Meeting flow requirements for licensable farm dams

Technical guidelines



Environment, Land, Water and Planning

OFFICIAL

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Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

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1. Introduction

The purpose of this document is to assist landholders incorporate into dam design a mechanism to meet passing flow requirements in accordance with government policy and any licence conditions. These guidelines are for dam owners and consulting engineers to assist in the preparation of suitable design drawings for submission to the relevant water corporation as part of works licence applications.

1.1 Background

Dams can have a major impact on the health of waterways and on the reliability of supply for downstream users.

As part of planning and design for all licensable dams in Victoria, landholders and relevant governing bodies need to maintain passing flows. Passing flows are water that is released from, or allowed to bypass, a storage such as a catchment dam or dam on a waterway. Passing flows help maintain environmental values and protect the reliability of supply for existing users. In Victoria, passing flow requirements are specified in licence conditions.

Further information on dam owner responsibilities and the management and safety of dams can be found in *Your Dam: Your Responsibility - A guide to managing the safety of small dams* (DELWP 2018) available online at <u>https://www.water.vic.gov.au/managing-dams-and-water-emergencies/dams/guidance-notes</u>.

1.2 What dams are licensed?

Licensing requirements for dams in Victoria are set out in the *Water Act 1989* and government Ministerial policies¹. Requirements fall into two main categories: the licensing of the construction, operation, alteration or decommissioning of a dam, and the licensing of taking and using water from a dam.

- A **works licence** under section 67 of the Act is a licence to construct, operate, alter, decommission or remove works associated with the extraction of water (i.e. bores, pumps and dams).
- A **take and use licence** is a fixed term entitlement to take and use water from a waterway, dam, spring, soak or aquifer.

Licences are issued by water corporations, as delegates of the Minister, and subject to conditions determined by the issuing water corporation.

The requirement for a bypass mechanism when constructing or operating dams is specified in the standard works licence conditions². Passing flow requirements are specified in either works or take and use licence conditions³.

1.3 Legislation and policy changes

In 2002, amendments were made to the Water Act to encourage sustainable development of water use and to protect the rights of existing users by requiring all irrigation and commercial water use in a catchment to be licensed (section 51 (take and use) licence)⁴. Prior to 2002,

^{1.} Policy requirements may be specified in policies endorsed by the Minister, and guidelines or strategies

^{2.} Standard conditions 16 and 17 in Schedule 1 to the Policies for Managing Works Licences

^{3.} See clause 21 and Schedules 1 and 2 of the Policies for Managing Take and Use Licences https://waterregister.vic.gov.au/waterentitlements/about-entitlements/take-and-use-licences

⁴ Rainwater harvested from rooftops and buildings is exempt from licensing requirements under the Water Act

only water taken from a **waterway for irrigation or commercial use** was required to be licenced.

Following on from these legislative amendments, guidelines and procedures were introduced to achieve the following objectives:

- to emphasise consideration of the environmental aspects of licensing (section 40 matters)
- to improve dam safety provisions
- to improve coordination between licensing and referral bodies
- to ensure consistency with water resource and related plans and strategies in consultation with catchment management authorities.

Ministerial Guidelines for Licensing Irrigation and Commercial Use of Surface Water were issued at this time to assist licensing authorities when issuing works licences. The Guidelines outlined that earthworks on or near waterways should be conducted in a way that minimises impacts on the environment. The Guidelines also articulated the Minister's policy that licensing authorities should not approve an application to construct a dam on a waterway with high ecological values unless the applicant has thoroughly investigated alternative sites for the dam and alternative sources of water supply.

In 2004, the Victorian Government released its action plan *Our Water Our Future* for sustainable water use⁵. This plan set out the new policy of no new summer diversions, in recognition of the ecological stress they cause and to protect the reliability of supply to existing users during summer. Since this time all new licences to take water from unregulated water systems have required landowners to harvest water in the winterfill period (now 1 July to 31 October)⁶.

In 2016, the government's strategic water plan *Water for Victoria* reinforced the challenge to the water entitlement and planning framework is flexible management options that do not adversely impact the environment or third parties in an increasingly variable climate. The framework needs to provide certainty to legal rights and obligations, and flexibility for entitlement holders to manage their own risks within a framework of sustainable use. This reinforces the changes made to licence conditions and requirements as detailed in this document.

1.4 Application of these guidelines

A bypass mechanism is required to be installed to meet passing flow requirements, as specified by the relevant rural water corporation, when:

- an application is made to construct a new irrigation or commercial dam
- when changing the use of an existing unlicensed dam to a (licensed) dam for commercial or irrigation use
- when altering an existing dam (unless for stock and domestic purposes and not in the potentially hazardous class of dams).

