EVENT BASED STORMWATER HARVESTING IMPACTS ON WATERWAY FLOWS IN NSW AUSTRALIA

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ABSTRACT (300 WORDS MAXIMUM)

In New South Wales (NSW) the Department of Primary Industries (DPI) sets onerous regulatory requirements on waterway extraction projects and directs designs towards having no impact on waterway base flows and no online storage or works within the waterway channels.

By designing event-based stormwater harvesting systems, the frequency and flow rate of downstream runoff can be reduced without removing waterway base flows and meeting NSW regulatory requirements. Stream bank diversions and offline storage can be used to capture storm events without impacting existing waterway channels. Detailed hydraulic modelling of an example project at the Blacktown Sports Park in NSW shows that waterway conditions downstream of an event based stormwater harvesting system to be more closely aligned with that of a rural stream than that of an urban stream. With a reduction in the frequency of high velocity runoff events improvements to downstream waterways are expected.

KEYWORDS

Stormwater Harvesting, Waterway rehabilitation, Event based harvesting, offline diversion, stormwater irrigation.

PRESENTER PROFILE

Andrew is a professional engineer experienced in the design and project management of engineering solutions to Australasian industrial, commercial and regulatory sectors. Andrew specialises in hydraulics, hydrology, water treatment, and WSUD. Prior to returning to New Zealand, Andrew spent six years working in Australia on large civil infrastructure projects.

1 INTRODUCTION

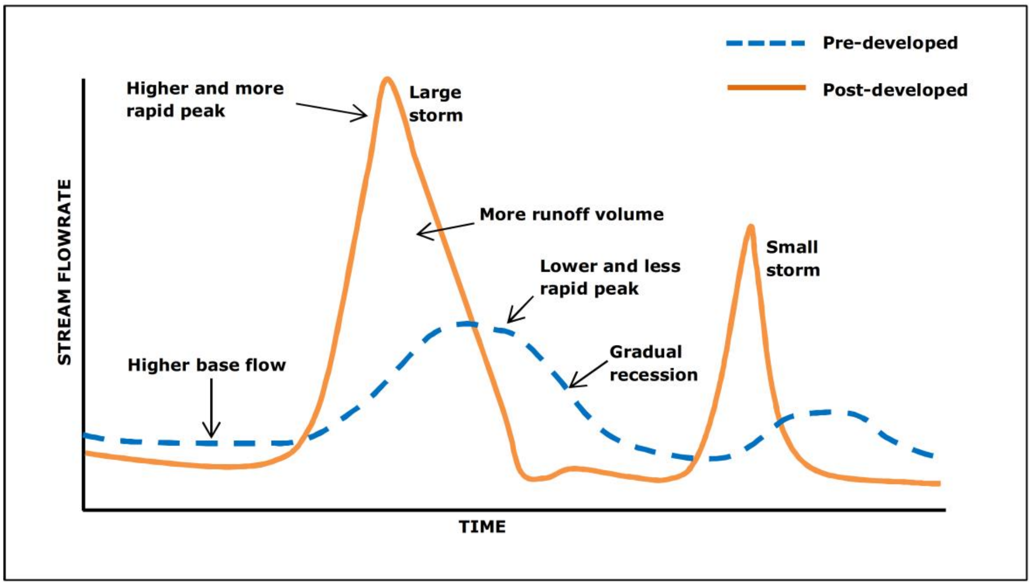
Stormwater harvesting is the diversion, storage, treatment and distribution of rainwater that is normally discharged by natural or man-made watercourses to receiving waterways. This alternative water source is now common practice in Australia (Philp 2008) where water resources are scarce or water supply costs justify an alternative supply. With potable water supply costs in Sydney at \$2.27 per m^3 (SWC 2016) and recycled water costs as low as \$1.45 per m^3 (Philp et el,. 2008) the commercial benefits of stormwater harvesting seem obvious. A 100 mega litre per year harvesting system has the ability to save up to $82,000 each year in water usage costs. However the viability of constructing the infrastructure required to divert, store, treat and distribute harvested stormwater is complex.

For a stormwater harvesting project to be viable it must have acceptable financial returns on capital investment and provide a water supply that is capable of meeting peak summer demands and of sufficient quality for plant growth and human contact (or consumption). Lastly, the environmental impacts of the project need consideration and designs must meet local regulatory requirements.

