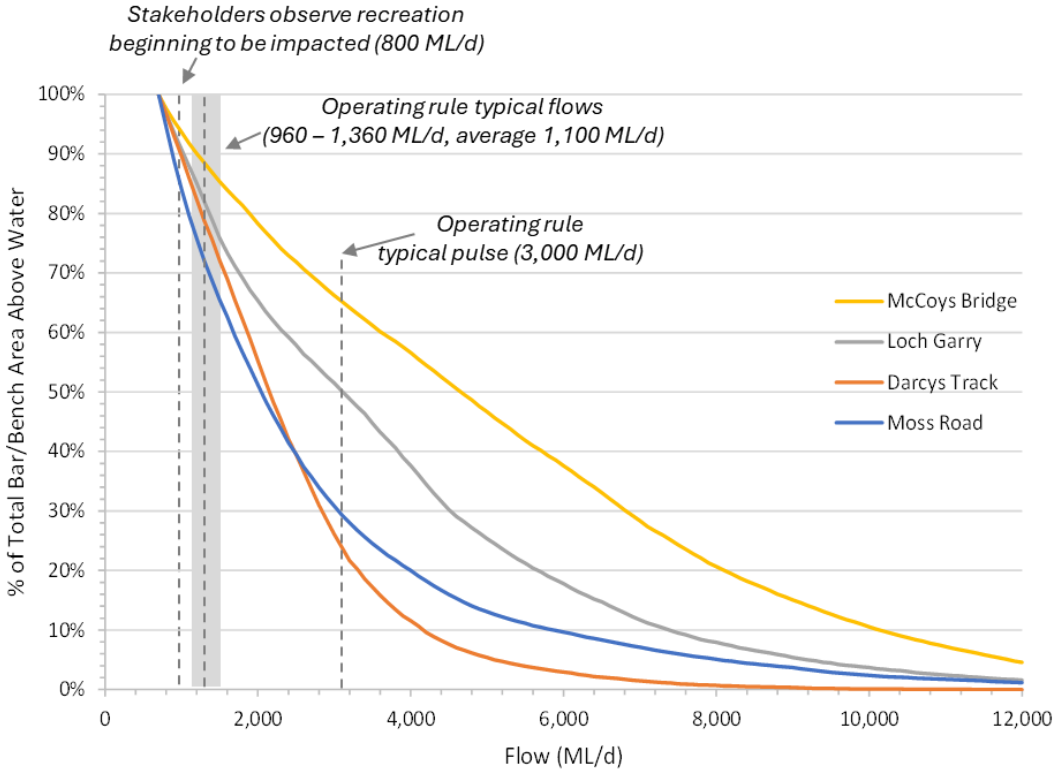


Figure 4. Flow-area relationship for all study areas, showing the percentage of bar and bench area remaining dry (compared to a low-flow baseline of 700 ML/d) at flows up to 12,000 ML/d. Annotations show impact of key flows related to the operating rules.

Inundation visualised

While graphs and tables of results may be useful to waterway managers, recreational river users want to see what different flows will look like for the sites they know and value. In Figure 5, lidar elevation data is presented in 3D, overlaid with inundation contours, as an example of how the results above are expected to impact an individual bar (Oval Bend Camping Area, Murchison). Aerial photos of the same example bar under low and high flows are provided in Figure 6. For examples from other recreational sites, refer to Streamology (2022).

The following observations can be drawn from the visualisations in Figure 5:

- Bars and benches are beginning to be visibly impacted by 1,000 ML/d, with the majority of each feature still above the water. This corresponds to just above the ~800 ML/d reported by stakeholders, and just under the monthly average flow of 1,100 ML/d for the operating rules.

- For large, low elevation, gently sloping features like the Oval Bend point bar, dry area decreases rapidly with increasing flow as small changes in water level cause large shifts in the horizontal position of the water line.

- By 3,000 ML/d (the limit for IVT pulses under the operating rules) most of the area for the example bar has been inundated, as predicted in the flow-area relationship curve in Figure 4.

On higher, steeper sided features like some benches, initial increases in flow (i.e., up to 2,000 ML/d) will result in a relatively smaller reduction in dry area, compared to sandy point bars like Oval Bend (Streamology, 2022).

