# Technical guidelines for flood work applications in areas without a floodplain management plan

## Guidance on the assessment of flood work applications in areas without an in-force floodplain management plan under the Water Management Act 2000

## Background

All flood works as defined by the *Water Management Act 2000* (the Act) require an approval. Approvals for a flood work are typically governed by rules in floodplain management plans (FMP) developed under the Act, which specify the types, location and size of flood works that may be constructed within the respective FMP management zones. WaterNSW may require applicants to submit technical studies or supporting information to demonstrate that a proposed flood work meets the rules and assessment criteria outlined in the relevant FMP. However, in many areas where there is no existing FMP, guidance is required to appropriately determine whether a flood work is having an acceptable impact on flow connectivity and third parties.

This guideline covers the following key technical issues in developing suitable supporting information for the assessment of an application for a flood work approval where there is no FMP in place:

1. Peak Flood Flow determination
2. Required Design flood events
3. Assessment criteria and allowable thresholds
4. Methods for hydraulic impact assessment

This guidance has been prepared based on information and processes used during FMP development in northern inland NSW and other relevant sources. The application of these guidelines will allow the assessment and determination of applications for flood work approvals to consider the water management principles set out in section 5 of the Act and address the minimal harm requirements under section 97 (2) of the Act by encouraging the use of the best available information.

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# 1. Peak Flood Flow determination

The following reference documentation serves as background material for this section:

- Geoscience Australia & Engineers Australia, Australian Rainfall & Runoff 2019, A Guide to Flood Estimation Book 3 – Peak Flow Estimation
- Geoscience Australia & Engineers Australia, Australian Rainfall & Runoff 2019, A Guide to Flood Estimation Book 4 – Catchment Simulation for Design Flood Estimation
- Geoscience Australia & Engineers Australia, Australian Rainfall & Runoff 2019, A Guide to Flood Estimation Book 5 – Flood Hydrograph Estimation

Estimated peak flood flows serve as inflows for hydraulic models to enable flood behaviour to be assessed and flood impacts associated with flood work development to be determined within a study area.

In smaller modelled areas within large inland floodplains, steady flow analysis, using peak flood flows as inflows, are generally appropriate to quantify hydraulic impacts as the flood wave is slow moving.

In smaller catchments with quick flood response times, where removal of floodplain storage and duration of flooding are critical issues, unsteady flow analysis, using flood flow hydrographs as inflows, are generally preferred. In these situations, the unsteady flow allows the attenuation of the flood wave to be quantified as it passes through developed areas.

Appropriate methods for peak flood flow and hydrograph determination in areas with no in-force FMP are presented in Table 1. Preference should be given to the methods listed in the table in descending order. That is, method A is preferable to method E.

Table 1. Peak flood flow and hydrograph methods for study areas with no in-force FMP

| Flow Determination Method | Peak Flood Flow | Flood Flow Hydrograph | Comments |
|---|---|---|---|
| A. **Flood Data extraction from existing flood studies commissioned by local councils** | **Yes** | **Yes** | A search of the NSW Flood Data Portal and/or queries in relation to available flood data/flood studies directed to relevant local councils can provide access to existing flood frequency analysis, hydrologic and/or hydraulic modelling within the study area can produce peak flood flows and hydrographs for use in hydraulic models developed for the study area. |

