Kinchela Creek System
Flood Levee Audit Report
Audit of Levee Banks of the Lower Macleay Floodplain

Report №: 113010-09

Kinchela Creek

December 2015

Revision № 01
Executive Summary

This report presents an audit of the Kinchela Creek levee system as of December, 2015. The levee system forms an integral part of the overall flood mitigation system on Kinchela Creek which is comprised of raised levees along both creek banks, a barrage (head works structure), two lift-gate overflow structures (floodways) and a number of drains constructed to remove nuisance floodwater from the floodplain. The aim of the levee system, as part of the overall flood mitigation system, is to contain floodwaters within the creek channel up to a gauge height of approximately 4.9m at the Kempsey Traffic Bridge (1).

This audit forms part of a widespread audit of the entire Lower Macleay flood levee system.

The scope of this audit included but was not limited to:

1. Compilation of all the known reports and information available on the levees and a summary of their findings and recommendations.
2. Comparison of the levee design crest levels, existing crest levels and flood levels
3. A defects inspection (visual) of the levees to identify areas of anomalies, such as missing levees, low sections, localised depressions, and signs of erosion/scour or instability.

It is noted that a geotechnical investigation was not undertaken as part of this audit. Furthermore, the following items were not included in the scope of the audit although it is recommended they be carried out at later date:

1. Preparation of cost estimate for the remediation of all identified defects and a total cost to repair the levees.
2. Preparation of a condition rating for each levee based on the risk of failure and the likely consequence of a failure.
3. Preparation of an Operation & Maintenance Manual. It is proposed that one document for the entire Lower Macleay flood levee system be developed.

As a result of this audit it was found that the Kinchela Creek levee system appears to be in relatively good condition with only minor structural defects identified on the earthen crest section of the levee system. Design plans for the levee system were unable to be located, however a constant design height of 3.05m AHD was identified in a 1997 report by Webb, McKeown & Associates Pty Ltd (1). The surveyed height of the levee crests were found to be generally consistent with this design level, aside from several low sections that were identified as being approximately 100-200mm below the design crest level. The location and extent of these low points are summarised in Appendix D of this report.

Aside from the 1 in 100 year flood level, no other flood modelling information was identified for the Kinchela Creek area. It is therefore not possible to accurately estimate the level of flood immunity provided by the levee. The provision of additional detailed flood information in the area may aid in assessing the suitability of the design levee crest level (3.05m AHD), in terms of the level of flood immunity provided.

Recommendations resulting from the audit include:

- All defects listed in this report to be remediated.
• The 2013 WMA water flood study (on behalf of the Kempsey Bypass Alliance) be extended or a new study be commissioned to include Kinchela Creek and the surrounding areas of interest to confirm the adequacy of the levee design crest levels and the level of flood immunity of the system.
• A geotechnical consultant be engaged to carry out a stability and seepage assessment on the Kinchela Creek levee system to gain an understanding of the structural reliability during a flood event.
• An Operation & Maintenance Manual to be developed in line with the information presented in this report.
# Table of Contents

1.0 INTRODUCTION ..........................................................................................................................................................6
2.0 SCOPE OF AUDIT .............................................................................................................................................................6
3.0 DESCRIPTION OF THE LEVEE SYSTEM .............................................................................................................................7
4.0 LEVEE CONDITION ............................................................................................................................................................8
  4.1 RIGHT BANK LEVEE GENERAL OBSERVATIONS ............................................................................................................8
  4.2 LEFT BANK LEVEE GENERAL OBSERVATIONS ................................................................................................................8
5.0 LEVEE DESIGN LEVELS, FLOOD LEVELS AND EXISTING LEVELS ...................................................................................9
  5.1 EXISTING LEVEE CREST LEVELS ....................................................................................................................................9
  5.2 LEVEE DESIGN CREST LEVELS .......................................................................................................................................9
  5.3 FLOOD LEVELS ...............................................................................................................................................................10
  5.4 DISCUSSION ....................................................................................................................................................................10
  5.4.1 Low Points/Sections ..................................................................................................................................................10
  5.4.2 Level of Flood Immunity ............................................................................................................................................10
6.0 PREVIOUS REPORTS AND INFORMATION ..........................................................................................................................11
  6.1 SUMMARY OF CURRENCY, FINDINGS AND RECOMMENDATIONS ................................................................................11
7.0 GEOTECHNICAL INVESTIGATION OF LEVEES ..................................................................................................................11
8.0 PREPARATION OF AN OPERATION & MAINTENANCE MANUAL .......................................................................................11
9.0 DEFECTS INSPECTION REPORT .......................................................................................................................................12
10.0 CONCLUSION ....................................................................................................................................................................12
11.0 RECOMMENDATIONS .....................................................................................................................................................13
12.0 REFERENCES ..................................................................................................................................................................13

APPENDIX A - PHOTOGRAPHS OF LEVEES
APPENDIX B - SUMMARY OF SCANNED REPORTS KEMPSEY MACLEAY FLOODPLAIN
APPENDIX C - EXISTING LEVEE SURVEY PLANS
APPENDIX D - DEFECTS INSPECTION REPORT
APPENDIX E - GENERAL ADVICE ON REMEDIATION MEASURES
APPENDIX F - INSPECTION AND MAINTENANCE INFORMATION
List of Figures and Tables

Figure A1: Kinchela Creek Left Bank typical roadway (levee)
Figure A2: Kinchela Creek left bank Floodway
Figure A3: Kinchela Creek head works structure
Figure A4: Section of levee across Kinchela Creek atop head works structure.
Figure A5: Kinchela Creek right bank levee typical formation
Figure A6: Kinchela Creek Left bank earthen levee typical formation (more pronounced on site)
Figure A7: Kinchela Creek left bank earthen levee vegetation issue
Figure A8: Kinchela Creek left bank earthen levee - river bank failure at levee toe
Table B1: Summary of all available flood reports
Table D1: Kinchela Creek right bank Defects Inspection Report
Table D2: Kinchela Creek left bank Defects Inspection Report
Table D3: Priority level description
Table F1: Inspection and maintenance information
1.0 INTRODUCTION

The audit of the Kinchela Creek levee system forms part of a widespread audit of the entire Lower Macleay flood levee system. Kinchela Creek connects to the Macleay River 5 kilometres downstream from the town of Gladstone. The creek extends into the floodplain on the eastern side of the Macleay River and along with the Belmore River, assists in draining the floodplains after rain events.

The flood levee system on Kinchela Creek forms an integral part of the overall Lower Macleay flood mitigation system, designed to protect important urban and rural agricultural land within the Kempsey Shire from the effects of minor flood events. Specifically, the aim of the Kinchela Creek levee system is to contain floodwaters within the creek channel up to a gauge height of approximately 4.9m at the Kempsey Traffic Bridge (1).

The Lower Macleay flood levee system was designed and constructed in the 1960’s. Since this time, the condition of the levees has deteriorated due to a lack of maintenance. The purpose of this audit is to assess the current condition of the Kinchela Creek levees and provide recommendations to remediate any issues found.

The location and site plan of the Kinchela Creek levee system is shown on the drawings located in Appendix C of this report.

2.0 SCOPE OF AUDIT

The breadth of the audit was restricted to the Kinchela Creek levee system. This system is made up of the right and left bank Kinchela Creek levees.

The scope of the audit included but was not limited to:

1. Compilation of all the known reports and information available on the levee system and a summary of their findings and recommendations.
2. Comparison of the levee design crest levels, existing crest levels and flood levels.

