

**Perth-Andover and Tobique First Nation
Mitigation Study – Final Report**

Submitted to the Government of New Brunswick

August 31, 2012

1.0 ACKNOWLEDGEMENT

We would like to thank the members of the Core Group Committee for their participation in the development of this report. Representatives on the committee include the Tobique First Nation, the Village of Perth-Andover, citizens of Perth-Andover, NB Power and government officials. Input from the Tobique First Nation and the Village of Perth-Andover have been submitted and are included in Appendices 1 and 2 of this report.

2.0 INTRODUCTION

Government has been working to help the communities and residents of the Village of Perth-Andover and Tobique First Nation to recover from the 2012 flood event. Apart from the immediate emergency response, the recovery effort has included a Disaster Financial Assistance program, which has provided for modest post-disaster recovery projects. There is wide recognition that further and more substantial mitigation efforts may be necessary to ensure the future long-term safety and viability of the community.

Government has committed to examine what could possibly be done to prevent or mitigate the risk or reduce the impacts of similar floods in the future. This examination has taken the form of a study into the known and anticipated flood risks, adaptation, mitigation or relocation measures that may be possible and what practical options may be available. Members of the Core Group Committee served as a liaison with their respective communities and those tasked with undertaking the Study. The Terms of Reference for the Mitigation Study are available in Supporting Document 1 by contacting the Department of Environment and Local Government (DELG).

3.0 UPDATE ON THE NATIONAL SCENE

Disaster risk reduction is a subject of interest to the Government of Canada and the Ministers Responsible for Emergency Management. There is recognition that coastal and inland flooding are generally the most serious hazards facing Canada today and in the future, in terms of life safety, and the associated public and private sector costs; about 80% of all disaster costs globally are for flooding. There is also broad consensus in the scientific, civil engineering and insurance communities that risk appears to be increasing. Certainly, the increasing costs of disaster financial assistance programs and private insurance claims over the past several decades bear this out.

There is a National Strategy on Disaster Mitigation and since 2010 there has been a National Platform for Disaster Risk Reduction, with an associated Annual Roundtable. The Platform and Roundtable were established as part of a commitment to the United Nations Hyogo Framework, which calls on member states to have a structured approach to risk reduction. The strategy and the platform are multi-sector, collaborative approaches, but as yet, have not generated any new financial programs. It is fair to say

the strategy and platform are influencing public policy to some degree and governments are recognizing the need to invest in measures that will help to flatten the cost curves associated with increasing risk.

The Government of Canada has committed publicly to a National Disaster Mitigation Program and such a program is currently in development. The federal, provincial and territorial ministers responsible for emergency management have endorsed a program design, one that focuses in the near term on flood risk reduction. The National Mitigation Disaster Program and funding are expected to be launched in fiscal year 2014. Each province will receive a base amount and a per capita allocation; New Brunswick's share is expected to be approximately 5% of the program, thus \$5 M of a \$100 M program, or \$1 M of a \$20 M program. The province and municipalities would match federal contributions, such that each project would be 50% federal and 50% provincial/municipal. It should not be difficult to identify \$2 M to \$10 M of eligible mitigation activity, given the level of annual public investment in infrastructure improvement.

Disaster risk and the associated costs are increasing. New Brunswick, for its part, has experienced a 100% increase in the number of disaster financial assistance programs in the last decade, compared to previous decades. There has been a significant increase in the last decade in the intensity of extreme rainfall events (events >50mm in 24 hours), although it is difficult to determine if the number of extreme weather events (storms) is increasing significantly. Canada does seem to be experiencing greater weather extremes, something consistent with climate change model predictions. A decade ago, federal disaster assistance payments of various kinds totaled about \$100 M annually. In recent years this has grown to about \$1 B annually, which has engendered greater interest across sectors and levels of government in prevention, mitigation and risk reduction measures.

There is a need to establish a provincial strategy, one aligned with national and international guidance, to reduce where possible the risk of future disasters. A provincial or Atlantic Region disaster risk reduction strategy would engage public and private sector stakeholders and the public at large in a dialogue about risk reduction, and inform public policy in areas such as land use planning, community resilience, disaster mitigation, emergency preparedness and disaster response and recovery. Such a strategy could assist in balancing responsibilities and expectations of individuals, communities, the insurance sector and governments in addressing disaster risk, and could contribute to the longer term sustainability of our communities.