| Flow Determination Method | Peak Flood Flow | Flood Flow Hydrograph | Comments |
|---|---|---|---|
| B. **At-site Flood Frequency Analysis** | **Yes** | Not applicable | For use in study areas with gauged stream flow data. Can provide AEP estimates from historical floods to determine an appropriate design flood event. |
| C. **Catchment runoff-routing modelling** | **Yes** | **Yes** | Where hydrographs are required to provide a more accurate assessment of flood work impacts, a runoff-routing hydrologic model using regional parameter estimates and design rainfall estimates can be applied for ungauged catchments. This approach can be combined with the RFFE method (Method D) to get a better estimate of peak flood flows. |
| D. **Regional Flood Frequency Estimation (RFFE) Method** | **Yes** | Not applicable | Application of the RFFE method is used in study areas with ungauged rural catchments greater than 0.5 square kilometres up to 1,000 square kilometres in size. Note the appropriateness is also dependent on catchment shape. |
| E. **Cross-sectional analysis using historic surveyed flood levels** | **Yes** | Not applicable | This simple approach uses surveyed flood levels, flood slopes or remote sensed extents and cross-sectional survey of the study area to obtain peak flood flows for historic flood events and estimated flood frequencies. Typically, the Mannings formula with suitable roughness coefficients is applied to estimate peak flood flows. Although not recommended over the other presented methods, it can provide an independent check to derive 'a best estimate'. |

For methods B, D and E, a hydrograph shape may be required dependent on the catchment size. If so, it is recommended that a recent historic event from a nearby gauged catchment with a similar peak flow is scaled to match the calculated peak flow.

## 2. Required design flood events

The following reference documentation serves as background material for this section:

- Rural floodplain management plans: technical manual for plans developed under the Water Management Act 2000, 2020, as updated or replaced from time to time

- Department of Planning & Environment, Flood risk management guideline LU01, Flood impact and risk assessment

Where an FMP has commenced under the Act, the adopted design flood events are used to determine the FMP floodway network and during the technical assessment of flood work approval applications against the assessment criteria. FMP design floods are usually based on recorded historical events that are preferably within the living memory of a local community. This approach enables the community to comprehend the magnitude of the flood events being modelled. Multiple design floods may be selected to account for the social, economic, and ecological consequences associated with floods of different magnitudes.

FMPs under the Act are generally assigned large and small design floods. The event referred to as the 'large design flood' usually has an AEP of around 5%. It may be larger if a historical flood has a lower exceedance probability and has been previously accepted by the local floodplain community as a basis for design.

The flood event referred to as the 'small design flood' is a smaller-scale event that generally has an AEP of less than 10%. This design flood is used to simulate events that are likely to be more frequent than the large design flood and is used to check that critical flow paths to floodplain assets are identified within the floodway network and management zone delineation.

For study areas with no FMP and no defined continuous floodway network, a larger range of design events needs to be considered when assessing the flood impacts of flood work development. This is to compensate for the lack of restrictive management zones, based on FMP floodway networks, and their associated rules for high discharge areas and environmental / cultural protection areas.

Required design flood events for study areas with no FMP are presented in Table 2.

Table 2. Required design flood events for study areas with no in-force FMP

| Design Flood Scenario | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1% AEP |
|---|---|---|---|---|---|
| Large design flood event – for study area with no high value infrastructure1 on the existing or proposed flood work property and/or adjacent properties and/or floodplain areas that could potentially be affected by the existing or proposed flood work | No | No | **Yes** | **Yes** | No |
| Large design flood event – for study area with high value infrastructure1 on the existing or proposed flood work property and/or adjacent properties and/or floodplain areas that could potentially be affected by proposed flood work | No | No | **Yes** | **Yes** | **Yes** |

| Design Flood Scenario | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1% AEP |
|---|---|---|---|---|---|
| Small design flood event – for study area with no known flood-dependent assets 2 on the existing or proposed flood work property and/or adjacent properties and/or floodplain areas that could potentially be affected by proposed flood work | No | **Yes** | No | No | No |
| Small design flood event – for study area with known flood-dependent assets 2 on the existing or proposed flood work property and/or adjacent properties and/or floodplain areas that could potentially be affected by proposed flood work | **Yes** | **Yes** | No | No | No |

**Notes.**

1. High value infrastructure includes but is not limited to houses/dwellings, infrastructure protection works, town levees, stockyards, sheds, and pump sites; it does not include farm levee banks, irrigation development and fences. For high value infrastructure, loss of life and property due to flood risk dictates flood impact analysis against higher magnitude design flood events with lower exceedance probability.