In NSW the extraction of water from a waterway is controlled by the DPI through the issue of a water supply works agreement. Water supply works agreements aim to protect existing water users and the ecology of waterways. In doing so, some strict regulations on the design of water extraction systems are in place. In addition to annual extraction volume limitations, the water extraction method typically is not allowed to change the existing stream channel, harvest base flows or incorporate in-stream works. These constraints are based around the protection of base flows during small rainfall events and allowing the waterway to transfer these flows unhindered downstream.

2 IMPROVING WATERWAYS

Urban pre-development and post-development catchment hydrology changes are well understood. With an increase in the frequency and flows of runoff from urban catchments, waterways become channelled and piped (Walsh, 2000). Waterways then suffer from erosion, degradation of habitat and loss of channel stability. As well as providing a valuable water supply source, stormwater harvesting projects benefits include the potential to enhance urban stream health through improvements to the flow regime (Mitchel et al,. 2006). These improvements are specifically the reduced frequency and peak flowrate of runoff events and a transition of flow regimes from post-developed towards pre-developed states.



3 EVENT BASED DESIGN

The ability of a stormwater harvesting system to capture runoff from a waterway is determined primarily by the availability of storage and simultaneous occurrence of rainfall runoff. With an event based stormwater harvesting system, if a rainfall event increases the flow in a waterway above environmental flow levels and storage is available, then stormwater can be diverted and stored within the harvesting project.

The collection, storage and demand of harvested stormwater is dynamic and experiences significant fluctuation in supply and demand over a typical year. During Spring and Summer months, less frequent rainfall events and higher supply demands mean storages are regularly less than full, allowing any subsequent rainfall runoff to be captured. In Autumn and Winter the opposite is true and storages are regularly full due to more frequent rainfall events and less demand than in Summer periods. At these times most rainfall events are passed downstream of the harvesting system. The design of stormwater harvesting systems is therefore focused on providing suitable storage capacity to hold water during Winter and Spring months for use during Summer. The system must also be capable of harvesting short rainfall events and transferring these into storage during Summer periods when the capture of runoff is more critical. Inline storage and high capacity pumping systems are therefore strongly preferred but not ideal due to NSW regulatory requirements and high pumping operational costs.

An offline diversion system can solve this issue by only collecting stormwater above a set base flow water level. By using a weir on the side of the waterway channel, flows that overtop the weir are then diverted for harvesting. By including water storage directly to the side of the waterway (offline), further increases in the rainfall runoff volume captured and reduced pumping costs can be achieved.

4 WATER BALANCE MODELLING

Due to the seasonal nature of stormwater harvesting, understanding demands and impacts of harvesting systems on stream flow regimes requires software water balance modelling to be undertaken over periods greater than one year. This modelling was completed using the GoldSim software package and a water balance model of an event based stormwater harvesting project installed at the Blacktown Sports Park in Western Sydney. The GoldSim model provides a water balance of runoff flows, pump capacities, available storage and irrigation demands of the Blacktown Sports Park system. The model uses 10 year pluvial rainfall data from the Camden rainfall gauge from 1967 to 1977. This data was supplied by Blacktown City Council and is considered by Council to represent average annual rainfall in the area.

The harvesting system incorporates the following components:

- 655 ha low density urban catchment area
- 211,600 m^2 irrigation area
- 200,000 m^3 annual irrigation demand
- 10 L/s base flow restriction
- 1,000 m^3 offline waterway storage
- 40 L/s harvesting pump station
- 9,500 m^3 pond treatment and storage
- 2,150 m^3 (4300m^2) wetland treatment and storage
- 1,800 m^3 treated water tank storage.

Modelling results in Figure 2 shows the comparison between the catchment runoff in a pre-developed state and in a post-developed state over 1967. Typical increases in runoff frequency and peak flows of the post-developed state over the pre-developed state can be seen.

Figure 3 shows the comparison between the post-developed runoff hydrology and the reduction in peak flows following extraction by the event based stormwater harvesting system. With the harvesting storage being filled in Winter, the system is regularly unable to divert water from the waterway and there is regularly very little change to downstream waterway flows. In Spring and Summer, harvesting of runoff events is more prolific as shown more clearly in October of 1967 (Figure 4). In Figure 4, the high water demand during Spring and Summer regularly empties storages and back to back runoff events can be harvested.

To show the reduction of peak flows over the entire 10 year period, a flow duration curve is presented in Figure 5. This plot shows the shift of flow frequencies downstream from the harvesting project towards pre-developed stream flow frequencies.