⁵ Sustainable use means that managing the allocation of water resources balances economic, environmental and social values

⁶ A winterfill licence means a licence that only entitles a person to divert surface water to, or harvest surface water in, a private dam during specified months including some winter months.

2. Waterway Health Perspective

In areas where many farm dams have been constructed, impacts on downstream flows can be significant. Annually, farm dams can reduce the flow from Victorian catchments by typically up to five per cent, although in some cases, annual flow reductions of over 30 per cent have been estimated. However, annual flow reductions reflect only part of the impact dams have on stream flow and waterway health. Seasonal assessment is required to determine the full impact.

Flow regimes in Victorian streams vary between years, seasons, months, weeks, and days. This variation is important for ecological and geomorphological processes. Water diversions by dams can change the magnitude and timing of the variation in flow regimes.

Seasonal flow variations have different flow components with each component having different benefits for waterway health.

Key components include:

- annual and seasonal low flows
- summer storm events
- cease-to-flow events
- seasonal high flows
- bank full (minor flood) flows

Various combinations of these components are required to maintain waterway health. The required combination and magnitude of each component is different for every waterway.

Downstream summer flows can be maintained by constructing new dams away from streams and by installing bypasses to allow the passing of flows outside the winterfill period. Bypasses are particularly important in summer when flows following summer storms occur and removal of summer flushes can have a pronounced impact on waterway health.

3. Licence requirements

These guidelines outline when and how mechanisms are installed on licensed dams to protect catchment flows by limiting water harvesting.

3.1 Passing flow requirements

Licensable farm dams used for irrigation or commercial use must include a bypass mechanism that enables passing flows as specified in any licence issued by the relevant water corporation.

Works licences include conditions relating to the construction and operation of dams as follows:

- water can only be harvested during the winterfill period⁷
- bypass mechanisms must be installed and maintained in good working order
- for a waterway dam, (i) outside the take period, no natural flow in the waterway is harvested into the dam, and (ii) during the take period, minimum passing flow rates (specified in the licence conditions) are passed by the dam.
- for a catchment dam, bypass mechanisms must be installed and maintained in good working order, to ensure no run-off is harvested outside the take period.

Any passing flow requirements will be specified in the operating or take and use licence conditions issued by the relevant water corporation. Passing flow rates are based on Victorian winterfill sustainable diversion limits (SDLs). In general terms, SDLs provide an indication of the sustainable volume of water that can be diverted from 1 July to 31 October without causing detrimental environmental impact⁸.

3.2 Sustainable diversion limits

Sustainable diversion limits (SDLs) provide water managers with the information they need to determine whether more surface water can be authorised for take from a catchment, while still maintaining healthy rivers and streams. SDLs provide information to assess applications for new licences to take water from unregulated catchments, including new farm dams, and to assess transfers between catchments.

For unregulated catchments across Victoria, the SDLs are one of several tools available to help water corporations to determine the upper limit on diversion, the maximum volume that can be taken under current licences, and the remaining volume available for use between July and October. This is important in unregulated catchments for assessing applications for new licences or trading licences.

SDLs have been developed for every catchment across Victoria and represent the upper total volumetric limit on winterfill diversions. SDLs were developed to protect both the health of rivers and streams and the rights of existing water entitlement holders.

SDLs were completed for Victoria for 1,611 catchments in 2004 and were updated in April 2014.

^{7.} The contemporary winterfill period is 1 July to 31 October, although there may be historical licences with longer fill periods e.g. 1 May to 30 November.

Note that winterfill SDLs in Victoria are not the same as the Murray Darling Basin Plan (MDBP) SDLs. MDBP SDLs apply in northern Victoria (the southern Basin) and represent the upper limit on the amount of surface water and groundwater that can be taken for consumptive use from Basin resources.

SDL volumes are based on three underlying constraints:

- The winterfill period all new take and use licences in Victoria must only extract water during the period from 1 July to 31 October unless otherwise defined in a streamflow management plan (SFMP) or in individual licence conditions.
- Minimum flow threshold the lower limit of flow in a waterway below which all diversions should cease (note that this is a theoretical limit, and is not usually the same as the restriction and ban flow thresholds that water corporations adopt as part of normal operations)⁹
- Maximum daily rate the total allowable volume of water that can be extracted from an SDL catchment within one day

Figure 1 shows how the winter minimum-flow threshold varies across Victoria. The minimum flow threshold tends to be higher in areas where streamflows are generally high, and lower where streamflows are generally lower or highly variable or ephemeral.



Figure 1: Winter minimum-flow thresholds

For a local catchment, the minimum flow threshold for farm dam bypasses (in megalitres per day) is the required capacity for bypass mechanisms for on-stream or off-stream dams. The value may need to be adjusted based on the area of the catchment upstream of the farm dam. The water corporation, to which the licence application is submitted, will calculate the exact passing flow requirement for the dam. SDL reports are available for catchments across Victoria at https://mapshare.vic.gov.au/mapsharevic/.