This was undertaken by:

a. Obtaining the levee design crest levels and flood levels from either:
   i. The original design plans, or
   ii. Previous flood studies.

b. Completing a survey of the Kinchela Creek levee system to confirm existing levels.

c. A defects inspection (visual) of the levee system to identify areas of anomalies, such as missing levees, low sections, localised depressions, and signs of erosion/scour or instability.
The following items were not included in the scope of the audit although it is recommended they be carried out at a later date:

1. Preparation of a cost estimate for the remediation of all identified defects and a total cost to repair the levee system.

2. Preparation of a condition rating for the levee system based on the risk of failure and the likely consequence of failure.

3. Preparation of an Operation & Maintenance Manual. It is proposed that one document for the entire Lower Macleay flood levee system be developed.

Due to budget constraints, a geotechnical investigation could not be undertaken on all levees within the Lower Macleay Flood Mitigation System. The Kinchela Creek levee system was considered lower risk as compared to the urban levees for the following reasons:

1. The levee system protects mostly agricultural land and only a small number of dwellings.

2. The levee system is low in height compared to the surrounding natural surface.

3. The levee crests are carrying a two way, two lane, sealed rural road in relatively good condition.

The urban levees were therefore given priority over the rural levees (including Kinchela Creek) and as a result this audit did not include any geotechnical investigation.

3.0 DESCRIPTION OF THE LEVEE SYSTEM

The Kinchela Creek flood levees form an integral part of the Kinchela Creek flood mitigation system, which is comprised of:

- Two lift-gate overflow structures (floodways) located on Kinchela Creek approximately 5km upstream of the Macleay River junction.
- A barrage (headworks) structure crossing the creek at the upstream end of the system.
- A number of earthen drains to remove flood-water from the floodplain.
- Earthen flood levees designed to create a consistent river bank level between the flood structures.

The flood levees are constructed on the left and right banks of Kinchela Creek, commencing at the Macleay River junction and terminating at the headworks structure. The levee system provides increased water storage within Kinchela Creek and the levees have been designed to overtop simultaneously along their entire length. To achieve this, the design crest level of the levee system was selected to be constant at 3.05m AHD (0.2m-0.3m above natural surface). The batter slopes along on either side of the levee bank typically range between 1V:2H and 1V:3H. The levee system was raised to the current height in 1999 in an attempt to decrease the frequency of overtopping and lessen the environmental impacts of the system (1).

The levees are approximately 6 kilometres long (each) and for the most part carry a two lane, two way, sealed rural road. The centreline of the road is generally considered to be the crest of
the levee, although this may deviate around banked corners and flood structures. An earthen crest section is also present on the left bank levee approximately 1.7km in length, extending from chainage 4880-6626 (refer drawings in Appendix C for details).

The location and site plan of the Kinchela Creek levee system is shown on the drawings located in Appendix C of this report.

4.0 LEVEE CONDITION

In accordance with the scope of this audit as outlined in Section 2.0, a defects inspection (visual) was carried out on both the left and right bank Kinchela Creek levees in order to assess their condition. Individual defects were visually identified during the walk-over inspection and have been discussed in Section 9.0 of this report.

Along with the individual defects, general observations from the walk-over inspection were also recorded. These observations are discussed in Section 4.1 and Section 4.2 of this report.

For the purpose of assisting in the identification of defects, guidance was taken from the information provided in the JK Geotechnics 2014 reports on the urban levees (3). Useful sections of this information has been summarised in Appendix E and Appendix F of this report.

4.1 RIGHT BANK LEVEE GENERAL OBSERVATIONS

The right bank levee supports a two lane, two way, sealed rural road on its crest for 100% of its length. Based on a visual inspection, the road appears to be in reasonable condition (refer Figure A5 of Appendix A of this report). No significant defects were identified on this levee throughout the visual inspection. However, inconsistent heights were identified along the length of the roadway (refer Section 5.1 for further discussion).

Given the large width and low height of the road/levee crest it is estimated that the risk of global instability during a flood event is low. However, further investigation should be undertaken by a suitably qualified engineer to confirm this estimate.

4.2 LEFT BANK LEVEE GENERAL OBSERVATIONS

No significant defects were identified on the section of the Kinchela Creek left bank levee which supports a two lane, two way, sealed rural road (75% of its length). Based on the visual inspection, the roadway appears to be in reasonable condition (refer Figure A1 of Appendix A of this report).

A large percentage of the earthen crest section of the levee was found to be covered in thick vegetation consisting of grasses and woody weeds. In these locations (Chainage 5380-5800) inspection of the levee surface was not able to be carried out (refer Figure A7 in Appendix A of this report).

The remaining earthen crest sections of the levee appeared to be in relatively good condition with rounded crests and a thick covering of grass with some minor cattle tracks identified (refer...
Figure A6 in Appendix A of this report). The cross sectional shape of the levee appears to have slumped over time to become rounded. However, this slumping appears to be relatively uniform and no major areas of erosion were identified.

It should also be noted that two areas of slope failure were identified on the river bank (refer Figure A8 in Appendix A of this report). Neither of these failures have occurred directly on a section of levee, however the distance between the river side levee toe and the top of the river bank have been significantly decreased, increasing the risk of localised instability. Further investigation of these two areas should be undertaken by a suitably qualified geotechnical engineer.

5.0 LEVEE DESIGN LEVELS, FLOOD LEVELS AND EXISTING LEVELS

5.1 EXISTING LEVEE CREST LEVELS

A topographic survey was carried out on the levee system to confirm the existing crest levels and identify any potential low points or sections. Given the large scale of the survey, vehicle mounted Global Navigation Satellite System (GNSS) surveying equipment was used. Generally the accuracy of the GNSS equipment is approximately ±30mm. However, as the equipment was mounted to a vehicle the survey data may be slightly less accurate. In particular, around banked corners, the centreline of the levee may shift from the road centreline to the outer edge of the road formation. Where the survey vehicle could not safely drive along the edge of the road formation an underestimate of the crest levels may have occurred.

The survey is presented in the longitudinal sections prepared for both of the left and right bank Kinchela Creek levees, which can be seen in Appendix C of this report.

5.2 LEVEE DESIGN CREST LEVELS

Design plans showing the original design levels of the Kinchela Creek levees could not be located. However, a single page document titled “Macleay River Levee Upgrade to contain Bankfull Flow after Kinchela and Belmore Leves are raised” (4) was sourced from Councils archives. It states that the Kinchela Creek levees were raised to a height of 3.05m AHD in 1999. The reasoning behind the selection of this level is discussed in the 1997 report by Webb Mckeown and Associates Pty Ltd (1). Based on this reasoning, it appears that the selection of the crest design levels was not supported by relevant flood modelling information.

Given that the raised levee height is still at a relatively low level (less than 0.5m) it is likely that the original roadways (levees) were constructed on or near the natural surface level.

Comparisons between the surveyed levee crest levels and the design crest levels can be seen in Appendix C and is discussed in section 5.4.1 of this report.
5.3 FLOOD LEVELS

The design level of flood immunity of the Kinchela Creek levee system is unknown. The most current flood study available to Council was carried out by WMA water on behalf of the Kempsey Bypass Alliance in 2013. This study yielded the 50%, 20%, 10%, 2% and 1% AEP flood levels across an area spanning from Kempsey to South of Smithtown, including the Macleay River and floodplain areas. Unfortunately the study area finishes some 4.0km upstream of Kinchela Creek and hence cannot be used directly.