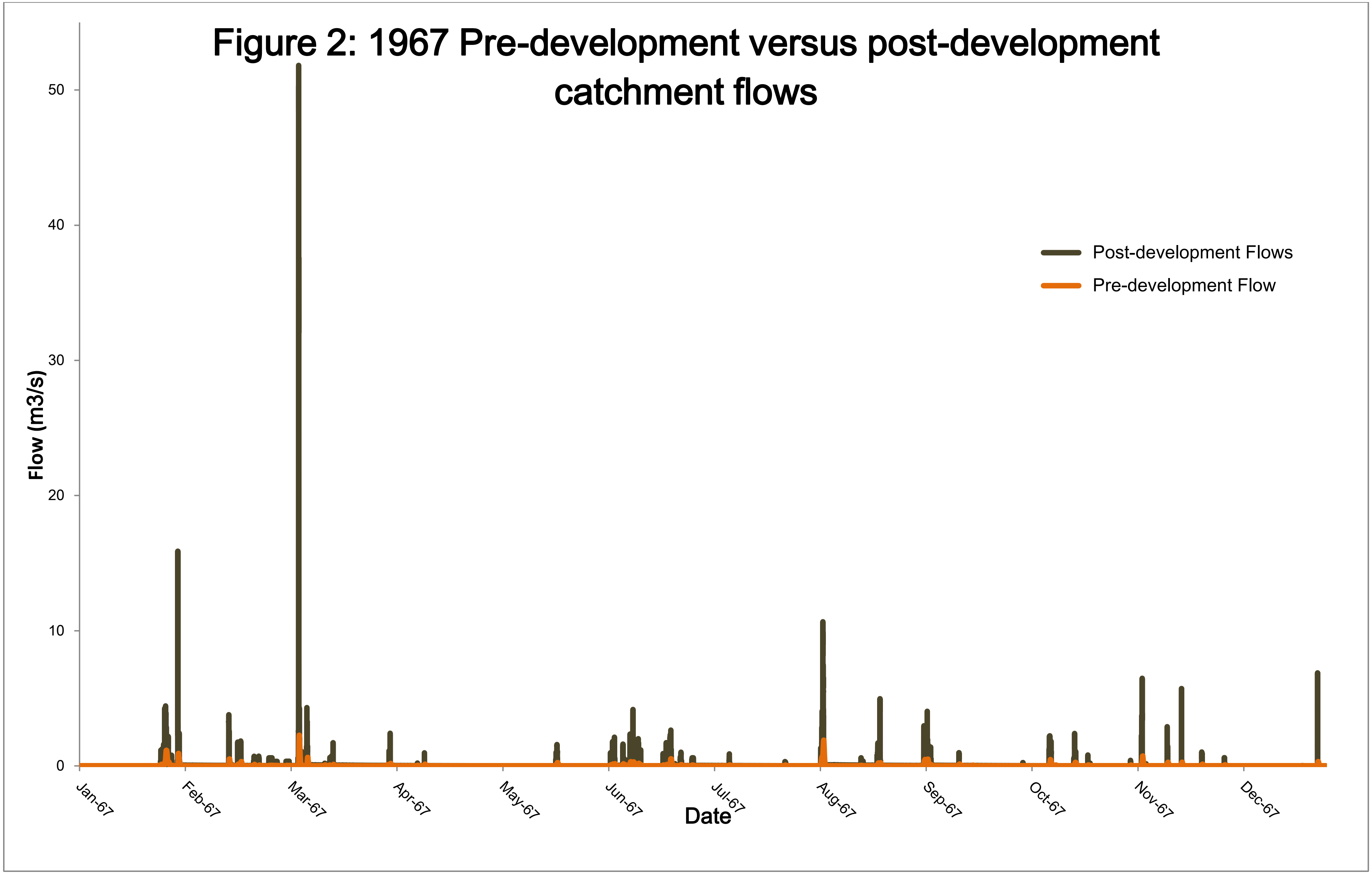


Figure 2: 1967 Pre-development versus post-development catchment flows

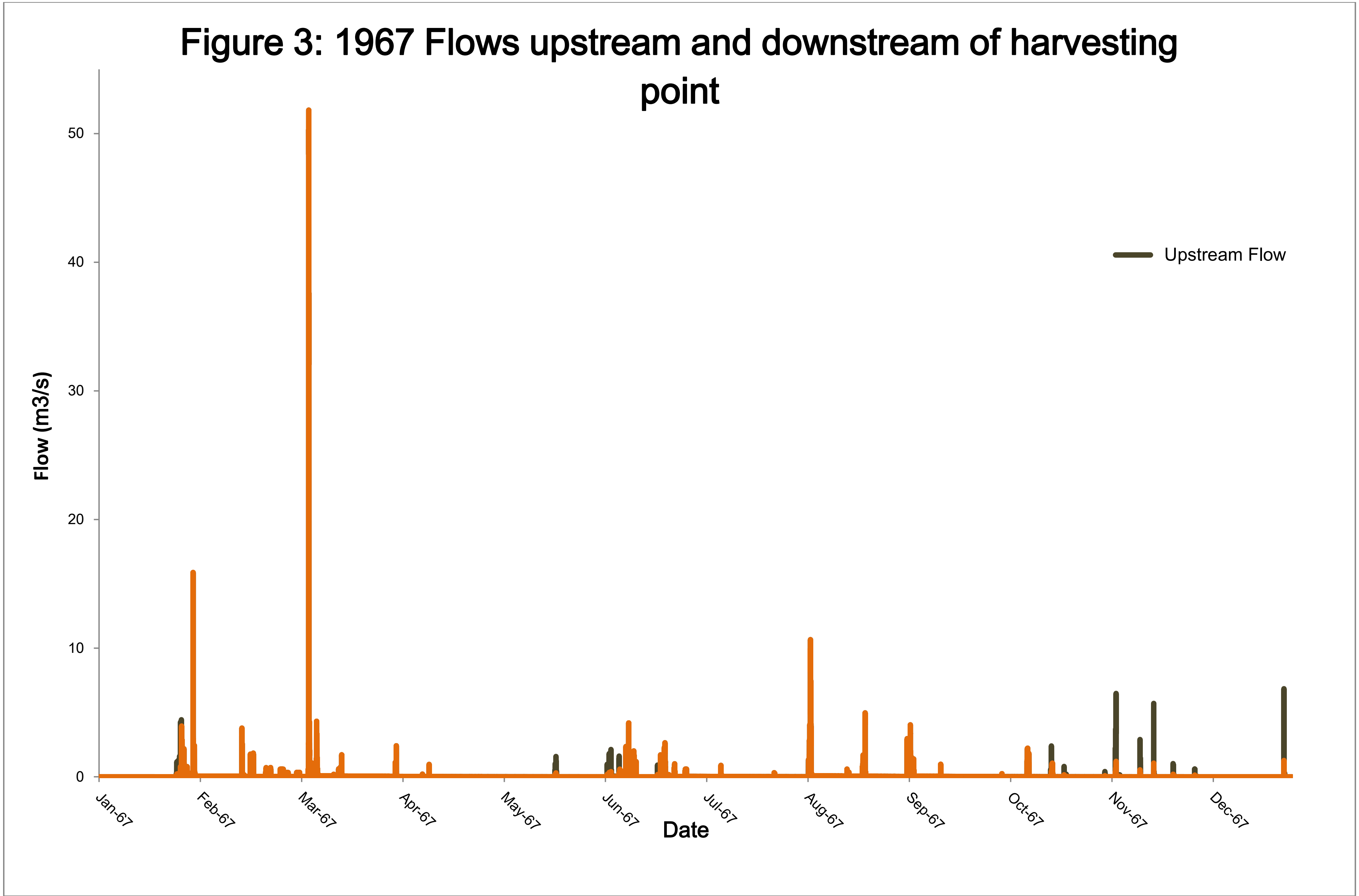


Figure 3: 1967 Flows upstream and downstream of harvesting point
Flow (m3/s)
0
10
20
30
40
50
Upstream Flow
Jan-67
Feb-67
Mar-67
Apr-67
May-67
Jun-67
Jul-67
Aug-67
Sep-67
Oct-67
Nov-67
Dec-67
Date