⁹ Note that for catchments with a SFMP, diversion rules may override the minimum-flow threshold

4. Types of private farm dams

Farm dams are earth structures designed to capture and store water for irrigation, aquaculture, stock watering, domestic supply or aesthetic purposes. The two main types of farm dams are:

- off-stream dams: located away from waterways and filled by pumping from a waterway, groundwater or by a diversion channel or from the dam's catchment
- on-stream dams: located on waterways and filled from the upstream catchment.

To comply with requirements for maintaining downstream flows, most new dams in Victoria will be constructed as off-stream dams. On-stream dams will generally only be permitted where there are no practical alternative sites and the environmental requirements are met. In most cases new on-stream dams will not be approved.

Existing on-stream dams may be increased in capacity provided they meet all current licensing requirements such as provision for passing flows, and any environmental assessment requirements.

4.1 Off-stream dams

Off-stream dams are typically turkey nest dams but might be hillside dams if they are located on moderately sloping ground.

4.1.1 Turkey nest dam

A turkey nest dam:

- is an above-ground storage confined within a continuous embankment
- does not capture surface run-off, but is filled by pumping from a waterway or groundwater source
- is usually rectangular and constructed on relatively flat land; borrow material is usually obtained from within the storage area
- only needs a small spillway, because inflows are controlled by pumping.

4.1.2 Hillside dam

A hillside dam:

- harvests run-off from a broad catchment with no well-defined waterway
- is typically built with an earthen bank on three sides on a broad inclined slope or hillside
- · borrow material for the embankment is usually obtained from within the storage area
- may have flows supplemented by diversion banks to increase the catchment area or with catch drains that divert water from nearby waterways
- can be filled by pumping from a waterway or groundwater source.

4.2 On-stream dams

An on-stream dam is typically built by constructing an earthen embankment across a waterway. The embankment typically:

- has a main spillway at one or both ends to pass inflows, once the dam is full
- a pipe spillway (that supplements the main spillway and is also known as a trickle pipe) set at full-supply level to convey small flows; it helps protect the main spillway
- has outlet pipes also called compensation pipes —through the embankment to supply water, dam de-watering and to pass environmental flows.

While new on-stream dams are unlikely to be approved, a proposal to change the use of an existing dam to a commercial or irrigation enterprise, or enlarging an existing dam, will necessitate installing a bypass mechanism as part of licence conditions.

5. Dams and bypass mechanism options

A number of methods are available to harvest water in dams while maintaining passing flows:

- locate the storage off-stream
- construct diversion works from upstream of dam
- divert from within a dam

Where off-stream storage is not feasible, on-stream dams with diversion works and flow bypasses may be approved provided there are no practical alternative dam sites and environmental requirements are met.

5.1 Diverting to an off-stream storage

The preferred approach for new dams in Victoria is to build off-stream storages that are filled by pumping from a waterway.

5.2 Upstream diversion works

For both off-stream and on-stream dams, construction can allow for passing a minimum flow and harvesting higher flows by putting in a flow regulator upstream of the dam. Flow bypass options include:

- contour channel around the dam to a flow-distribution pit to pass low flows downstream of the dam
- upstream weir with bypass pipe to pass low flows downstream of the dam.

5.3 Diverting from within a dam

For both off-stream and on-stream dams, through flows can be maintained by constructing diversion works within the off-stream or on-stream dams. Diversion options include:

- V-notch weirs upstream and downstream of the dam, with an outlet valve operated to match flows in summer
- gauge board in the dam to monitor the water level and an outlet valve to release any inflows in summer
- floating offtake and manually operated outlet valve, to release any inflows in summer from the dam surface
- pressure-operated, electrically actuated outlet valve to automatically release summer inflows from the base of the dam
- floating offtake and pressure-operated, electrically actuated outlet valve, to automatically release summer inflows from the dam surface.

5.4 Preferred bypass mechanisms

Table 1 shows the various bypass mechanisms that have been evaluated and which best meet the acceptability criteria for a range of commercial and irrigation dams.

Dam type	Local situations	Preferred bypass type
Turkey nest	Pumped diversion from waterway	Off-stream type
Hillside	Broad sheet flow, no well-defined depression or waterway	Contour channel and distribution pit
Hillside	Broad sheet flow, no well-defined depression or waterway, uses diversion banks or catch drains	Upstream weir and bypass pipe in a diversion bank
Hillside	Broad sheet flow, no well-defined depression or waterway	Floating pipe offtake
On-stream	Typical on-stream dam, 50–200 m long	Upstream weir and bypass pipe
On-stream	Very long dams, typically 200–1000 m long	Floating pipe offtake
On-stream	Multiple tributaries at dam site	Upstream weir and bypass pipe on a significant tributary

Table 1: Preferred	bypass mechai	nisms
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6. Turkey nest dams

The preferred approach for new commercial and irrigation dams in Victoria is to use offstream dams that are filled by pumping from a waterway. These dams will generally be turkey nest dams but may also be hillside dams if they are located on moderately sloping ground.