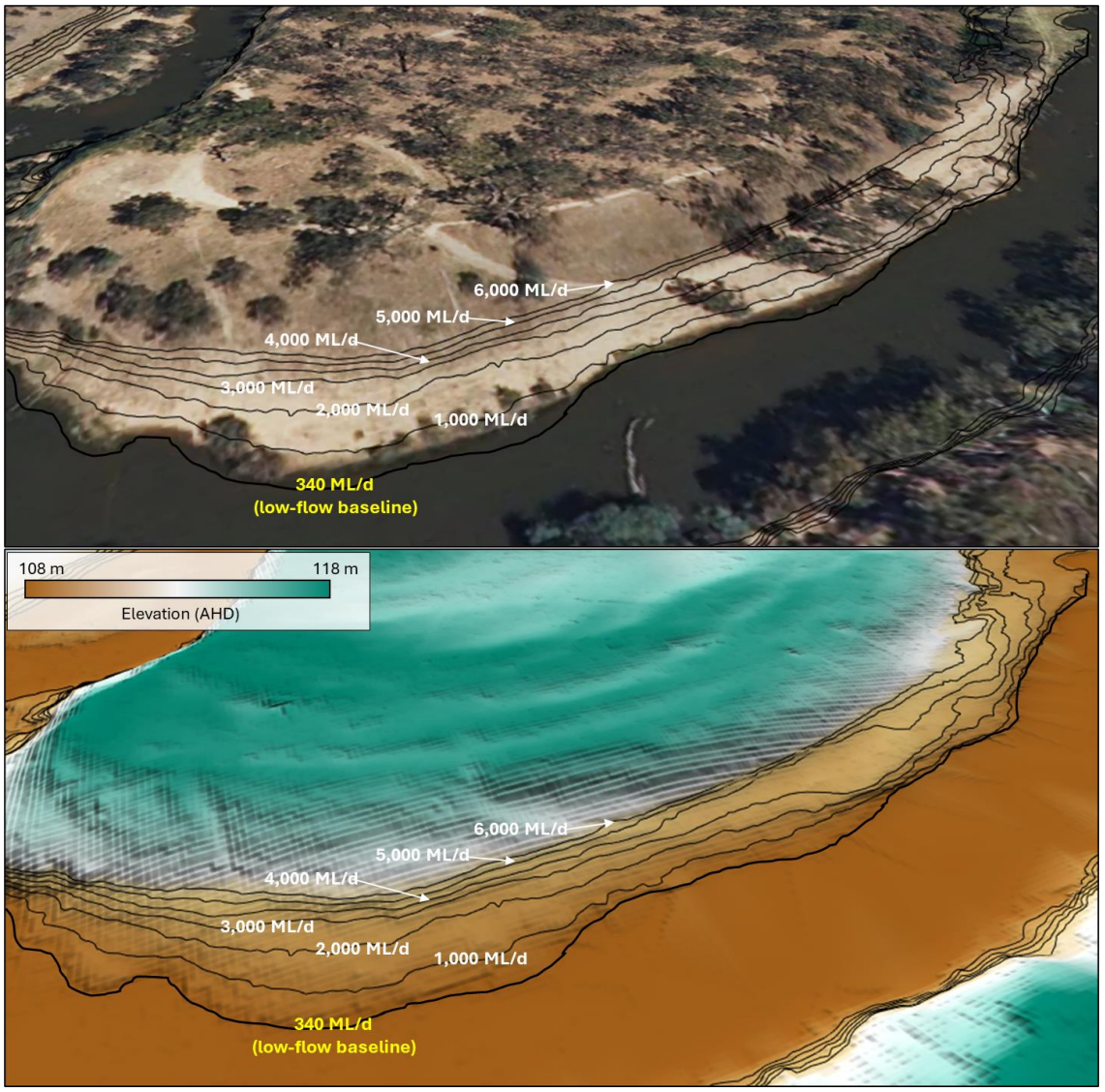


Figure 5. Simulated inundation at Oval Bend Camping Area under flows ranging from 340--6,000 ML/d. The site is within the Moss Road study area.

Figure 6. Aerial photos at Oval Bend Camping Area showing mean daily flows at Murchison of 818 ML/d on 2 March 2022 (A), and 5,700 ML/d on 21 March 2022 (B). White dashed line in panel A indicates approximate water line in panel B.