4.0 FOCUS OF THE STUDY

The Mitigation Study examined known and anticipated flood risks, possible adaptation, mitigation and relocation measures, and practical options.

5.0 AREAS OF INVESTIGATION

The Mitigation Study examined whether there are opportunities to reduce the risk of ice jam flooding on the Beechwood Head Pond in and around the communities of Perth-Andover and Tobique First Nation. As indicated in the terms of reference the focus is on five specific areas of investigation. The study also includes looking at current and deemed best practices for potential adaptation and mitigation measures as well as investigating the option of relocation.

FINDINGS OF THE REPORT

5.1.0 The known and anticipated risks of ice jam flooding, both generally, and determined for the Perth-Andover and the Tobique First Nation area.

Actions to date

5.1.1 Action: Undertake a review of historical floods using the Historical Flood Information System (HFIS) database to determine specifics of the recorded floods for the Perth-Andover and Tobique First Nation area.

Findings:

- From the historical review it has been determined that there are approximately 19 flood events on record for the Perth-Andover and the Tobique First Nation area with the earliest being in 1887 and the most recent in 2012. The details of these floods are provided in the Supporting Document 2 that is available by contacting DELG.
- The flood events are associated with either one or a combination of the following causes: heavy rain, warmer weather, ice jams and/or spring freshet.

5.1.2 Action: Complete a geographic flood impact assessment to better understand the geographic impact of the most recent flood event and establish a frequency at which open water flooding and/or ice jam flooding occurs in the Perth-Andover and the Tobique First Nation area.

Findings:

- Hatchard Engineering Ltd., was hired to manage a Survey Assessment that would determine the geographic impact of the most recent flood event in the Perth-Andover and the Tobique First Nation Area.
- The 1976, 1987, and 1993 flood events impacted the Perth Andover area at an elevation of 76.2 m, 79.3 m, and 78.7 m respectively. The most recent flood event, March 2012 flood event, has been assessed to have impacted the Perth Andover

area up to the 80.25 m elevation. The flood line maps for these major floods are provided in Supporting Document 3 that is available by contacting DELG..

- RV Anderson Associates Limited was hired to determine a frequency at which open water flooding and/or ice jam flooding occurs in the Perth-Andover and the Tobique First Nation Area.
- The frequency of another event like the March 2012 flood event or worse has been predicted. This predicted frequency is provided in Supporting Document 4 that is available by contacting DELG.Note: This is a prediction and should be treated as a prediction and should not be relied upon as an absolute determination.

Options for further action

5.1.3 Action: Review current practices for monitoring and forecasting flood events in New Brunswick.

Findings:

- It was determined that New Brunswick, like predominately all other jurisdictions across North America, needs to enhance the monitoring and forecasting capacity to provide: real-time flow and water level monitoring; and risk assessments of ice break-up, movement and ice jam formation. This is an area being recommended for further investigation with a onetime cost of \$400,000 and an annual operating cost to be determined.
- In order to identify the current community vulnerabilities across the Province as it relates to ice jams and associated flooding, the Department of the Environment and Local Government is in the process of updating the 1987 Ice Jam Location Map for the Province. This map is intended to be included on the New Brunswick River Watch website for the 2013 season and available for public viewing in an effort to make the general public and communities more aware of the locations in the Province that are vulnerable to ice jams.

5.1.4 Action: Develop maps for the Tobique First Nation and the Village of Perth Andover that will provide an illustration of the areas within their communities that would be vulnerable in the event of future flood events. This is referred to as Inundation Mapping.

Findings:

- This work is currently on-going and is expected to be completed by the end of this year.
- This work will assist the communities, region, and the province with one or more of the Adaptation Options that include: Education and Awareness; Land Use Planning; and Emergency Planning.

5.2.0 The extent to which the St. John River itself is a factor contributing to ice jam flooding, and possible measures that if implemented would reduce the risk of ice jam formation.

Actions to date

5.2.1 Action: Determine what physical features in the St. John River are factors that contribute to ice jamming and subsequent flooding.

Findings:

- It is well understood that the physical features in the River that are high risk areas for ice jamming are at bends, narrow sections, and shallow depths. Also, obstacles like bridges and piers may be considered high risk areas.