However, another study from 1999 (2) was found that estimates the 1% AEP flood levels for Kinchela Creek. These levels can be seen in Appendix C of this report. For simplicity the AEP term has been converted to its corresponding Average Recurrence Interval (ARI) i.e. 1 in 100 year ARI flood.

5.4 DISCUSSION

5.4.1 Low Points/Sections

A low point or section of levee bank may lower the flood immunity level provided by the levee, increasing the frequency of flooding of the protected area. As the low points/sections will likely be overtopped more frequently than the rest of the levee crest, localised erosion and further deterioration of the may occur in these areas.

For the purpose of the investigation a low point or section on the levee is defined as:

- A point or section at which the existing crest level is a minimum of 100mm lower than the original design level or;
- In the case where the levee crest has been constructed above the original design level for the majority of its length, a point at which the existing level is a minimum of 250mm lower than the surrounding levee will be considered a low point/section.

The levee crest levels generally meet the design level of 3.05m AHD. There was however a number of minor low points/sections identified on both levees. Given the nature of the survey methodology (refer section 5.1) some of the low points/sections may not be as significant as the longitudinal sections suggests.

These low points/sections have been summarised in Table D1 and D2 of Appendix D of this report.

5.4.2 Level of Flood Immunity

Given the lack of flood information in the Kinchela Creek system (and the surrounding area) it is difficult to determine a predicted flood immunity level. As shown on the drawings in Appendix C of this report the current crest levels are typically 1.15m below the 1 in 100 year flood levels. In order to estimate the level of flood immunity provided by the system more detailed flood modelling information is required.
6.0 PREVIOUS REPORTS AND INFORMATION

6.1 SUMMARY OF CURRENCY, FINDINGS AND RECOMMENDATIONS

Since the construction of the Macleay Valley flood mitigation system in the 1960’s a number of reports and assessments have been completed that present information regarding the maintenance and operation of the Lower Macleay flood levee system.

Council currently does not have an information register identifying all the available information on the levee banks or the flood mitigation system as a whole. In order to increase the accessibility of this information in future, the following activities were completed as part of this audit:

- All of the available reports concerning the Lower Macleay levees were compiled. To achieve this a thorough search of Council archives was undertaken.
- All reports were then electronically scanned, filed and summarised.

A summary of this information can be seen in Table B1 in Appendix B of this report.

A number of reports were found that directly relate to the Kinchela Creek flood mitigation system, including the flood levees. These reports are highlighted in table B1 of Appendix B.

7.0 GEOTECHNICAL INVESTIGATION OF LEVEES

As stated in Section 2.0, due to budget constraints, a geotechnical investigation could not be undertaken on all levees within the Lower Macleay Flood Mitigation System. The Kinchela Creek levee system was considered lower risk as compared to the urban levees for the following reasons:

1. The levee system protects mostly agricultural land and only a small number of dwellings.

2. The levee system is relatively low in height compared to the surrounding natural surface (less than 0.5m).

3. The levee crests are carrying a two lane, two way, sealed rural roads that are in relatively good condition for the majority of their length.

The urban levees were therefore given priority over the rural levees (including Kinchela Creek) and as a result this audit does not include geotechnical investigation.

8.0 PREPARATION OF AN OPERATION & MAINTENANCE MANUAL

In order for Council to prioritise any remediation measures recommended in this study it is recommended that an Operation & Maintenance plan be developed as one document for the entire Lower Macleay flood levee system.
The preparation of this manual is not part of the Scope of this Audit. It has not yet commenced and has been listed as a recommendation in Section 11.0 of this report.

Appendix E and Appendix F of this report summarise typical levee defects and their corresponding management measures as outlined during the inspection of the Lower Macleay urban flood levees carried out by JK Geotechnics in July 2014 (3). This information may be used for guidance when creating the operation and maintenance plan. However, it should be noted that the remediation measures outlined are site specific and remediation works should not be undertaken prior to seeking advice from a suitably qualified geotechnical engineer.

9.0 DEFECTS INSPECTION REPORT

In order to summarise the defects noted in this audit a Defects Inspection Report was created. This report is presented in Appendix D of this report.

The Defects Inspection Report incorporates the defects identified as part of this audit including:

- The observations of the walkover inspection (Section 4.0).
- Low points identified as part of the topographic survey (Section 5.0).

The information provided in the defects inspection report, along with the information in Appendix E and Appendix F of this report should form the basis for the prioritisation of each of the proposed remediation measures and the associated cost estimation.

10.0 CONCLUSION

An audit in accordance with the scope outlined in Section 2.0 of this report was carried out on the Kinchela Creek levee system. All available reports on the levees were compiled, a topographic survey was completed and a walkover (visual) defects inspection was carried out.

Both the left and the right bank Kinchela Creek levees are relatively low (less than 0.5m in height) and for the majority of their length support a two lane, two way, sealed rural road. The condition of these roads appeared to be relatively good and no areas of obvious instability were identified (this should be confirmed by a suitably qualified geotechnical engineer).

On the earthen crest section of the left bank levee, dense low level vegetation was identified between chainages 5380-5800, as such a visual inspection could not be carried out over this section of levee. Two areas of river bank instability were also identified on this section of the left bank levee at chainage 5220 and chainage 6290. These areas of instability have not directly affected the levee however at chainage 5220 the distance between the top of the river bank and the levee toe has been significantly decreased, potentially leading to future instability.

The topographic survey showed that the heights of the levee crests are generally consistent with the constant design height of 3.05m AHD. There were however, a number of low points and sections ranging between 100mm - 200mm below the design level identified, potentially
leading to premature overtopping of the levees during a flood event. The location and extent of the identified low points are summarised in Appendix D.

Aside from the 1 in 100 year flood level, no other flood modelling information was identified for the Kinchela Creek area. It is therefore not possible to accurately estimate the level of flood immunity provided by the levee. The provision of additional detailed flood information in the area may aid in assessing the suitability of the levee design crest level (3.05m AHD), in terms of the level of flood immunity provided.

11.0 RECOMMENDATIONS

In order to gain an understanding of the flood immunity level of the Kinchela Creek levees and to assess the suitability of the levee design crest level it is recommended that a hydraulic study be commissioned on the Kinchela Creek area or the 2013 WMA water flood study be extended to include Kinchela Creek and the surrounding areas of interest.

It is recommended that all defects listed in the Defects Inspection Report in Appendix D of this report are to be remediated. The priority level and description of each of the defects listed in Appendix D should be taken into account when prioritising the remediation works.

An Operation & Maintenance Manual should also be developed in line with the information presented in this report (specifically Appendix D, E and F) to ensure that the appropriate level of maintenance of the levee system is upheld to avoid further degradation of the levees in future.

All of the low points outlined in Appendix D occur on the sections of the levees supporting a two lane, two way, sealed rural road. As such the costs associated with raising the crest (roadway) will likely be significant. Prior to undertaking crest raising works, it is recommended that up-to-date flood modelling information is obtained in the area, as discussed above. This information would provide a better understanding of the significance of these low points and assist in identifying the level of urgency of the remediation works.

In order to gain an understanding of the reliability of the levee during a flood event, it is recommended a stability and seepage analysis be undertaken by a suitably qualified geotechnical engineer. Where appropriate, the information provided by such an assessment should then form part of the levee system Operations and Maintenance plan.