2. Flood-dependent assets are ecological assets, Aboriginal cultural values, or heritage sites that have important ecological or cultural features which rely on inundation by floodwaters to sustain essential processes. More frequent flooding requirements for flood-dependent assets entails flood impact analysis against design flood events with a higher exceedance probability.

# 3. Assessment criteria and allowable thresholds

The following reference documentation serves as background material for this section:

- Rural floodplain management plans: technical manual for plans developed under the Water Management Act 2000, 2020, as updated or replaced from time to time
- Floodplain management plans commenced under the Act in northern NSW: the Gwydir, Namoi (Upper and Lower), Barwon-Darling, Macquarie and Border Rivers valleys.

Management zones established in FMPs under the Act (typically defined as A, B, C & D) coordinate the development of flood works on rural floodplains by assigning specific rules and assessment criteria that limit the type and nature of flood works that can be approved.

For study areas with no FMP, no defined continuous floodway network or restrictive management zones (A – main flood ways and D – special protection areas) the assessment criteria and allowable thresholds generally specified for management zone B are recommended. Management zone B assessment criteria provides a comprehensive hydraulic assessment of flood impacts due to proposed flood works. Transitional provisions in newly commenced FMPs may rely on the use of the

comprehensive management zone B assessment criteria to assess undetermined applications for flood work approvals in restrictive management zones (A/D)

An application for a flood work approval is assessed by comparing flood behaviour under different modelled development conditions (Table 3) and different scenarios of development change (Table 4).

Table 3. Development conditions to be modelled as part of a Flood Study

| Development condition | Definition |
|---|---|
| **Pre-development conditions** | Floodplain model set-up[1] without flood work development on the applicant landholding. |
| **Existing development conditions** | Floodplain model set-up[1] with the approved level of flood work development on the applicant landholding at the time the application is made. |
| **Proposed development conditions** | Floodplain model set-up[1] with the approved level of flood work development on the applicant landholding at the time the application is made and the proposed flood work[2]. |

**Notes**

[1] for all model set-ups existing development conditions on the floodplain surrounding the applicant landholding are to be adopted.

[2] A proposed flood work is the subject of the application for a flood work approval and may include:

- A new flood work or
- An existing unapproved flood work or
- A modification to an approved flood work.

Table 4. Development change scenarios to be examined as part of a Flood Study

| Development change Scenario | Definition |
|---|---|
| **Scenario A** | Proposed development conditions[1] compared to existing development conditions[1]. |
| **Scenario B** | Proposed development conditions[1] compared to pre-development conditions[1]. |
| **Scenario C** | Existing development conditions[1] compared to pre-development conditions[1]. |

**Notes**

[1] Refer to Table 3 for development condition descriptions.

Required assessment criteria and thresholds for study areas with no in-force FMP are presented in Table 5.

Table 5. Assessment criteria and allowable thresholds for study areas with no FMP

| Assessment criteria | Allowable thresholds and comments |
|---|---|
| **Flood connectivity to flood-dependent assets:**<br>Adequate flood connectivity to known flood-dependent assets[1] and to facilitate fish passage[5] is to be maintained on applicant landholding, adjacent landholdings and other areas that may be affected by a proposed flood work. | Flood connectivity is adequate when it allows for the unimpeded passage of water for required small and large design flood events[6] to reach flood-dependent assets[1] that depend on the water for their survival and to facilitate fish passage[5]. Flood connectivity can include:<br>• longitudinal connectivity (upstream-downstream)<br>• lateral connectivity (channel-floodplain) and<br>• vertical connectivity (groundwater).<br>**Notes.**<br>1. Flood-dependent assets are ecological assets[2], cultural assets[3], or heritage sites[4] that have important ecological or cultural features which rely on inundation by floodwaters to sustain essential processes.<br>2. Ecological assets are wetlands or other floodplain ecosystems, including watercourses that depend on flooding to maintain their ecological character and areas where groundwater reserves are recharged by floodwaters, which are spatially explicit and set in the floodplain landscape.<br>3. Cultural assets are objects, places or values that are important for people to maintain their connections, beliefs, customs, behaviours, and social interactions. Includes Aboriginal cultural assets and values listed in the Aboriginal Heritage Information Management System.<br>4. Heritage site means a cultural heritage object or place that is listed on a Commonwealth, state or local government heritage register.<br>5. Fish passage refers to connectivity that facilitates the movement of native fish species between upstream and downstream habitats (longitudinal connectivity) and adjacent riparian and floodplain areas (lateral connectivity); areas that are important for fish passage include rivers, creeks and flood flow paths.<br>6. Refer to **Table 2** for required design flood events. |