5.2.2 Action: Develop a Depth Map of the Beechwood Reservoir from the confluence of the Tobique River to the Beechwood Dam. The Depth Map is intended to assist in identifying narrowing channels and shallow depths in the Reservoir that may be considered high risk areas for ice jam formation.

Findings:

- P.J. Cronin was hired to collect depth data and develop a Depth Map of the Beechwood Reservoir.
- The Depth Map of the Beechwood Reservoir was developed and is provided in Supporting Document 5 that is available by contacting DELG.
- In general, the shoreline is precipitous (very steep) and the 'channel' is uniform in depth at around 9 to 12 meters. The deepest water is between 17 and 21 meters and is found in a 3.5 km reach just upstream of the Beechwood dam. The shallowest depths across the width of the river are found just below the confluence of the Tobique River (4 to 6 meters).

Options for further action

5.2.3 Action: Determine what physical features of the River could be augmented to reduce ice jam formation and subsequent flooding and determine the scope, cost and timeline to complete the work.

Findings:

- Dillon Consulting was hired to determine what physical features of the River could be augmented to reduce ice jam formation and subsequent flooding and to determine the scope, cost and timeline to complete the work.

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- Two possible River augmentation options were identified and include: Pier Removal (piers 4.5 km from the Beechwood Dam) and Dredging.
 - The Pier Removal could be done in 1 year at a cost of approximately \$1.5 M;
 - It is important to note the removal of the piers will not likely result in any significant reduction in flood potential in the Perth-Andover and Tobique First Nation communities, which is the focus of this Mitigation Study.
 - The dredging could be done at a unit rate cost of \$25 per m³ at a rate of 200,000 m³ per year.
 - From the review of the data provided in the Depth Map work this year, included above, there does not appear to be any obvious signs of severe localized high spots in the River bottom that would be areas for dredging
 - A comparative analysis with the Department of Natural Resources 1996 Study on depths in the reservoir has proven to be inconclusive to determine that the River is becoming shallower or the channel is narrowing. Efforts will continue to gather data that can support such a comparative analysis and possible determination of dredging areas.
 - In order to relate the magnitude of cost of dredging, and (not to be considered an identified area for dredging within this study), an example for cost calculation purposes was focused on the Upper Kent area. If 1 meter of sediment was dredged along the river bottom for the entire width 160 m and along the 2.5 km distance referred to as Upper Kent, the volume of material would be 400,000 m³, the cost would be approximately \$5M per year and take 2 years to complete.

5.3.0 Possible non-structural mitigation measures that if implemented would reduce flood risk to individual properties and in the community as a whole.

Options for further Actions

5.3.1 Action: Provide each community with the services of a planner. The planners are intended to be used to assist the communities with developing short and long term land use planning options that are designed to reduce the flood risk to individual properties and the community as a whole.

Findings:

- The communities are using the planning services for emergency, land use, mitigation, relocation and community planning efforts.
- There is some potential to reduce risk through improved community planning with controls on development in at risk areas.

5.4.0 Possible measures for managing ice and river flows that if implemented would reduce the risk of ice jam formation.

Actions to date

5.4.1 Action: An internal review was done by NB Power to examine the circumstances, opportunities and actions taken to mitigate ice jam formation, management of river flows and associated flooding. (The internal review was validated by Hatch Canada, an independent consulting engineering firm. See 5.4.2)

Findings:

- All facilities (Grand Falls Generating Station, Tobique Narrows Generating Station and Beechwood Generating Station) operated as intended during the event, safely passing the rapidly varying flow.
- NB Power staff recognized potential for ice jam formation and flooding early in the event and took appropriate actions to deal with the potential. These actions included dispatching ice observers to observe and report on ice conditions and jams, manning stations at critical times, providing data to River Watch and communicating with River Watch and communities affected by the ice jams.
- Operating guidelines developed to manage high flows and ices in the St. John River were generally followed. An exception to this was the attempts to dislodge the final ice jam that had formed at Upper Kent. With the jam in place and water level at its peak, NB Power staff tried to move the ice on three occasions by rapidly increasing the discharge flow at Beechwood Generating Station. Immediately after each attempt, the discharge was decreased and the head pond was returned to full. The first attempted resulted in the jam shifting a few hundred meters but subsequent attempts yielded no result.
- Recent work by CEATI (of which NB Power is a member) has produced modeling software that is intended to be used to predict ice jam formation and behaviour. NB Power has a license for this program (CRISSP) and will work with River Watch to determine if it can provide value on the St. John River and if so, will move towards its implementation.
- Dam operations are not a significant contributing factor to ice jam formation. Furthermore, there is little if any opportunity through the operation of dams or management of water levels or flows to lower the incidence or mitigate the consequences of ice jams.