These types of dams have several advantages over on-stream dams:

- · involve minimal works on the waterway
- · cause minimal change to the stream hydrology
- · cause minimal change to water quality passed downstream
- · create no barriers for fish and other aquatic life
- · water is only diverted during significant flow events in winter

A typical general arrangement for these works is shown in Figure 2. The works will typically consist of a natural or excavated pumping pool and a pump station. A deep pool is necessary to provide sufficient submergence of the pump suction intake screen.

Figure 2: Turkey nest dam



Constructing a low-level weir to create a pumping pool may be acceptable in some circumstances such as small, highly-ephemeral waterways, or areas with relatively disturbed natural values. Constructing weirs is generally unacceptable because it creates a barrier to movement of native fish and other aquatic fauna.

To meet licence conditions, diversions are only permitted when the following conditions are met:

- harvesting occurs between July and October
- when flows are above the minimum flow threshold.

7. Hillside dams

The general arrangement for hillside dams involves harvesting runoff from a broad catchment with no well-defined waterway. Diversion banks or catch drains may be used to increase the catchment area. Hillside dams may also be filled by pumping from a waterway or groundwater sources.

Figure 3 shows a typical design for a hillside dam. Bypass arrangements for hillside dams can be achieved using either:

- bypass pipe and diversion weir (as Figure 3 shows)
- contour channel and distribution pit
- · floating pipe offtake.

These options would also be appropriate for an existing dam that is to be enlarged or being used for a new purpose, necessitating a change in license conditions.



Figure 3: Hillside dam with bypass pipe

7.1 Bypass pipe in a diversion bank

Where diversion banks are used, an effective bypass can be constructed using a low-level weir with a bypass pipe to divert runoff from part of the catchment. The actual catchment area would need to be a significant proportion of the total catchment for this arrangement to meet bypass requirements. The bypass capacity would be based on the total dam catchment. The pipe and weir would be designed based on the approach described in the bypass pipelines section of this guide.

7.2 Contour channel and distribution pit

Flows can be diverted around a hillside dam using a contour channel and distribution pit. This is similar to the diversion bank and bypass pipeline option, except the water is conveyed below ground compared to above ground.

The general arrangement and details of the distribution pit are shown in Figure 4, Figure 5 and Figure 6.





Figure 5: Distribution pit, isometric view



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Figure 6: Distribution pit, elevation



Typical design details for this system are:

- the contour channel is designed with a bed grade of 1:1,000 towards the distribution pit. No banks are needed, and high flows will overtop the channel and flow into the dam
- the pit is used to control flows: low flows pass through the bypass pipe and higher flows pass over the weir. The hydraulic design is detailed in the bypass pipelines section of this guide
- the pit also acts as a silt trap, with the pit floor set at least 300 mm below the bypass pipe invert to allow for silt accumulation
- the bypass pipe and overflow weir are typically set up with a 300 mm height difference
- the weir and pit length are sized to suit the catchment area
- an inlet screen and a flow-control orifice designed as detailed in the bypass pipes section of this guide
- rock beaching is needed to control erosion downstream of the weir and bypass pipe.

7.3 Floating pipe offtake

A hillside dam can also be bypassed with a <u>floating pipe offtake</u>, that passes the required flows from within the dam (as detailed in the floating pipe offtakes section of this guide).

8. Bypass pipelines

A bypass pipeline is an effective way to pass flows past off-stream (hillside) and on-stream dams.

Minimum passing flows for farm dams require bypasses with capacities typically in the range of 0.2 to 2 ML/d. Pipelines are the most economical and practical means of conveying flows in this range.

The inlet structure is the most critical part of the bypass works and consists of:

- a diversion weir
- a pipe offtake and orifice (to regulate flows to the specified rate).

Figure 7 shows a typical bypass pipe arrangement and Figure 8 a typical longitudinal section. The pipe runs around the dam and discharges into the waterway below. This ensures low flows pass directly into the waterway rather than flow down a spillway, which can result in some loss of water through absorption and/or erosion of the spillway.

This arrangement will suit new dams and retro-fitting existing dams.

Figure 7: Bypass pipeline general arrangement







Design guidelines require the following to be determined:

- minimum-flow threshold
- minimum pipe diameter for the flow
- orifice size to pass the specified flow
- weir type.