12.0 REFERENCES

1. Webb, McKeown & Associates Pty Ltd
   *Raising of Kinchela Creek Levees and Associated Works – Review of Environmental Factors*
   December 1997

2. Webb, McKeown & Associates Pty Ltd
   *Lower Macleay Floodplain Management Plan*
   March 1999

3. JK Geotechnics
   *Report to Kempsey Shire Council on Geotechnical Investigation for Lower Macleay Floodplain Levee Assessment*
July 2014

4. Kempsey Shire Council
   Macleay River Levee Upgrade to contain Bankfull Flow after Kinchela and Belmore Levees are raised
   1999

5. CIRIA
   International Levee Handbook
   2013
Figure A1: Kinchela Creek Left Bank typical roadway (levee)

Figure A2: Kinchela Creek left bank Floodway
Figure A3: Kinchela Creek head works structure

Figure A4: Section of levee across Kinchela Creek atop head works structure.
Figure A5: Kinchela Creek right bank levee typical formation

Figure A6: Kinchela Creek Left bank earthen levee typical formation (more pronounced on site)
Figure A7: Kinchela Creek left bank earthen levee vegetation issue

Figure A8: Kinchela Creek left bank earthen levee - river bank failure at levee toe
APPENDIX B -

SUMMARY OF SCANNED REPORTS

KEMPSEY MACLEAY FLOODPLAIN

(Reports specifically related to Hat Head not included)
<table>
<thead>
<tr>
<th>Report By Macleay River County Council’s Civil Engineer</th>
<th>Report Date</th>
<th>Summary of Aims</th>
<th>Findings / Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reviewing the 1953 Proposal of the Macleay Valley Flood Mitigation Committee.</td>
<td></td>
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<tr>
<td>Submitting an overall Plan of Flood Mitigation for the Lower Macleay Valley.</td>
<td></td>
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</tr>
<tr>
<td>Macleay River County Council.</td>
<td>October 1962</td>
<td>Review the 1953 Proposal of the Macleay Valley Flood Mitigation Committee and prepare an overall Plan of Flood Mitigation Works for the Lower Macleay Valley. A description of the various works proposed and estimated costs of their construction.</td>
<td>The 1953 Proposal of the Macleay Valley Flood Mitigation Committee substantially endorsed a comprehensive and detailed plan of works (including estimate of cost). This was based on additional and more accurate data and detailed investigation. The works envisaged compromised in the main, levees, floodgated headworks, floodways, drains and river bank stabilisation and protection.</td>
</tr>
</tbody>
</table>
| Macleay River Flood Mitigation Model Investigation. Manly Hydraulics and Soils Laboratory. Department of Public Works. | August 1963 | Construction of a physical model in order to investigate the effect of various flood mitigation works. | Found that the following works would reduce the flood menace:
- Raising Eden St embankment
- Removing the Pola Creek Island
- Incorporating the addition of a training wall trough in central Kempsey |
<p>| Flood Mitigation Report on Investigation of Alternative Methods for the further drainage of floodwater from the Swanpool, Kinchela and Ball’s Creek Areas. | August 1965 | Explore the possibility of and consider alternative schemes to provide for the further requirements of flood drainage of the Swanpool, Kinchela and Ball’s Creek areas. | Recommend submission to the Department of Public Works for approval to the Korogora 1964 Scheme combined with a Ball’s Creek to Saltwater Inlet Scheme. |
| Report on the Hydrological Implications of Flood Mitigation works on the floodplain of the Macleay River below Kempsey. University of New England. | August 1967 | Measure and analyse the manner in which inundation has been reduced by flood mitigation measures | Demonstrated reduction in area, depth and time of inundation of floods due to mitigation measures. |</p>
<table>
<thead>
<tr>
<th>Report</th>
<th>Report Date</th>
<th>Summary of Aims</th>
<th>Findings / Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Resources of the Macleay Valley.</td>
<td>May 1968</td>
<td>Study of the physiography, climate, groundwater potential and surface water resources. Review the current water requirements Assessments made of possible future water development.</td>
<td>Achieved study aims. Provides good historical records of rainfall and runoff.</td>
</tr>
<tr>
<td>Macleay River County Council. Additional Works Programme 1970 -1976.</td>
<td>Sept 1970</td>
<td>Feasibility, benefits and costs of constructing and operating Ryan’s Cut investigated.</td>
<td>Recommended construction of Ryan’s Cut Construction determined to be feasible. Benefit to cost ratios ranged from 1 to 2.5 at discount rates of 7% and 5% respectively.</td>
</tr>
<tr>
<td>Macleay River County Council Additional Works Programme 1970 -1976.</td>
<td>October 1970</td>
<td>Summarise results of and prepare BCRs on the studies of the following projects: Bellimbopinni Drainage, Big Hill Cut, Ryan’s Cut, Gladstone Bank Protection, Kempsey Training Levee, Macleay River Floodways, Additional Drainage.</td>
<td>All Project s except for Bellimbopinni Drainage and Macleay River Floodways showed a benefit from the provision of flood mitigation exceeding the cost of the works required.</td>
</tr>
<tr>
<td>Report</td>
<td>Report Date</td>
<td>Summary of Aims</td>
<td>Findings / Recommendations</td>
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</tr>
<tr>
<td>Site Investigation of Fabridam, Belmore Floodway. Sinclair Knight</td>
<td>August 1971</td>
<td>Site Investigations to study:</td>
<td>Results indicated:</td>
</tr>
<tr>
<td>Consulting Engineers.</td>
<td></td>
<td>• The extent, quality and compaction of fill areas.</td>
<td>• Poor compaction and high moisture contents indicating significant fill settlements likely to occur.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The adequacy of the foundations.</td>
<td>• Existing floor foundations founded in cut can safely take a bearing pressure of 1,500 pds. per sq. ft.</td>
</tr>
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<td></td>
<td></td>
<td>• The overall stability of the Fabridam and structure under operating conditions.</td>
<td>• Structure has a factor of safety of 3 with respect to stability.</td>
</tr>
<tr>
<td>15th Annual Conference of Flood Mitigation Authorities of NSW</td>
<td>May 1975</td>
<td>Summary of Proceedings including Agenda and Key Note Speakers’ Notes.</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Flood Mitigation on the Macleay River.</td>
<td>6 Dec 1976</td>
<td>Provide a scope and purpose of efforts to mitigate the effects of flooding in</td>
<td>Provides a factual account of flood mitigation works undertaken over the previous 21 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the Macleay River Valley.</td>
<td>Provides a historical record of levee bank construction.</td>
</tr>
<tr>
<td>Environmental Impact Statement Additional Drainage Seven Oaks Area</td>
<td>Nov 1978</td>
<td>EIS on the effects of the proposed additional drainage works in the Seven Oaks</td>
<td>EIS prepared</td>
</tr>
<tr>
<td>Department of Public Works.</td>
<td></td>
<td>Area.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Council 25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feb 1980</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report</td>
<td>Report Date</td>
<td>Summary of Aims</td>
<td>Findings / Recommendations</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
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<td>----------------------------</td>
</tr>
<tr>
<td>NSW Coastal Rivers. Flood Plain Management Studies. Summary Report Macleay Valley. LM &amp; P Consultants.</td>
<td>Dec 1980</td>
<td>Report on flood management measures currently in operation and constraints on their effectiveness. Identify areas of potential for flood losses, assess their significance and evaluate practical mitigation measures. Recommend proposals which conform to an overall flood plain management strategy. Report on economic constraints to the implementation of these proposals.</td>
<td>Provided a prioritised list of recommended works and measures. (no list was ever provided)</td>
</tr>
<tr>
<td>Flooding Effects From The Raising of The Pacific Highway North Of Frederickton. Public Works Department.</td>
<td>May 1981</td>
<td>Investigation of the flooding effects of the raising of the Pacific Highway North of Frederickton on surrounding properties. The proposed work on the Pacific Highway is from 8 km to 13.25 km North of Kempsey.</td>
<td>The report recommended modifications to the design proposed by the Department of Main Roads in order to reduce the impact to an acceptable level.</td>
</tr>
<tr>
<td>Macleay River Flood Study Webb, Mckeown &amp; Associates Pty Ltd. NSW Public Works, Report No. 88050.</td>
<td>April 1989</td>
<td>Flood Study of the Lower Macleay River to determine the design conditions for the 1 in 20, 1 in 50 and 1 in 100 year floods and an extreme event.</td>
<td>Flood Behaviour throughout the study area for the 1 in 20, 1 in 50 and 1 in 100 year floods and the extreme flood calculated and results provided on plan views.</td>
</tr>
<tr>
<td>Report</td>
<td>Report Date</td>
<td>Summary of Aims</td>
<td>Findings / Recommendations</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Lower Macleay Valley Flood Mitigation.     | July 1994   | The Kinchela Creek and Belmore River Floodways were originally designed based on the use of Fabridams. These were constructed but failed soon after. Subsequently replaced with lift gates. The aim of this report is to assess the actual capacity of these lift gates compared to the original floodway design capacity of the Fabridams. | Kinchela Creek Findings/Recommendations  
Original Fabridam Floodway Design Capacity of 71cum/sec as against actual lift gate capacity of 41cum/sec.  
- Greater discharge could be achieved by enlarging lift gates  
Belmore River Findings/Recommendations  
- Original Fabridam floodway Design Capacity 560 cum/sec as against actual lift gate capacity of 400 cum/sec.  
- To achieve a greater floodway discharge the Belmore River would have to be widened at the same time.  |
| Review Of Kinchela Creek and Belmore River Floodway Capacities. |             |                                                                                                                                                                                                             |                                                                                                                                                                                                                             |
| NSW Public Works.                          |             |                                                                                                                                                                                                             |                                                                                                                                                                                                                             |
| Kinchela EIS  
Kinchela Creek Flood Channel  
Stage 1 Report. | July 1994   | Investigate implications of constructing a channel to be linking the eastern floodway to the headwaters of Korogoro Ck. The purpose would be to pass the smaller floods direct to the ocean after the eastern floodway was opened thereby preventing major inundation of the swamps and reducing the depth and duration of flooding on farmlands. This Stage 1 Report is an assessment of the general hydraulic feasibility of the proposal. | Flood models with various options run which demonstrated that the proposal was hydraulically feasible.  