Flow scenarios

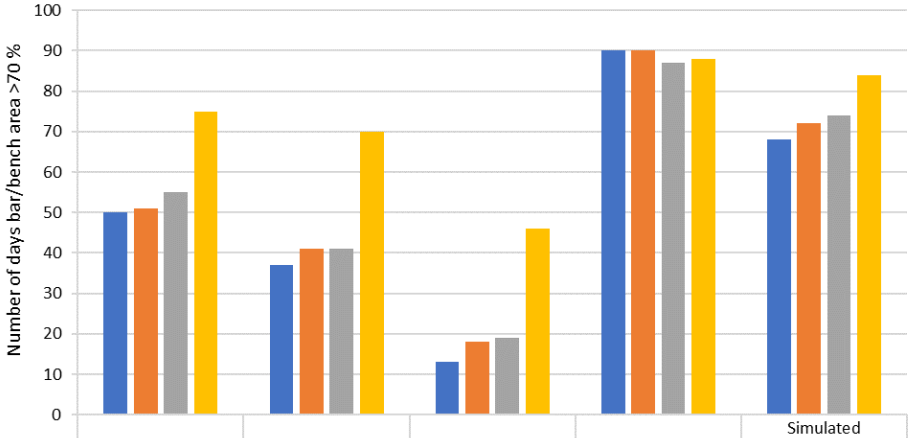
In this section we compare the effects of four different representative IVT periods and two simulated flow series representing operating rule conditions when maximum allowable flows are delivered. The years and the scenarios they represent are:

- High IVT flow volume (2017-18 and 2018-19)
- Moderate IVT flow volume (2014-15)
- Negligible IVT flow volume (2021-22)
- Simulated operating rule conditions (including 3,000 ML/d pulses)

A key metric for recreational potential on the river is the number of days per summer that bars and benches remain 'mostly dry', and therefore available for the community to enjoy. For this analysis, we have defined mostly dry as 70 % of a feature's area being above the water level (compared to the 700 ML/d low-flow baseline). Figure 7 depicts the number of days in summer that the total dry bar and bench area was greater than 70 % of the low-flow baseline, for the five flow scenarios.

Key observations related to Figure 7 include the following:

- Overall, operating rules more than double the time for which bars and benches are mostly dry compared to large IVT years (e.g., 2018-19).
- The 2018-19 summer had the greatest impact on bars and benches, with the number of days where dry area was >70 % ranging from 13 to 46 (out of 90). 2017-18 had the next greatest impact. These were both summers in which IVT deliveries were high, reaching 2,000-3,000 ML/d for months at a time.
- The summer of 2021-22 saw the least impact overall, with 87-90 days where bars and benches were mostly dry. This year was different to others in that there were essentially no IVT deliveries (except for a ten-day period in January).
- Simulated operating rule conditions, with 3,000 ML/d pulses, results in the second smallest impact (i.e., second largest number of days >70% dry) with 68-84 days. Bars and benches are mostly dry for longer than in a year with moderate IVT delivery volume (2014-15).



	2014-15	2017-18	2018-19	2021-22	Simulated Operating Rule (3,000 ML/d pulses)
Moss Road	50	37	13	90	68
Darcy's Track	51	41	18	90	72
Loch Garry	55	41	19	87	74
McCoy's Bridge	75	70	46	88	84

Figure 7. Number of days in summer (Dec-Feb) where the amount of bar and bench area remaining above the water was over 70% for five flow scenarios.

Summary and Conclusions

In the lower Goulburn River, low-lying features like bars and benches are highly valued spaces that provide recreational opportunities including fishing, swimming, and camping. In this investigation we have assessed the impact that different flow conditions, particularly IVT operations, have on the ability of bars and benches to support recreational activities. The key findings include the following:

- Bars and benches are common features within the Lower Goulburn River and are often found near known popular recreation sites, like camping areas (they appear to initiate the popularity of some of these sites).
- Bars and benches have been readily impacted by IVT releases (i.e., up to 3,000 ML/d), greatly reducing availability and the potential for recreation when the duration of these higher flows are not restricted.
- The lower Goulburn operating rules (DELWP, 2022a), which place limits on IVT delivery volumes and timing, will result in greater availability of bars and benches (68-84 days per summer where at least 70% of bar and bench area remains dry), compared with years without operating rules and higher IVT flows, like 2018-19 (13-46 days over summer).
- The same operating rules will result in slightly greater impacts when comparing to 2021-22 flows, a year in which IVT deliveries, for the most part, did not occur (resulting in 88-90 days over summer when bars and benches remained at least 70% dry).

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