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8.1 Pipeline design

8.1.1 Alignment

- Locate the diversion weir at a level at or above the dam crest level, to provide enough head for the gravity diversion flows.
- Lay the pipe where it is practical to do so. It should preferably follow the contour or be on a slight downward slope to the dam.
- Do not lay the pipe down the spillway: trenching is likely to be a weak point and lead to erosion.
- Extend the pipe upstream to a point where the design pipe gradient intersects with the creek bed, as shown in Figure 8.

8.1.2 Gradient

- Lay the pipe on a uniform, falling grade, so there are no high points where air can collect to reduce the pipe's capacity. This also makes sure the pipe is self-cleansing.
- If you can't avoid high points, install air valves or air vents.
- A minimum velocity of 0.6 m/s is typically required for the pipe to clean itself of sediment. The grade depends on the available slope, which determines the pipe diameter for the required flow.

8.1.3 Pipe type and size

- Make the minimum pipe diameter 100 mm, to minimise the risk of blockage.
- PVC and HDPE are suitable pipe types for flows up to 2 ML/d. PVC is less than half the cost of HDPE in sizes around 100–150, so most people would use PVC.
- The pipe will operate under gravity flow only, so the lowest-pressure-class pipe is adequate for hydraulic purposes. Provided it is properly installed, this class of pipe is also suitable for external loading.

Table 2 shows typical pipe capacities: other pipe sizes and slopes might suit particular sites better. The minimum flow achieves a self-cleaning velocity; the maximum flow is the full pipe capacity under gravity flow.

Table 2: Pipe capacity

Pipe size (mm)	Pipe slope	Minimum flow (ML/d)	Maximum flow (ML/d)
100	1:100	0.1	0.9
100	1:200	0.3	0.6
150	1:100	0.1	2.1
150	1:200	0.3	1.4

Note: the table is based on PVC Pipe Class PN 4.5 (Vinidex).

8.1.4 Flow-control device

To ensure excessive flows are not diverted during the permitted water harvesting period, a flow control device (orifice or valve) is required. This will provide a "choke" in the pipe, limiting the capacity to the required bypass flow rate.

A fixed control is preferred because no adjustment or interference can be made to the capacity once installed. This can be achieved using an orifice plate inserted into the pipeline. The orifice plate must be installed where the upstream section of pipe will be full under normal operating conditions. When flows are very low the orifice will flow part full.

It is proposed that the orifice plate be installed near the inlet screen where the pipe is always full, and the hydraulic conditions are known. This makes the calculation of the orifice size more accurate as more stable flow conditions occur.

The equation for orifice plate flow is ¹⁰:

 $Q = 86.4 \times CA(2gH)^{0.5}$, where:

Q = flow (ML/d)

C = coefficient of discharge (0.6 normally used)

 $A = \text{orifice area } (m^2)$

g = acceleration due to gravity (9.81 m/s²)

H = head of water above centreline of orifice (m)

For farm dam bypasses, the equation can be used to determine the required diameter for a given flow and head condition. For most applications, the weir crest can be set to provide a fixed head for the orifice.

Figure 9 shows the required orifice diameter for a range of flows and head loss.

When there are flows over the weir, the total head is higher and the bypass flow will increase. If the pipe downstream of the orifice is not flowing full, the bypass flow will be 40% higher with 0.3 m flow over the weir.

Make the orifice plate from a sheet of PVC or stainless steel and install it between two PVC flanges close to the diversion weir. An inspection opening made from a PVC tee is recommended next to the orifice to enable it to be inspected and cleared of debris.

¹⁰ Brater and King, 1976

Figure 9: Orifice diameter



8.1.5 Pipe cover

The pipe should be buried to protect it from exposure from ultraviolet light and physical damage from stock or farm machinery. The depth of cover depends on the likelihood and consequences of damage. Table 3 shows typical cover requirements.

Table 3: Pipe cover

Feature	Minimum pipe cover (mm)
No vehicles/grazing paddock	300
Vineyard headlands	450
Under vehicle tracks	600

8.1.6 Air valves and vents

At any high points and changes of grade in pipelines it essential to have air valves to allow air to be released from the pipe on filling, and to enter when flow ceases. The air valve/vent ensures that flows are stable for part-full pipe flows and avoids possible airlocks and surging.

The critical points for air valves and vents in bypass pipelines are located where the pipe will run partially full under normal operating conditions. These points are immediately downstream of the orifice controlling the flow rate and at the change in slope where the pipe grade steepens downstream of the dam.

Proprietary air valves could be used. Alternatively, as the pipe flows are not under pressure, an air vent can be made using a T-fitting and a vertical length of pipe which extends vertically above the hydraulic grade line. To prevent objects being dropped down the vent, the top needs to have a cap with small holes or have an inverted U-bend (Figure 10). The riser pipe can be ABS or HDPE. PVC pipe could also be used as long as it is painted for protection from ultraviolet light.