The construction of the Flood Channel would necessarily lead to more frequent moderate to high flows in the creek but would not increase the peak flows from major floods. |
| Webb, Mckeown & Associates Pty Ltd.        |             |                                                                                                                                                                                                             |                                                                                                                                                                                                                             |
| Kinchela EIS  
Kinchela Creek Flood Channel  
Stage 2 Report. | October 1994 | This second stage of the investigation is concerned with the economic appraisal of the proposal. This involves the calculation of the Benefit Cost Ratio. Two alternative proposals examined:  
1. Alter the operation of the Kinchella and Belmore Floodways so that the gates are opened at a higher flood level (on the Kempsey Traffic Bridge). Would require raising the levee system on Kinchela Creek and possibly the minor raising on the Macleay | Original proposal (channel to be constructed linking the eastern floodway to the headwaters of Korogoro Creek) had a Benefit Cost Ratio of 0.5. Alternative Proposals:  
1. Benefit Cost Ratio of 2.4. Almost equivalent benefits to the channel could be achieved by modifying the operation of the floodway gates and carrying out minor levee amplification. Costs would |
<p>| Webb, Mckeown &amp; Associates Pty Ltd.        |             |                                                                                                                                                                                                             |                                                                                                                                                                                                                             |</p>
<table>
<thead>
<tr>
<th>Report</th>
<th>Report Date</th>
<th>Summary of Aims</th>
<th>Findings / Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinchela EIS. Kinchela Creek Flood Channel Stage 3 Report. Webb, Mckeown &amp; Associates Pty Ltd.</td>
<td>Nov 1995</td>
<td>Provide a summary of the benefits and costs associated with a range of mitigation strategies including those options outlined in the Stage 1 &amp; 2 Reports. No EIS to be prepared.</td>
<td>Summary of Benefit Cost Ratios for 8 different mitigation strategies ranging from a do nothing option to major works – including the options considered in the earlier reports. Opening the headworks gates on the Belmore River and Kinchela Creek during a flood not a viable option – disbenefits of allowing a lot more water onto properties in the headwaters would outweigh any measurable benefits elsewhere. No EIS ever completed.</td>
</tr>
</tbody>
</table>
| Lower Macleay Floodplain Management Study. Webb, Mckeown & Associates Pty Ltd. | Feb 1997 | Review previous flood study using currently available data and up-to-date technology to determine the nature and extent of the flood problem. Using this updated study, examine options to be incorporated into a floodplain management study. | Recommendations of various options regarding  
- Village Mitigation  
- Structural  
- Changes to Operations  
- Drainage Modifications  
- Water quality/Data Collection |
<table>
<thead>
<tr>
<th>Report</th>
<th>Report Date</th>
<th>Summary of Aims</th>
<th>Findings / Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review of Environmental Factors for the raising of Kinchela Creek Levees and Associated Works.</td>
<td>Dec 1997</td>
<td>Prepare a REF for the raising of the levees along Kinchela Creek, Belmore River and Rainbow Reach together with the modification to the management of Council’s Flood Mitigation System and the proposed modifications to drainage systems.</td>
<td>REF Determined 2 December 1997 by Council’s Director Operational Services.</td>
</tr>
<tr>
<td>Lower Macleay Floodplain Management Plan. Draft for Public Exhibition. Webb, Mckeown &amp; Associates Pty Ltd</td>
<td>March 1999</td>
<td>In February 1997, Council published the Lower Macleay Floodplain Management Study. It provided recommendations covering works, practices and changes to planning instruments which would provide the framework for more effective management of the floodplain. This Plan now draws the Study recommendations together into a formal plan of management for the floodplain within which specific works and measures can be implemented.</td>
<td>Floodplain Management Plan produced tabulated Elements of the plan prioritised.</td>
</tr>
<tr>
<td>Report</td>
<td>Report Date</td>
<td>Summary of Aims</td>
<td>Findings / Recommendations</td>
</tr>
<tr>
<td>---------------------------------------------</td>
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<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Upper Belmore Flood Management Strategy.</td>
<td>July 2000</td>
<td>Undertake a Floodplain Management Strategy Study to identify actions and works need to enhance the environment and improve water quality and sustain the land productivity of the Upper Belmore area.</td>
<td>Five Strategies developed which provided a framework for the future direction of water quality and land management in the Upper Belmore Study Area. Actions, Management Options, Considerations, Responsibility and Costs prepared for each of these Strategies.</td>
</tr>
<tr>
<td>Webb, Mckeown &amp; Associates Pty Ltd.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macleay River Flood March 2001 Flood Damages Data Collection.</td>
<td>March 2004</td>
<td>Gather Information in relation to the March 2001 flood including: • Damage and costs incurred • Brief verification of results produced by previously established hydrologic and hydraulic models • Compared observed flood behaviour with previous predictions and studies.</td>
<td>Damage costs were quantified. The Actual Flood Damage Costs compared to the Potential Flood Damage Costs were low due to the length of flood warning time and the flood awareness of the affected population. Difference between the modelled and reported flood behaviour in reasonable agreement. Cochrane St and RSL levees reportedly overtopped in good agreement with the model. Eden St Levee overtopped 0.4 m earlier than anticipated – further investigation beyond the scope of the study.</td>
</tr>
<tr>
<td>Webb, Mckeown &amp; Associates Pty Ltd.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macleay River at Kempsey. Draft Geomorphologic Assessment.</td>
<td>August 2007</td>
<td>Identify any morphological trends in the Macleay River channel between the Kempsey Railway Bridge and Frederickton. Morphological trends determined through the collation and analysis of available hydrosurvey. Hydraulic Modelling also undertaken to quantify the potential impacts of observed bed changes in terms of flood levels.</td>
<td>The waterway areas along the study reach have not varied significantly over the last 50 years (ie between 2007 and 1957.) Virtually no change in the flood level in the in 100 flood resulting in changes in the underlying bathymetry adopted in the model.</td>
</tr>
<tr>
<td>Report</td>
<td>Report Date</td>
<td>Summary of Aims</td>
<td>Findings / Recommendations</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>-------------</td>
<td>-----------------</td>
<td>--------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Kempsey Flood Study. Hydraulic Modelling Draft Report. Webb, Mckeown &amp; Associates Pty Ltd.</td>
<td>Jan 2008</td>
<td>Provide: 1. A summary of available data. 2. A description of the hydraulic modelling approach adopted. 3. Details of the calibration and verification of the hydraulic models. 4. An analysis and interpretation of model results to quantify the design flood behaviour for the CBD under existing conditions.</td>
<td>Numerical models to quantify the hydrology and hydraulics of the Macleay River Catchment established and calibrated making best use of data currently available. Detailed 2D hydraulic model of the study area around Kempsey established (Model Details spatial distribution of flood levels, depths and flow velocity) Current Models significantly more detailed and refined compared to previous studies. Enables a sound technical basis upon which the future development of the CBD can be assessed. Models developed suitable for use in the assessment of strategic development and redevelopment options for the CBD.</td>
</tr>
<tr>
<td>Kempsey Levee Gradient Sensitivity Assessment. Department of Environment and Change. Webb, Mckeown &amp; Associates Pty Ltd.</td>
<td>March 2008</td>
<td>Identify how different shaped hydrographs (i.e. those of similar peak magnitude but of different volumes and/or rates of rise) affect the flood gradient and whether this in turn affects the location and/or sequence in which the Kempsey CBD levees are overtopped.</td>
<td>Eden and Cochrane St Levees would be overtopped in a 1 in 5 year, Short St Levee in a 1 in 100 year and the RSL Levee in a 1 in 10 year event. Eden St Levee would overtop first in most circumstances. Recommend low points in the Eden St and Cochrane St Levees be filled to achieve protection at 7.4m and 5.9m AHD respectively.</td>
</tr>
<tr>
<td>NSW Levee Study for Emergency Management SES</td>
<td>Sept 2008</td>
<td>Provide current information of a number of Levees throughout NSW including those of the Lower Macleay.</td>
<td>Unable to locate Appendices relating to Lower Macleay Floodplain</td>
</tr>
<tr>
<td>Report</td>
<td>Report Date</td>
<td>Summary of Aims</td>
<td>Findings / Recommendations</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
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<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Floodgate and Drain Management Guidelines.</td>
<td>March 2002</td>
<td>Guidelines developed by Council to assist Council staff, private contractors and landholders to undertake “Best Practice” in flood mitigation drain and flood gate management.</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Design Report. Fredericton Levee North (constructed as part of the Kempsey Bypass)</td>
<td>Nov 2011</td>
<td>Design Report provides information on the alignment of the Fredericton Levee, the proposed wall and embankment sections, design details and associated issues. Prepared by Kempsey Bypass Alliance.</td>
<td>Construction Plans prepared. Levee designed to retain the 1 in 100 year flood with a freeboard of 500mm. Cantilever sheet piles provided along the river bank where an earth levee is not feasible. Reinforced concrete flood wall on secant piles used where vibrations caused by construction of sheet piles may endanger properties.</td>
</tr>
<tr>
<td>Development and Operation of the Macleay River Flood Mitigation System.</td>
<td>Not Known</td>
<td>Details the Scheme’s history of construction, basic aims and its Operation in times of flood.</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Maintenance and operating manual flood control structure at Kinchela Creek.</td>
<td>Not Known</td>
<td>Sets out a Maintenance and Operating Manual for the flood control structure at Kinchela Creek.</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>List of all Flood Mitigation Engineering Design / Construction Plans going back to 1955.</td>
<td>Not Known</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>
APPENDIX C -