Options for further Actions

5.4.2 Action: Hatch Canada, a consulting engineering firm, was hired to conduct an external review of dam operations and get an independent examination of the circumstances, opportunities and actions taken to mitigate ice jam formation, management of river flows and associated flooding.

Findings

- Hatch concurs with the NB Power review, they recognize that subsequent attempts to move the ice jams were not successful and “recommended that when ice is moving the guidelines ... are followed.”
- Hatch reviewed the critical variables that contribute to ice jams and compared previous events. This comparison serves to provide a sense of the variables that should be monitored during the late winter and early spring. These variables are:
 - The date of the start of the spring freshet. The earlier the spring flows start to rise, the greater the risk since the ice does not have a chance to thaw and weaken in place.
 - The rate of flow increase. Rapid flow increases have the potential to dislodge solid ice and precipitate movement.
 - Date of peak flow versus date of start of freshet. If the flow peaks early in the freshet, the ice has no time to melt and weaken in place.
 - The peak flow rate. This determines how much water is flowing into an ice jam and subsequently the ultimate elevation of the water upstream of the jam.
- The removal of the piers 4.5 km above Beechwood were considered and, while it was agreed that the piers have the potential to increase the probability of an ice jam at that location, “removal of the piers will not likely result in any significant reduction in flood potential in Perth-Andover and Tobique First Nation.”
- Operating the Beechwood head pond to create “hinges” along the shoreline was considered. NB Power currently operates the head pond with the intent of maintaining ice in the pond for the longest time possible, so that it has a chance to melt in place. “Lowering the head pond to create ice hinges and then refloating the ice cover will have very little to no effect on the stability of the ice cover.” Further, “raising the water level after the ice cover has formed may break the cover into an ice melee that can move downstream prematurely.” The consultants point out that “breaking up the ice and moving it prematurely increases the risk of ice jam flooding.”
- **2012 Ice Jam Cause and Severity**
 - The 2012 ice jam flooding was the result of an early and rapid rise of flow in the River to a peak value well in excess of that required to realize flood levels in Perth-Andover,; these hydrographical attributes being the consequence of natural climatic events and beyond human control.
 - The 2012 combination of these attributes was found to be the most severe in the eight incidences of ice jam flooding that have occurred in Perth-Andover and Tobique First Nation Area since 1963.
- **NB Power Operating Practices**

The Beechwood operations during the course of the 2012 flood event by and large followed the established operating guidelines. The attempts to move the stationary jam further downstream by manipulation of the Beechwood headpond level had limited success and is expected to have limited success in future ice jam events. A review of the operating guidelines established on the basis of the 1993 study work and as modified by NBP in 2004 in light of the 2012 flood experience indicates no need for modification of these guidelines at this time.

5.4.3 Action: Current and deemed best practices (active and passive measures) for ice control and ice breaking were investigated.

Findings:

1. R.V. Anderson Associates Limited was contracted to look at viable options for the management of ice that if implemented, would reduce the risk of ice jam flooding. High level findings to date are as follows:
 1. ice control measures can be effective but are costly and may pose significant environmental impacts,
 2. ice growth suppression measures are less costly but are very sensitive to environmental conditions and the timing of their application such that their use or effectiveness every year is unlikely,
 3. ice cutting and breaking measures can be effective for certain ice conditions if carried out at appropriate times in the pre-breakup period but these measures also are sensitive to environmental conditions

1. R.V Anderson examined a wide variety of options with a view to their cost, effectiveness, and environmental impact and will consider six potentially helpful options in more detail. The detailed technical report in draft form will be delivered in mid October. The potential success of any of these six options as part of a strategy to reduce ice-jam flooding will be discussed in that report.

5.5.0 Possible structural mitigation measures that if implemented would reduce flood risk to individual properties and in the community as a whole.

Actions to date

5.5.1 Action: Investigate current and deemed best practices for buyout, relocation and flood proofing buildings.

The Department of Public Safety consulted with emergency management senior officials in other Canadian jurisdictions and Maine and compiled a comparative analysis of prevention and mitigation practices in ten jurisdictions.