8.1.7 Pipe through embankment

Part of the pipe may pass through the embankment. Even with the pipeline invert level at fullsupply level, there could be leakage during a flood event, so seepage cut-offs should be installed along the pipe.

8.1.8 Pipe outfall

Figure 10 shows a typical pipe outfall. The outlet section of the pipe is usually the same size and class of pipe as the upper section of the pipe. The pipe should then discharge into the waterway without eroding the stream bed or banks. A simple and effective energy dissipater for the bypass flow range (up to 2ML/d) is to construct a rock pool using rocks up to 300mm to submerge the pipe outlet.

Figure 10: Typical pipe outfall



8.1.9 Installation

Figure 11 shows a typical pipe installation. PVC pipes need to be correctly installed so that they can carry externally applied loads. Installation details are provided in *AS/NZS 2032:2006 Installation of PVC pipe systems*. Additional information can also be obtained from pipe manufacturers.





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8.2 Bypass offtake design

A bypass offtake has three elements:

- a hydraulic control structure (such as a weir), to submerge the inlet of the pipe
- a screen, to keep debris from blocking the orifice or pipe
- a silt trap, to minimise silt in the pipeline.

The expected silt load will help determine the type of works. Where silt loads will be high, the offtake should be a diversion weir or a submerged pipe offtake in a scour hole.

If you expect a low silt load, the offtake can be a pipe junction pit, set below the bed level and with a control weir.

8.2.1 Diversion weir

A weir across the upstream waterway is usually necessary to provide a pool in which to create sufficient head to allow the gravity diversion of water into the bypass pipe. A typical weir is:

- 300 mm high above the bed, but could be up to 600 mm high, depending on site conditions
- located where the pipe gradient intersects the creek bed (Figure 8), where it is readily
 accessible for construction and future maintenance, especially for desilting and for
 compliance inspections by the water corporation
- · constructed from reinforced concrete, steel sheet piling or timber
- uses rock beaching on the bed and batters, to control erosion.

Figure 12, Figure 13 and Figure 14 show details of a typical diversion weir. The type of weir depends on the size of the waterway, site access, when construction can occur, construction skills and budget.

Figure 12: Diversion weir



The weir pool:

- · will drain down to the level of the inlet screen when streamflows stop
- must have a small sump an earthen sump or concrete pit near the screen, to act as a silt trap.

The sump needs to be cleaned periodically, depending on the silt and debris load. An inspection opening is recommended next to the orifice, to enable it to be inspected and cleared of debris.



Figure 13: Diversion weir, cross section

Figure 14 shows the pipe offtake, attached to the upstream side of the weir where it will be out of the way of mechanised equipment used to desilt the bed. The screen could also be installed to pass through the weir wall.

Figure 14: Diversion weir, bypass offtake



8.2.2 Submerged pipe offtake

At some sites, it may be possible to have the same general pipe offtake, but without a diversion weir. Figure 15 shows the screen located in a shallow, longitudinal sump. Hydraulically, this arrangement is the same as the weir offtake arrangement, except it is set at a lower elevation.

To ensure the hydraulic characteristics of the site remain constant, the stream bed needs to be stabilised with a fixed bed level at the downstream end of the sump. This could be made of rocks which could be in-filled with concrete to provide a well-defined crest level.

To reduce sedimentation in the sump, flows should be concentrated using logs or rocks to maintain a scour hole. The degree of self-cleaning required depends on flows and the type and quantity of sediments and other matter. The amount of manual cleaning required should be less than for the weir type offtake.

As the pipe must be set at least 0.3 m below the creek bed, the offtake may need to be further upstream than for the weir-type offtake to achieve sufficient head. This means a longer pipeline is needed, but the extra cost will be offset by the savings in not needing a weir.

Figure 15: Submerged pipe offtake



8.2.3 Junction pit offtake

Pipe bypasses only involve small flows, so for waterways with low silt loads a suitable offtake could simply be a prefabricated HDPE pipe junction box used for stormwater and a bed level weir, as shown in Figure 16. The control weir would be the same as for a submerged pipe offtake.

An offtake pit is typically 450 mm by 450 mm by 600 mm deep, has an aluminium grate cover and is fitted with a basket, to remove accumulated silt. The pipe offtake is set in the top part of the pit, to allow for silt to accumulate below it.

Unless the silt basket is very small, some form of mechanical lifting will be needed to remove it; or the pit could be sized to be easily cleaned with a shovel. The orifice for the flow control can be made by drilling a hole in a PVC end cap, which is then attached to the pipe in the junction pit.

If silt loads are high and pit cleaning becomes too time-consuming, a silt trap could be excavated upstream of the junction pit.

Figure 16: Junction pit offtake



8.2.4 Inlet screen

A screen is required over the inlet pipe to prevent debris entering the pipeline. A number of different screen types can be used including:

- perforated pipe
- stormwater drainage entry pit/trench
- circular wedge wire screen.