EXISTING LEVEE SURVEY PLANS
LOWER MACLEAY FLOOD LEVEE AUDIT
KINCHELA CREEK LEVEE - RIGHT HAND & LEFT HAND BANK

Sheet No. Description
Sheet 1 - Cover and Locality Plan
Sheet 2 - Right Bank Plan & Longitudinal Section Ch. 0 - 700
Sheet 3 - Right Bank Plan & Longitudinal Section Ch. 740 - 1480
Sheet 4 - Right Bank Plan & Longitudinal Section Ch. 1480 - 2220
Sheet 5 - Right Bank Plan & Longitudinal Section Ch. 2220 - 2980
Sheet 6 - Right Bank Plan & Longitudinal Section Ch. 2980 - 3740
Sheet 7 - Right Bank Plan & Longitudinal Section Ch. 3740 - 4500
Sheet 8 - Right Bank Plan & Longitudinal Section Ch. 4500 - 5260
Sheet 9 - Right Bank Plan & Longitudinal Section Ch. 5260 - 5925
Sheet 10 - Left Bank Plan & Longitudinal Section Ch. 0 - 700
Sheet 11 - Left Bank Plan & Longitudinal Section Ch. 700 - 1460
Sheet 12 - Left Bank Plan & Longitudinal Section Ch. 1460 - 2220
Sheet 13 - Left Bank Plan & Longitudinal Section Ch. 2220 - 2980
Sheet 14 - Left Bank Plan & Longitudinal Section Ch. 2980 - 3740
Sheet 15 - Left Bank Plan & Longitudinal Section Ch. 3740 - 4500
Sheet 16 - Left Bank Plan & Longitudinal Section Ch. 4500 - 5260
Sheet 17 - Left Bank Plan & Longitudinal Section Ch. 5260 - 6020
Sheet 18 - Left Bank Plan & Longitudinal Section Ch. 6020 - 6626
Sheet 19 - Left Bank Typical Cross Sections

LOCALITY PLAN
Shire Council
KEMPSEY
PLAN
Floodgate Kinchela
East Floodway
Kinchela
Right
Bank
Road
Floodgate Kinchela
School Drain

PLAN
SCALE 1:10000

LONGITUDINAL SECTION: KINCHELA CREEK RIGHT BANK
SCALE 1:10000

LOWER MACLEAY FLOOD LEVEE AUDIT
KINCHELA CREEK LEVEES

This Plan is Approved and Authorized for Construction.
Manager Technical Services: Date: / / Signed:

This drawing is confidential and remains the property of Kempsey Shire Council. It must not be disclosed to a third party, copied or loaned without written permission.
PLAN