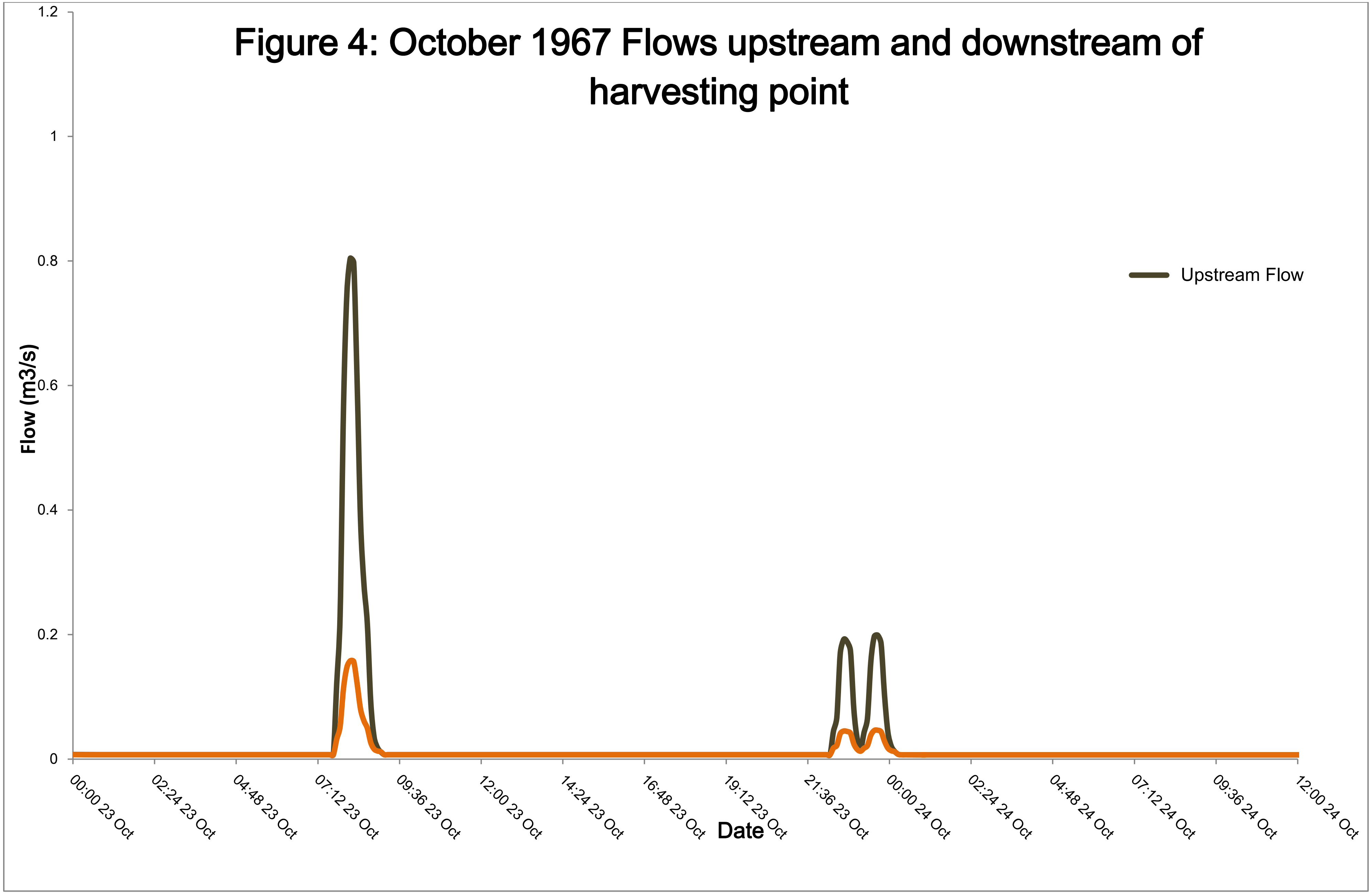


Figure 4: October 1967 Flows upstream and downstream of harvesting point
Upstream Flow
Flow (m3/s)
1.2
1
0.8
0.6
0.4
0.2
0
00:00 23 Oct
02:24 23 Oct
04:48 23 Oct
07:12 23 Oct
09:36 23 Oct
12:00 23 Oct
14:24 23 Oct
16:48 23 Oct
19:12 23 Oct
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Date