| Assessment criteria | Allowable thresholds and comments |
|---|---|
| **Heritage site impacts:**<br>Prevent ground disturbance and minimise erosion of any known heritage sites[2] located on the applicant landholding. | The construction of a flood work is not to disturb the ground surface[1] of a heritage site[2] or cause more than minimal[1] erosion to a heritage site[2] due to proposed flood work impacts.<br>**Notes.**<br>1. Heritage sites may be sensitive to changes in flood behaviour or disturbance from the construction of flood works.<br>2. Heritage site means a cultural heritage object or place that is listed on a Commonwealth, state or local government heritage register, such as:<br>a. NSW State Heritage Register,<br>b. NSW State Heritage Inventory,<br>c. Aboriginal Heritage Information Management System,<br>d. Murray-Darling Basin Authority Aboriginal Submissions Database,<br>e. Historic Heritage Information Management System,<br>f. Commonwealth Heritage List. |
| **Local drainage impacts:**<br>Adequate drainage to be maintained on adjacent landholdings and other areas that may be affected by a proposed flood work. | Hydraulic analysis outputs from the applicant's flood study are to be interpreted to provide a qualitative or quantitative assessment of any likely changes to local drainage for required large and small design flood events[1] on adjacent landholdings or other areas that may be affected by a proposed flood work. This entails determining if drainage is adequate: remnant or ponded waters can drain in a reasonable time to a main floodway or to an area where the water can spread quickly to avoid waterlogging soils.<br>**Notes.**<br>1. Refer to Table 2 for required design flood events. |
| **Peak Flood Flow Redistribution:**<br>Minimise peak flood flow redistribution impacts on adjacent landholdings and other | Peak flood flow redistribution to be a **maximum of 5%** on overall floodplain, individual landholdings, flow paths and smaller areas of the floodplain for **scenario A**[1,2] and required large design flood events[3].<br>**Notes.** |

| Assessment criteria | Allowable thresholds and comments |
|---|---|
| areas that may be affected by a proposed flood work. | 1. Where proposed floodway / flow path restoration work may cause **scenario A**[2] flow redistribution to exceed 5%, the following provisions are to be met for flood work approval:<br>• Proposed flood work improves flood connectivity and restores flood flow behaviour closer to pre-development conditions (**scenario B**[2] flow redistribution is less than **scenario A**[2]) for study area.<br>• Potential impacts (including social) have been considered and mitigation strategies have been provided.<br>2. Refer to **Table 4** for development change scenarios.<br>3. Refer to **Table 2** for required design flood events. |
| **Increase in Flood levels (afflux):**<br>Minimise afflux impacts on adjacent landholdings and other areas that may be affected by a proposed flood work. | To minimise incremental cumulative impacts, the sum total of affluxes should **not exceed 10 cm** for **scenario B²** and required large design flood events[3].<br>To avoid excessive change to flood behaviour under existing conditions, affluxes should **not exceed 10 cm** for **scenario A**[1,2] and required large design flood events[3].<br>Larger affluxes **up to 20 cm** are acceptable for **scenario B²** if they maintain status quo or are lower when compared to **scenario C²** affluxes.<br>**Notes.**<br>1. Where proposed floodway / flow path restoration work may cause scenario A[2] affluxes to exceed 10 cm the following provisions are to be met for flood work approval:<br>• Proposed flood work improves flood connectivity and restores flood flow behaviour closer to pre-development conditions (**scenario B**[2] affluxes are less than **scenario A**[2]) for study area.<br>• Potential impacts (including social) have been considered and mitigation strategies have been provided.<br>2. Refer to **Table 4** for development change scenarios.<br>3. Refer to **Table 2** for required design flood events. |