SCALE 1:10000

1 IN 100 YR FLOOD LEVEL
EXISTING SURFACE

LONGITUDINAL SECTION: KINCHELA CREEK RIGHT BANK

LOWER MACLEAY FLOOD LEVEE AUDIT
KINCHELA CREEK LEVEES

KINCHELA CREEK RIGHT BANK LEVEE PLAN AND LONG SECTION CH. 2980–3740

This Plan is Approved and Authorized for Construction
Manager Technical Services: Date: / / Signed:

This document is confidential and remains the property of Kempsey Shire Council. It must not be disclosed to a third party without written permission.
PLAN

Scale 1:1000

Floodgate Kinchela West Floodway

Kinchela Left Bank Road

Floodgate

1 in 100 yr flood level

Existing surface

Design surface

Longitudinal section: Kinchela Creek Left Bank

Lower Macleay Flood Levee Audit

Kinchela Creek Left Bank levee plan and long section Ch. 0-700
APPENDIX D -

DEFECTS INSPECTION REPORT
Table D1: Kinchela Creek right bank Defects Inspection Report

<table>
<thead>
<tr>
<th>Defect No.</th>
<th>Chainage</th>
<th>Description</th>
<th>Priority Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCRB 1</td>
<td>340</td>
<td>Low point 100mm</td>
<td>1</td>
</tr>
<tr>
<td>KCRB 2</td>
<td>700-1160</td>
<td>Low section up to 150mm</td>
<td>1</td>
</tr>
<tr>
<td>KCRB 3</td>
<td>1760</td>
<td>Low point 130mm</td>
<td>1</td>
</tr>
<tr>
<td>KCRB 4</td>
<td>1960-2020</td>
<td>Low section up to 120mm</td>
<td>1</td>
</tr>
<tr>
<td>KCRB 5</td>
<td>2080</td>
<td>Low point 130mm</td>
<td>1</td>
</tr>
<tr>
<td>KCRB 6</td>
<td>2320</td>
<td>Low point 100mm</td>
<td>1</td>
</tr>
<tr>
<td>KCRB 7</td>
<td>3240-3300</td>
<td>Low section up to 170mm</td>
<td>1</td>
</tr>
</tbody>
</table>

Table D2: Kinchela Creek left bank Defects Inspection Report

<table>
<thead>
<tr>
<th>Defect No.</th>
<th>Chainage</th>
<th>Description</th>
<th>Priority Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCLB 1</td>
<td>260-460</td>
<td>Low section up to 150mm</td>
<td>1</td>
</tr>
<tr>
<td>Defect No.</td>
<td>Chainage</td>
<td>Description</td>
<td>Priority Level</td>
</tr>
<tr>
<td>-----------</td>
<td>----------</td>
<td>------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>KCLB 2</td>
<td>800-960</td>
<td>Low Section up to 140mm</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 3</td>
<td>1200-1280</td>
<td>Low section up to 110mm</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 4</td>
<td>1540</td>
<td>Low point 100mm</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 5</td>
<td>2000</td>
<td>Low point 100mm</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 6</td>
<td>2140</td>
<td>Low point 100mm</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 7</td>
<td>2280</td>
<td>Low point 110mm</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 8</td>
<td>2360</td>
<td>Low point 100mm</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 9</td>
<td>2520-2580</td>
<td>Low Section up to 140mm</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 10</td>
<td>3320-3500</td>
<td>Low Section up to 150mm</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 11</td>
<td>3720-3860</td>
<td>Low Section up to 200mm</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 12</td>
<td>5190-5225</td>
<td>Section of river bank instability that has caused erosion of the levee toe.</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 13</td>
<td>5225</td>
<td>Cattle Track on levee</td>
<td>3</td>
</tr>
<tr>
<td>Defect No.</td>
<td>Chainage</td>
<td>Description</td>
<td>Priority Level</td>
</tr>
<tr>
<td>-----------</td>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>KCLB 14</td>
<td>5380-5800</td>
<td>Thick vegetation on levee. Unable to inspect section due to thick grass and woody weeds</td>
<td>1</td>
</tr>
<tr>
<td>KCLB 15</td>
<td>6290</td>
<td>Section of river bank instability that has caused erosion of the levee toe.</td>
<td>2</td>
</tr>
</tbody>
</table>

**Table D3: Priority level description**

The recommended priority levels are based on the following criteria:

<table>
<thead>
<tr>
<th>Priority Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Poor Condition - Needs to be urgently actioned</td>
</tr>
<tr>
<td>2</td>
<td>Poor Condition – Needs to be actioned as soon as possible</td>
</tr>
<tr>
<td>3</td>
<td>Average Condition – Needs to be actioned when practical</td>
</tr>
</tbody>
</table>
APPENDIX E -

GENERAL ADVICE ON REMEDIATION MEASURES
INTRODUCTION

As part of the Audit of the Levee banks of the Lower Macleay Floodplain, JK Geotechnics were commissioned to carry out geotechnical investigations on the following urban levees:

- Eden Street Levee (refer Report N²113010 - 01)
- Cochrane Street levee (refer Report N²113010 - 01)
- Hat Head Village levee (refer Report N²113010 - 02)
- Hat Head Control levee (refer Report N²113010 - 02)
- Smithtown levee (refer Report N²113010 - 03)

As part of this work JK Geotechnics provided guidance and general comments regarding a number of remedial measures to be carried out on the levee banks. Due to budget constraints and the lower risk nature of the rural levees, geotechnical investigations were not carried out on the rural levees as part of this audit. In the interim the advice provided in the urban levee reports has been summarised for guidance on all levees. It should be noted that the following advice is site specific and should be used for planning and cost estimation purposes only. Advice from a suitably qualified geotechnical engineer must be sought prior to carrying out works which may affect the structural or operational integrity of the levees.

TREE AND ROOT REMOVAL

Beyond upstream (protected side) toe

Where dense tree coverage occurs beyond the upstream levee toe, it is recommended that all trees be removed for a 2.5m zone width along the toe. This should only be completed once after completing the relevant consultation process (if required) and obtained all appropriate approvals. Some large mature trees may be left if an experienced geotechnical engineer deems it appropriate.

The trees should be cut down at their bases. Following cutting, the bases should be ground down to surface level. All felled trees and existing fallen branches should then be removed from the strip and appropriately disposed, off site.

Levee and downstream (water side) toe

Trees and roots identified on/in the levee and along the downstream toe must be completely removed, including their root balls and as much of their root system as possible. This will inherently require removal of sections of the levee and reconstruction to an engineering design. It is recommend that a suitable geotechnical engineer be on site whilst the levee sections are being boxed out to confirm the extent of removal, and more so to prevent unnecessary over-excavation.

Removal of woody vegetation

All small woody vegetation located on the levees should be completely removed, together with their root balls and as much of their root system as possible. This work may comprise of a localised excavation to remove the root ball. This small excavation should then be backfilled
with roadbase in maximum 150mm layers and rigorously compacted with a vertical rammer compactor, then top dressed and grassed.

**ANIMAL BURROWS AND NESTS**

Any animal burrows or nests should be filled as soon as possible. Where possible a grout tube should be inserted to the end of the hole. CIRIA C7321 (2013) suggests that the holes be filled with a low pressure, flowable grout at an appropriate viscosity to adequately fill the horizontal holes. The grout should comprise a 3:1, cement:bentonite mix (5). Under no circumstances should the grout be placed at sufficient pressure to cause hydraulic fracture of the levee. Care must be taken so that slumping of the grout does not cause loss of contact with the crown of the holes. Once the grout emanates onto the upstream shoulder, the grout tube should be retracted whilst still pumping. Immediately on completion of pumping, the holes should be plugged/dry-packed with a non-shrink grout which should prevent grout loss.