Findings:

1. Mitigation is seen as an important component of emergency management programs in the United States and in Canada and the requirement for preventative and mitigative measures is recognized in emergency management program standards, such as NFPA 1600 and CSA Z1600. Nevertheless, only BC, MB and QC have provincial level programs with stable funding. Other jurisdictions have dealt with mitigation on an ad hoc basis, and typically post disaster. There is however broad recognition of the need for a National Disaster Mitigation Program with targeted funding for mitigation activities.
2. In those jurisdictions where mitigation programs are currently in use, only Manitoba is investing public funds on private property; Manitoba has identified a business case for flood proofing private property in high risk areas. In the United States and in other Canadian practice, mitigation projects are normally managed as strategic infrastructure projects with a variety of federal, provincial and municipal contributions. Most such initiatives have been the result of bi-lateral negotiations with the federal government; some of used strategic infrastructure allocations but some have been unique partnership arrangements between the federal and provincial governments. This has been common in Manitoba (flood control structures) and was in fact the case for the 1993 mitigation initiative in Perth-Andover, NB.
3. Generally speaking in Canada and the US public funds are being used for mitigation projects on public infrastructure or for non-structural mitigation activities, such as risk assessment, engineering studies, land use planning or public education. The use of public funds for relocation, flood proofing or buy out of private sector properties seems to be the exception, and has only occurred historically in a few cases.
4. It can be advantageous to invest public funds in measures that reduce the incidence of similar disasters in the future and the associated consequences. The risk to Perth-Andover and Tobique First Nation is relatively high with a flood event occurring about every five years over the past decade. In recent years New Brunswick has been experiencing weather conditions that contribute to the early break-up and movement of ice, which in turn results in ice jams and flooding. The observed warming trend is expected to continue. Thus it is reasonable to consider relocation of the most seriously affected residences (those that experienced main floor damage) and to consider flood proofing other affected properties.
5. If relocation and flood proofing are considered, it will be necessary to determine what is and is not in scope for government funding as well as an appropriate distribution of the associated costs, including consideration of the respective

responsibilities of property owners, the local government and other levels of government. (Supporting Document 6)

Options for further action

5.5.2 Action: An analysis of flood impacts in the affected communities was carried out and mitigation options for affected areas and individual properties were identified.

Findings:

- Information has been gathered from on-site inspections, the Disaster Financial Assistance (DFA) program, high-resolution aerial imagery and aerial survey (LIDAR).
- The Village has emphasized that the relocation of residential properties is of greatest importance, for life-safety as well as ensuring the long-term viability of the community. The Village also believes that additional financial support is needed to assist the business sector with recovery and relocation.
- DPS has produced impact maps that indicate the locations and extent of damage, as well as potential relocation opportunities for residential properties at the 2012 flood level of 80.25m, at 1M higher at 81.50m and 2 m higher at 82.50m. Maps for each of these three levels are in Appendix 5.
- It appears that about 190 individual properties were affected significantly by flooding by the 2012 event. Of these, 83 are residential, 33 are apartment buildings, 51 are businesses or not for profit, 15 are government offices and 8 abandoned. Eleven of the 83 residential properties have been or will be demolished, leaving approximately 72 candidates for relocation or flood proofing. There are a few houses outside village limits which may also be candidates for relocation. (Supporting Document 7)
- The estimated cost of relocating a house to a serviced lot within the municipality is \$100,000, thus a residential relocation program for residences would require approximately \$8 M for a residential relocation program.
- There are a few homes in Tobique First Nation that could be relocated given the availability of suitable sites, thus approximately \$700,000 of additional funds would be required. but it may be possible however through other proposed mitigation initiatives to avoid the need for relocation. (Appendices 3&4)

5.5.3 Action: An investigation of current and deemed best practices for structural mitigation in other jurisdictions was done, including storm water, flood control systems and structures.

Findings

- The Departments of Environment and Local Government and Public Safety have consulted with the Department of Transportation and Infrastructure (DTI) on

opportunities to improve access to communities under flood conditions and to mitigate future impacts to roads and bridges.