To use the full capacity of the bypass pipe, the inlet screen must have sufficient open area to allow flow to enter the pipe with minimal head loss.

8.2.5 Perforated pipe screen

A suitable screen for bypass offtakes attached to a diversion weir or placed in an excavated sump can be made from PVC or HDPE pipe and fittings. The total open area of the screen needs to be larger than the pipe area to allow for partial blockage between periodic maintenance. It is recommended that the open screen area is at least three times the pipe area.

Figure 17: Inlet screen

END CAP HOLES TOP HALF ONLY PVC OR HDPE PIPE

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Table 4: Inlet screen details

Pipe diameter (mm)	No. 15 mm holes	Screen length (mm)
100	130	560
150	300	840

The holes are only in the upper half of the pipe, as the underside is likely to silt up over time. Instead of drilling holes in a length of pipe, a perforated stainless steel or aluminium screen could be used. The screen can be made from a straight length of pipe or made as a T-shape.

8.2.6 Stormwater drainage

A stormwater drainage screen for an excavated sump can be made using HDPE stormwater drainage products. A typical drainage channel is 100 mm wide, has a rounded base and is supplied with a fitted grate. It comes with fittings to connect it to PVC pipe, and it connects to a junction pit silt trap, as discussed in the junction pit offtake section. The components are readily available from plumbing or hardware suppliers.

Embed the HDPE channel in concrete or anchor to prevent floatation.

A 1 m length of channel would suit bypasses of up to 2 ML/d.

8.2.7 Circular wedge-wire screen

A hydraulically more efficient screen is a wedge-wire screen usually used for borehole pumps. Screens can be made to order with end fittings to suit the connecting pipe. They are available from irrigation equipment suppliers. A suitable screen would be made from grade-304 stainless steel and have 3 mm slot openings.

Table 5: Wedge-wire inlet screen details

Pipe diameter (mm)	Minimum length (mm)
100	230
150	340

Note: The minimum lengths assume the underside of the screen is ineffective or blocked, and the screen has 66% open area to provide three times the pipe area.

8.2.8 Screen performance

The effectiveness of the screen needs to be monitored and cleaned it as required so the dam complies with licence conditions. Whatever type of screen is selected, if it becomes blocked too readily or causes the orifice to block, the screen needs to be changed to better suit the type of debris on that particular waterway.

9. Floating pipe offtakes

For hillside dams and long, on-stream dams, a floating pipe offtake will usually be the most practical bypass mechanism. A floating bypass can also be used to retro-fit a bypass to an existing dam, where there is a compensation pipe. These offtakes will pass surface water from the dam, even when the dam is below full supply level.

Figure 18 and Figure 19 show a typical arrangement for a floating pipe offtake. The advantages of this offtake are that the total inflow volume can be passed, although at a lower flow rate, and water quality will be similar to the inflowing water.

Floating pipe offtakes are commonly used for irrigation pumps and urban storages.



Figure 18: Floating pipe offtake typical arrangement (elevation)

Figure 19: Floating pipe offtake typical arrangement (plan view)



9.1 Bypass variations

Table 6 shows several types of floating pipe offtakes and the advantages and disadvantages of each. All types take water from near the surface and convey it downstream through a pipeline. The variations relate to flow control. Options to consider are:

· floating offtake with manually operated valve

- floating offtake with automatically operated valve
- floating offtake with locking mechanism and open outlet pipe

The choice of type depends on the degree of automation required and budget.

Table 6: Types of floating pipe offta

Туре	Advantages	Disadvantages
Floating offtake with a manually operated valve	Simple, reliable bypass mechanism	Requires operation after run-off occurs
Floating offtake with automatically operated valve	Saves on operator's time	Additional cost, yet to be tested
Floating offtake with a locking mechanism and an open outlet pipe	Simple, semi-automatic system	Yet to be tested

9.2 Design features

A floating pipe offtake can be made from a flexible pipe (such as HDPE or rubber). The pipe length is based on the manufacturer's limits of pipe flexure (e.g. 33 times the pipe diameter (Vinidex fabrication requirement). The pipe diameter would usually be the same as the diameter of the compensation pipe.

The connection between the semi-flexible HDPE pipe and the compensation pipe needs to be a flexible coupling to mitigate flexure and vibration from wave action being passed through to the compensation pipe. The coupling could be a flanged rubber expansion joint, or a one metre length of rubber hose with suitable fittings. A concrete headwall will also dampen any potential movement.

A typical flanged rubber expansion joint might be a 100 mm or 150 mm diameter flanged rubber expansion joint with grade 316 stainless steel flanges drilled to Table E of Australian Standard 1289. Mild steel flanges are also available but are subject to corrosion.