As an alternative to grouting, the affected sections of the levee could be boxed out down to a level where the holes and nests are revealed. The ends of the boxed out sections should be graded at no steeper than 1V on 1H to reduce side wall collapse in the earthfill and to facilitate compaction up against the cut faces. The base of the larger boxed out section be compacted with at least eight passes of a 4-5 tonne self-propelled smooth drum roller. If the subgrade is sand it should be moistened during rolling to facilitate compaction. Consideration must be made as to the type of compaction noting that a vibratory roller may cause vibration induced damage to nearby residence.

The backfill material and methodology will be site specific, depending upon the existing levee conditions. However, most of the rural levees are likely to be constructed of silty floodplain type soils. As such the Earth fill procedures outlined in the Cochrane Street, Eden Street and Smithstown levee geotechnical reports produced by JK Geotechnics will likely provide a general idea of the required works.

**STORMWATER OUTLET STRUCTURES**

The existing stormwater outlets that are present underneath a number of the levees need routine inspection, vegetation clearing, clean out and maintenance. Some common problems identified during this audit include:

- Inlets have no measures preventing inflow of litter, eroded debris and leaf litter.
- Headwalls adjacent to the flood gates require repair or reconstruction.
- Flood flaps/gates can become forced closed and partially buried by accumulated debris.

Common maintenance measures may be used to rectify these issues. Where levee bank sections must be reinstated an appropriate engineering methodology is to be used.

**FENCES ON LEVEE**

Issues regarding fences on the levee may occur if the fences were ever knocked out by flood debris, vandals, etc., they could gouge out the levee and possibly cause a breach during an overtopping event. JK Geotechnics have stated that they would prefer the removal of the
majority of fences off the levees. This however, may not be possible in every case. If a fence is thought to create a potential issue but may not be removed, a geotechnical engineer should be consulted.

REINSTATING THE LEVEE CREST

A methodology for the reinstatement of minor low points in the levee crests has been outlined by JK Geotechnics in the Cochrane Street and Hat head levee reports. A number of the details are site specific and hence for other locations a suitably qualified geotechnical engineer will need to be consulted prior to carrying out these works. A summary of the methodology is outlined in the following:

- Strip topsoil and grass, dispose of spoil
- Drain the site during construction using appropriate measures throughout excavations
- Proof roll the subgrade using a static roller ensuring no soft or unstable areas
- Choose materials similar in nature and grading as the existing levee for earth fill
- Compact imported earth fill using large pad foot roller to a density ratio of 98% SMDD
- Top dress and grass earth fill area with a hardy perennial grass

For a more detailed description of potential required works see the Cochrane Street and Hat head levee 2014 geotechnical reports.

RE-CONSTRUCTING A SECTION OF LEVEE

If a defect has caused significant damage to a levee bank, an entire section of levee may need to be re-constructed. If unsure whether the entire section of levee will need to be rebuilt a geotechnical engineer should be consulted. An example of reconstructing a section of levee can be seen in the Hat Head 2014 geotechnical report by JK Geotechnics. It must be noted that this is a site specific design and hence will not directly apply to any other levee bank. However, the construction process outlined may be useful for cost estimation and planning purposes. Geotechnical advice should be sought prior to any levee reconstruction works.
APPENDIX F -

INSPECTION AND MAINTENANCE INFORMATION
<table>
<thead>
<tr>
<th>Item to Inspect</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass Cover on Crest and Shoulders</td>
<td>The grass cover on the levee must be regularly mowed. The inspecting officer must check grass cover and health to ensure that there is sufficient surface protection against erosion. Top dress and re-grass as appropriate.</td>
</tr>
<tr>
<td>Vegetation (trees, bushes &amp; weeds)</td>
<td>No such vegetation is permitted to grow on the levee. Should new vegetation be encountered, then it should be removed together with its root ball. The localised excavation required to remove the root ball should be backfilled with road base in maximum 150mm layers and rigorously compacted with a vertical rammer compactor, then top dressed and grassed. For all large plants seek advice from a suitably qualified geotechnical engineer.</td>
</tr>
<tr>
<td>Animal Burrows</td>
<td>Burrows should be filled as soon as possible following Identification. If burrows are found, then a suitably qualified geotechnical engineer should be contacted for further advice. General guidance on remediation is also provided in Appendix E of this report.</td>
</tr>
<tr>
<td>Slope Instability and Erosion</td>
<td>The crest and shoulders should be inspected for evidence of slope instability and erosion; for example, tension cracks, scarp, slumps, subsidence and erosion rills. Should these be found, a suitably qualified geotechnical engineer should be contacted for further advice.</td>
</tr>
<tr>
<td>Seepage</td>
<td>If seepage at the downstream (protected side) toe is observed during flood periods, a suitably qualified geotechnical engineer should be contacted immediately.</td>
</tr>
<tr>
<td>Crest Settlement</td>
<td>If longitudinal and/or transverse cracking and/or depressions are observed along the crest, a suitably qualified geotechnical engineer should be contacted for further advice. General guidance on remediation measures is also provided in Appendix E of this report.</td>
</tr>
<tr>
<td>Tampering with Levee Condition</td>
<td>If any excavation appears to have been completed on or adjacent to the levee, a suitably qualified geotechnical engineer should be contacted for further advice. Notwithstanding, small excavations would need to be boxed out (if already backfilled) and replaced with compacted road base, as per ‘Vegetation’ above. Service providers should not install additional buried services within or in close proximity to the levee. If additional buried services need to be installed, a suitably qualified geotechnical engineer should be contacted for further advice. If wheel ruts have removed the grass cover, then the surface protection should be repaired.</td>
</tr>
<tr>
<td>Subsidence of Backfill at Test Pit Locations</td>
<td>In completing geotechnical investigations on the urban levees test pits may be carried out on the downstream batter of the levees. Should subsidence of the test pit backfill be observed, then the grass cover should be stripped, and backfill topped up with roadbase in maximum 150mm layers and rigorously compacted with a vertical rammer compactor. Following this, the roadbase should be top dressed and grassed.</td>
</tr>
<tr>
<td><strong>Fences over Levee</strong></td>
<td>Inspect the condition of the fences. If the fences have been impacted and have caused disturbance to the levee, then a suitably qualified geotechnical engineer should be contacted for further advice.</td>
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<tr>
<td><strong>Stormwater Outlet Pipes</strong></td>
<td>All inlet and flood gate structures must be inspected and appropriately maintained. Any obstructions to the inlets (eg. Long grass, eroded debris, leaf litter, general litter, etc.) must be removed. The flood gates must not be obstructed and their operation must be checked. A CCTV inspection of each outlet pipe should be completed on a yearly basis to assess the condition of the pipe and whether it requires cleaning. If any damage of the pipes is observed, causing potential damage to the levee, then a geotechnical engineer should be contacted for further advice.</td>
</tr>
<tr>
<td><strong>River/Creek Bank Erosion/Regression</strong></td>
<td>River and Creek bank erosion should be monitored where it is close to the upstream toe of the levee. Should regression occur such that it removes support from the upstream toe, then a geotechnical engineer should be contacted for further advice.</td>
</tr>
<tr>
<td><strong>Transition points of levee and flood gate abutment/roadway etc.</strong></td>
<td>Inspect either side of the transition point for evidence of seepage and movement (eg. differential settlement and cracking). Should these be found, then a geotechnical engineer should be contacted for further advice.</td>
</tr>
</tbody>
</table>