- DTI provided cost estimates for a variety of road improvement projects that would improve access under flood conditions. Taken together, these projects totaling \$27M would improve access to the various areas of the community during high water, but they would not contribute significantly to public safety. DTI also determined that their assets are not at significant risk from ice jam flooding and indeed were not impacted by the 2012 event.
- The obvious exceptions to the finding above are two projects totaling approximately \$1.4 M that if implemented, would ensure continuity of access between the Tobique First Nation and Perth. Completion of these projects is the highest priority for the Tobique First Nation.
- DTI also examined the potential options to improve access between Perth and Andover via the existing bridge and considered three costs estimates for options for a replacement. It was determined that it is not practical to improve on the existing bridge. Estimates for a replacement ranged from \$18 M to \$25 M. The least expensive option is to use the existing footprint, but that would disrupt traffic for two-years during construction. The least expensive practical option is about \$20 M. A new bridge and approaches constructed above the historical high water mark would ensure continuity of access between Tobique First Nation, Perth, and Andover and beyond during flood conditions, with obvious benefits to the health and safety of the local population.
- The most practical and beneficial infrastructure projects are those that will enable residents in flood-isolated areas continued access to essential services, such as energy, fuel, food and medical care. The needs of the Tobique First Nation are very significant in this regard. Although expensive, it is possible to construct a new bridge that could similarly ensure connectivity between Perth and Andover in flood conditions.

5.5.4 Action: Determine possible options and costs for managing localised flooding from specific watercourses during times when the water levels restrict flow to the River. The specific watercourses include: Jamer Brook, Tibbitts Brook and the McLaughlin Brook.

Findings:

1. Hatchard Engineering Ltd., was hired to determine possible options and costs for managing the localised flooding problem.
2. There are options that include pumping stations and can be implemented to reduce the localised flooding.
3. The cost of this work is estimated to be \$ 1 M.

6.0 CONCLUSION

This report is being released per Government's commitment. The options are to be considered by Government for determination of further actions to be taken. Dialogue will continue with the communities of Perth-Andover and the Tobique First Nation as activity goes forward.

7.0 OPTIONS AND COST SUMMARY

Based on the findings, the potential options have been listed in the Table below. These options have been grouped in three streams; Adaptation, Mitigation and Relocation. The affected areas for each option have also been identified for each community, the region and province wide.

The options of Awareness and Education, Emergency Planning and Land Use Planning are ongoing activities that are covered under existing budgets. However, these elements are part of the adaptation process to prepare for and plan for future flood events.

Table of potential options

Community	Adaptation	Mitigation	Relocation
Tobique First Nation	<ul style="list-style-type: none"> • Awareness & Education • Emergency Planning • Land Use Planning 	<ul style="list-style-type: none"> • North Bank Stabilization \$900,000 • River Street / Pit Road \$360,000 (See Appendices 3&4) 	<ul style="list-style-type: none"> • Move / Flood Proof \$700,000
Village of Perth-Andover	<ul style="list-style-type: none"> • Awareness & Education • Emergency Planning • Land Use Planning 	<ul style="list-style-type: none"> • Alternate Access to Hospital \$1M • Pumping Stations \$1M • Other Road Improvements \$25M 	<ul style="list-style-type: none"> • Move / Flood Proof \$8M
Region	<ul style="list-style-type: none"> • Emergency planning • Land Use Planning • Ice Management 	<ul style="list-style-type: none"> • Raise Route 105 (2 occasions) \$1.5M • East Bank Stabilization \$550,000 • Bridge and Abutments \$20M 	
Province	<ul style="list-style-type: none"> • Emergency Planning • Monitoring & Forecasting \$400,000 • Flood Risk Reduction Strategy 		

8.0 APPENDICES

(Note: Documents are provided in the language in which they were prepared)

- [Community Input from the Village of Perth-Andover](#)
- [Community Input from the Tobique First Nation](#)
- [Tobique First Nation Flood Mitigation Proposal](#)
- [Environmental Impact Assessment and Riverbank Stabilization Study for the North Bank Tobique River](#)
- [Impact maps for flood level of 80.25m, at 1M higher at 81.25m and 2 m higher at 82.25m.](#)

9.0 SUPPORTING DOCUMENTS

Available on request from DELG

1. Mitigation Study Terms of Reference
2. Historical Flood Events for the Perth-Andover Area
3. Flood line maps of 1976, 1987, 1993, & 2012
4. Perth Andover Stage Frequency Curve
5. Depth Map of Beechwood Head Pond
6. Cost estimates for the relocation program
7. Potential number of residents to relocate or flood proof
8. Glossary