



1 Public Safety

Two types of flood mitigation structures have been proposed, these are stopbanks (embankments designed to hold back flood water) and flood ways, dedicated areas designed to convey flood waters during major flood events. Both pose different risks to public safety, during normal operation, operation during a flood and during failure or over-design events (events beyond that allowed for in the design).

Below each flood mitigation structure is considered in terms of public safety risks considering the following categories:

- Public access and safety under normal conditions
- Risk to livestock and people under flood conditions
- Potential to catch people and livestock un-prepared
- Vehicle hazards
- Speed and consequence of failure
- Potential for failure
- Evacuation
- Ability to trap / strand livestock and people
- Ability to carry debris

These categories are discussed below for each mitigation structure with a calculated risk score. The risk scores have been calculated using the NZ Transport Agency Waka Kotahi Risk matrix and definitions (<https://www.nzta.govt.nz/roads-and-rail/rail/operating-a-railway/risk-management/risk-matrix-likelihood-and-consequence-tool/>). Options have been scored based on the proposed scheme assuming appropriate design and construction.

Risk Category	Stop Bank		Flood Way	
	Risk Description	Risk Score	Risk Description	Risk Score
Public access and safety under normal conditions	Stopbanks, subject to height can reduce natural surveillance and their slopes can be a risk to the public (where access is encouraged). However, the crest width is normally sufficient to mitigate the risk of slips as are slopes of 1:3 now commonly used for stopbank construction. In the case of Wairoa, the proposed stopbank alignment and height is not expected to generate any significant antisocial behavior.	10	Floodways, being lowered ground, have good natural surveillance and flatter cut slopes.	5

Risk Category	Stop Bank		Flood Way	
	Risk Description	Risk Score	Risk Description	Risk Score
Risk to livestock and people under flood conditions	Stopbanks are generally low risk during floods for the public and livestock unless people try to walk down the river side slopes or access them during floods. Public access should be discouraged during floods to mitigate this risk. Stopbanks can also raise the rivers flood elevation and push flood waters out into other areas. Livestock may congregate on stopbanks as floodwaters approach and could then become trapped if the embankment is overtopped, outflanked or breached.	10	Floodways pose a significant risk to people and livestock once operational. In the case of the floodways proposed in Wairoa, the water would deep and fast flowing and would sweep away cars, people, and livestock. As the floodway starts to operate, it would be quickly flooded. The flow may also carry debris. To protect people and livestock, a warning system would be needed to ensure the area is cleared of livestock / people and closed to access.	20
Potential to catch people and livestock un-prepared	People are generally not caught off guard by stopbanks, unless the stopbank fails or is overtopped. In the case of Wairoa, the stopbank will only be functional during significant flood events and there is level monitoring upstream that will provide advance warning. There is not a significant flood plain / land area between the proposed stopbank alignment and the river channel which also reduces this risk.	4	Floodways can catch people off guard as the onset of their operation can be swift and would quickly be a significant flood hazard to the public once operating.	16
Vehicle hazards	Where the stopbank forms a public road, it can be designed to be safe to the public and safe to use during floods (e.g. suitable scour protection). Where the stopbank does not form a road, access should be limited to maintenance vehicles only.	10	The floodways will require ford crossings and may also be accessed to feed or move livestock. The main hazard will be vehicles trying to cross the floodway to either evacuate the area or to access their property or livestock. Roads crossing the flood way should include a gate and warning lights to close the road once a particular flood elevation upstream is exceeded to mitigate this hazard. A land span bridge across the floodway would significantly reduce this risk but would add significant cost. In the case of Wairoa, the flood way would only operate	20



Risk Category	Stop Bank		Flood Way	
	Risk Description	Risk Score	Risk Description	Risk Score
			infrequently, for example, twice in 100 years (on average).	
Speed and consequence of failure	Stopbanks can fail rapidly and release large volumes of water posing a significant risk to anyone nearby. This can also direct flood waters into areas that might not otherwise have flooded (flooding properties unaware they are at risk of flooding). Appropriate design practices and construction can significantly reduce the likelihood of this happening; hence the risk score is reduced accounting for this.	10	Floodways, being in cut are much less likely to fail in a dramatic way. They may experience erosion and scour during major flood events, but the scour is typically limited in scale and extent and would not redirect floodwater outside of the channel. They cannot suddenly release impounded water like a stopbank.	4
Potential for failure	Well designed and constructed stopbanks should not fail during floods, so the likelihood of failure is low. However, the consequence is significant.	10	Floodways constructed in cut (excavation of a channel into existing ground) are much less likely to fail, though damage and erosion may occur. Erosion is most likely to occur at the entry and exit points. The option concept includes scour protection at these locations to mitigate the risk of erosion.	4



Risk Category	Stop Bank		Flood Way	
	Risk Description	Risk Score	Risk Description	Risk Score
Evacuation	Stopbanks, in the context of those proposed for Wairoa, allow for access to inland properties and evacuation during floods (unless overtopped or breached). However, localized run-off may become trapped behind stopbanks causing localized flooding.	6	Floodways, once operating, will cut off properties forming an island. This will prevent access and evacuation whilst operating and may also delay access following operation if the crossing roads have been damaged or covered with debris. Should there be a medical emergency whilst a floodway is operating a rescue boat or helicopter would be required. A land span bridge can be included to mitigate this risk but would add significant cost.	15
Ability to trap / strand livestock and people	Low risk, but can raise the flood level and push flood waters into new areas.	4	High risk, unless bridged in at least one location.	16
Ability to carry debris	Stopbanks keep debris in the main river channel and do not trap it. However, it is important to keep a maintained clear zone along the river side of the stopbank without fencing or trees that might trap debris and block flow or cause localized scour issues.	2	Floodways can carry debris, such as trees or silage bales if not screened at the inlet which increases the flood risk hazard. The change in environment from deep to shallow as debris enters the floodway can result in debris stopping in the channel and accumulating, especially when the channel is not flowing at its full capacity. This can be partly mitigated, for example, by using debris dooms and an over-sized channel inlet.	12
Total Risk Score		66		112

Overall, flood ways are considered a higher risk to the public so long as the stopbanks have been well engineered to minimize the potential for failure.

The risks associated with floodways can be reduced if at least one crossing point were constructed as a land span bridge to maintenance egress and access during flood events. However, construction of land span bridges over the distance involved would be very expensive.