| Assessment criteria | Allowable thresholds and comments |
|---|---|
| **Increase in Flood levels and resulting high-value infrastructure impacts:**<br>Minimise flood level increases to reduce high-value infrastructure impacts on adjacent landholdings and other areas that may be affected by a proposed flood work.<br>**Notes.**<br>1. High value infrastructure includes but is not limited to houses/dwellings, infrastructure protection works, town levees, stockyards, sheds, and pump sites; it does not include farm levee banks, irrigation development and fences. | Flood level increases due to proposed development conditions are not to impact high value infrastructure[1] for calculated affluxes **equal to or greater than 1 cm** under the various development change scenarios[2] considered and under required large design flood events[3].<br>**Notes.**<br>1. This assessment will need to consider the sensitivity of the high value infrastructure to flooding.<br>2. Refer to **Table 4** for development change scenarios.<br>3. Refer to **Table 2** for required design flood events. |
| **Increase in flood flow velocities and soil erodibility:**<br>Minimise flood flow velocity increase impacts and soil erodibility on the applicant | 1. Soil Erodibility<br>Flood flow velocities for proposed development conditions are to be below the threshold of erosion for the potential land usage and ground cover on affected landholdings and areas.<br>Where the erosion threshold is exceeded, consideration will be given to accepting velocities for the proposed development conditions if: |

| Assessment criteria | Allowable thresholds and comments |
|---|---|
| landholding, adjacent landholdings and other areas that may be affected by a proposed flood work. | a. they are less than or equal to the existing development conditions and there are minimal signs of erosion, and<br>b. flood flow velocity increase thresholds under section 2 are met.<br><br>**2. Flood flow velocity increases**<br>To minimise incremental cumulative impacts, velocity increases are limited to a **maximum of 50%** for **scenario B[2]** and under required large design flood events[3].<br><br>To avoid excessive change to flood behaviour under existing conditions, velocity increases are limited to a **maximum of 50%** for **scenario A**[1,2] and under required large design flood events[3].<br><br>Larger velocity increases (> 50%) are acceptable for **scenario B[2]** if the following provisions are met:<br>a. Velocity increases (> 50%) in isolated areas on applicant landholding are mitigated by applicant (e.g., energy dissipaters) so that the average impact across the landholding does not exceed 50% and velocity increases do not exceed 50% at the boundary of the landholding.<br>b. Velocity increases (>50%) on adjacent landholdings and other areas are equal to or less than **scenario C[2]** velocity increases and are below erosion thresholds.<br>c. Affected velocities on applicant landholding, adjacent landholdings and other areas are small in magnitude (< 0.1 m/s) so that velocity increases (>50%) do not have a measurable impact on flood flow behaviour or soil erodibility.<br><br>**Notes.**<br>1. Where proposed floodway / flow path restoration work may cause **scenario A[2]** velocities to increase by more than 50% the following provisions are to be met for flood work approval:<br>• Proposed flood work improves flood connectivity and restores flood flow behaviour closer to pre-development conditions (**scenario B[2]** velocity increases are less than **scenario A[2]**) for study area.<br>• Potential impacts (including social) have been considered and mitigation strategies have been provided.<br>2. Refer to **Table 4** for development change scenarios.<br>3. Refer to **Table 2** for required design flood events. |