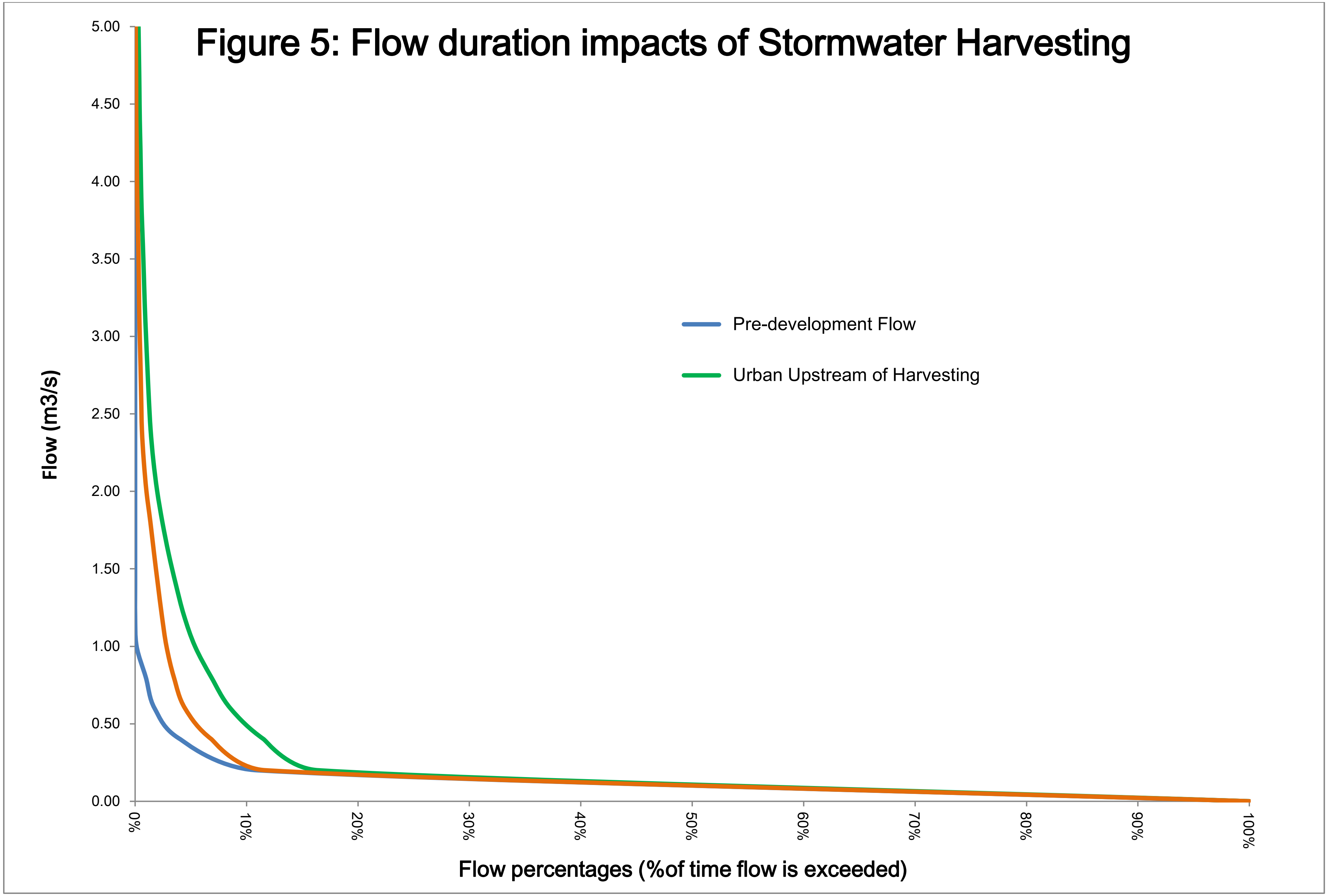
Figure 5: Flow duration impacts of Stormwater Harvesting
Flow (m3/s)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Flow percentages (%of time flow is exceeded)
Pre-development Flow
Urban Upstream of Harvesting

5 OPPORTUNITIES FOR IMPROVEMENT

There are a number of opportunities to improve event based stormwater harvesting systems through the application of metering and controls. As rainfall events are frequent and water demand is low during Winter, smarter harvesting regimes can be set for the system which aim at reducing pumping requirements. An example of this would be to set the storage full levels to around 60% to 70% of capacity during Winter months.

Further improvements can also be achieved by using rain gauges to predict runoff duration. If a long duration rainfall event is noticed further up in the catchment, then pump rates can be set to maximum efficiency flows rather than the maximum pump rates normally used to maximise the capture of short rainfall events.

Further improvements in downstream waterway ecology can be achieved by restoring base flows through the implementation of over-irrigation or storage infiltration. Although these methods impact operational costs and security of harvested stormwater supply, the benefit to downstream waterway health may be justified.

6 CONCLUSIONS

Event based stormwater harvesting projects allow the diversion of waterway flows without impacting baseflows, requiring significant streambed works or inline waterway diversions. By harvesting rainfall runoff events there is the potential to reduce downstream peak flow event frequencies and return downstream flow regimes towards pre-developed flows regimes.

Further improvements to event based harvesting systems is possible with intelligent control systems. Further improvements to downstream waterway health is also possible with the diversion of excess harvested stormwater being returned to waterway baseflows.

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