Figure 20 shows an alternative connection for 100 mm pipes: a rubber hose with a brass-flanged tailpiece and stainless steel Bandit straps.

Figure 20: Floating offtake pipe connection



The dam owner would monitor and record the water level. If the level rises between November and June, they would open the outlet valve to pass all inflows until the water returns to its previous level.

If automatic operation is required, the valve could be upgraded to a pressure operated electrically actuated valve. The specifications for this valve would be:

- valve: a flanged-gate or diaphragm valve (butterfly valves are not recommended because of potential for debris to get caught which prevents valve closure)
- actuator: solar/ battery-powered 12-volt electric motor actuator
- pressure transducer: attachable to the pipe upstream of the valve, with an accuracy of +/-0.02 m over a range of 10 m, with an electrical output
- programmable logic controller: to average water levels (to counter wave action) with resettable trigger points for opening and closing of the actuator/valve: that is, when the water level rises 0.15 m, the valve opens until the water level (pressure) drops to the previous set point.

Automatic systems are more expensive, and the owner may decide if the time savings are justified.

The pipe and inlet must be supported by a float or buoys, as Figure 21 shows. The inlet screen is similar to that for bypass pipes, as described under 'Inlet screen'.

Figure 21: Submerged floating offtake



Secure the end of the pipe with posts or guy ropes (for example, of nylon or polypropylene), to avoid excessive lateral movement of the float and inlet.

9.3 Semi-automatic operation

The release of inflows can be done semi-automatically using a rope and pulley system. After each irrigation diversion, the bypass offtake float is secured in the drawdown position by a rope and pulley system to the bank. If there are inflows, they will directly enter the pipe and discharge downstream through the compensation pipe. The compensation pipe valve is left open. The pipe screen and inlet would be set as shown in Figure 21.



Figure 22: Floating inlet screen typical arrangement

This achieves the bypass objectives, but the dam owner must decide if the advantages of this system advantages justify its increased complexity.

10. Compliance

10.1 Works must be compliant

Licences for works are issued and managed by water corporations in accordance with legislative requirements and government policy. Suitable design drawings are required in works licence applications. The requirement for a bypass mechanism when constructing or operating dams is specified in the standard works licence conditions¹¹ and suitable design drawings are required in licence applications. These guidelines may assist dam owners and consulting engineers in the preparation of suitable design drawings.

Passing flow requirements are specified in either works or take and use licence conditions¹².

10.2 Maintenance and operation

Dam owners are required to ensure any works are operated in accordance with licence conditions by periodically inspecting and maintaining any bypass mechanism. Inspections of the bypass inlet and outlet must confirm that passing flows are continuing down the waterway when there are flows upstream of the dam. To demonstrate compliance, the owner should keep a diary to record rainfall events, dates and flow observations upstream and downstream of the dam.

For bypass pipelines, the main maintenance requirement is cleaning the screens. The frequency of cleaning depends on streamflows and the type of debris the waterway carries. Typically, cleaning consists of just brushing debris from the screen and inspecting and cleaning the orifice opening.

The effectiveness of the screen also needs to be monitored by the dam owner. If the screen is blocked too readily or causes the orifice to block, it needs changing to better suit the type of debris in the waterway. The depth of silt also needs to be monitored and periodically removed to ensure the screen does not become blocked.

The dam owner needs to maintain access tracks to the bypass inlet and outlet, to allow for easy and safe inspection and maintenance and compliance inspection by the water corporation.

^{11.} Standard conditions 16 and 17 in Schedule 1 of the Policies for Managing Works Licences

^{12.} See clause 21 and schedules 1 and 2 of the Policies for Managing Take and Use Licences <u>https://waterregister.vic.gov.au/water-entitlements/about-entitlements/take-and-use-licences</u>

11. References

Brater E F & King H W, 1976. *Handbook of Hydraulics for the Solution of Hydraulic Engineering Problems* (6th ed.).

Lee S, Napier G & Pearce M, 2007. *Low flow bypass trial in the Marne catchment*, Flinders University, poster paper.

Lewis B, 2002. Farm dams: Planning, construction and maintenance.

SKM, 2007. Guidelines for meeting the passing flow requirements for Licensable Farm Dams in Victoria.

Standards Australia. AS2032:2006 Installation of PVC pipe systems.

Victoria. Department of Natural Resources and Environment, 2002. Your dam: Your responsibility - A guide to managing the safety of farm dams.

Victoria. Department of Natural Resources and Environment, 2002. *Healthy rivers, healthy communities & regional growth: Victorian river health strategy.*

State of Victoria, 2003. *Irrigation and Commercial Farm Dams Compendium of Ministerial Guidelines and Procedures*.

Vinidex Tubemakers Pty Ltd, undated. Flow charts for PVC pressure pipe.