| Assessment criteria | Allowable thresholds and comments |
|---|---|
| **Hydraulic cumulative impacts:**<br>Reduce hydraulic cumulative impacts at the regional scale resulting from a proposed flood work and existing approved development by minimising the redistribution of overall peak flood flows at the downstream boundary/cross-section[1] of the applicant's adopted flood study hydraulic model (may include 1D, 2D or 1D/2D modelling or backwater calculations or cross-sectional analysis). | Overall peak flood flow redistribution at the downstream model boundary/cross-section[1] to be a **maximum of 2%** for **scenarios A[3] and B[2,3]** and under required large design flood events[4].<br>**Notes.**<br>1. The model boundary/cross-section should be placed far enough downstream of the area of interest to ensure that any errors in flood flow estimates and/or flow direction do not have a significant effect on the model results.<br>2. Scenario to be used for assessment if proposed flood work on applicant landholding includes floodway / flow path restoration.<br>3. Refer to **Table 4** for development change scenarios.<br>4. Refer to **Table 2** for required design flood events. |

# 4. Methods for hydraulic impact assessment

The following reference documentation serves as background material for this section:

- Rural floodplain management plans: technical manual for plans developed under the Water Management Act 2000, 2020, as amended or replaced from time to time
- Geoscience Australia & Engineers Australia, Australian Rainfall & Runoff 2019, A Guide to Flood Estimation Book 6 – Flood Hydraulics

A variety of modelling and computational approaches are available to carry out hydraulic impact assessments for a proposed flood work. Each approach will have different input data requirements, computational effort and resulting outputs. A flood study accompanying an application for a flood work approval must demonstrate that the approach selected is best suited to the flood work proposal. For areas with no FMP, and no existing flow path/floodway network delineation for large and small design floods, it is important that the approach adopted has the computational capacity to delineate:

- discharge, velocity and depth at key locations across the study area
- high discharge areas (floodways) for the large and small design floods
- flood flow paths (flood connectivity) for small design floods
- inundation extents of the small and large design floods
- flood behaviour for different modelled development conditions —
  - pre-development conditions
  - existing development conditions
  - proposed development conditions.

The above modelling/computational products will need to address the hydraulic assessment criteria (refer to section 3 of this guideline).

Although the hydraulic models for proposed flood works are not required to undergo extensive calibration/validation to the same degree as strategic models used for areas with an FMP, it is expected that key model parameters such as surface roughness and inflows undergo a sensitivity analysis. Likewise, local flood knowledge, flood satellite imagery and aerial photography, if available for historic flood events approximating design flood magnitudes, should be utilised to fine tune model parameters and validate modelling outputs.

For most flood work proposals, a two-dimensional (2D) model or integrated 1D/2D model approach should be used. The 2D model is best for modelling wide, flat floodplains where flow paths are poorly defined. The integrated 1D/2D model is best if important structures are in channels or the

channel size enforces fine resolution. A linked 1D/2D model allows transfer of flow between the channel and out-of-bank flow.

In areas with no FMP and multiple applications for flood work approvals, consideration can be given to developing a regional 2D (or integrated 1D/2D) model from one supplier. This would be used to carry out a regional scale flood study to determine the hydraulic impacts from proposed flood works on adjoining or nearby landholdings. Where flood work applicants agree to share the costs for a regional scale flood study, there are benefits in integrating assessments for a more consistent set of modelling results and a better assessment of cumulative impacts. Appropriate computational grid sizes should be maintained if a regional flood assessment is undertaken.

Two dimensional or 1D/2D modelling may not be required if the flood work proposal has a minor footprint, the site is subject to non-complex flood behaviour and there is good flood imagery to support decision making. Assessment against the hydraulic assessment criteria using a simple backwater analysis or non-model hydraulic calculation will still be required.

The final choice of appropriate model/computational approach is governed by the availability of data and the complexity of the study area. Where a 1D model, non-model hydraulic calculations or a backwater analysis has been selected for areas with complex flood behaviour, justification for not using 2D or 1D/2D modelling will need to be provided.