List of Figures

- Figure 1.1: The Floodplain Risk Management Process
- Figure 3.1: Bega Valley Shire Council Local Government Area
- Figure 5.1: Catchment Diagram
- Figure 5.2: Perspective View of Catchment
- Figure 5.3: Histogram of Elevations within Catchment
- Figure 5.4: Bega Township
- Figure 5.5: Jellat Jellat
- Figure 5.6: Kalaru, Mogareeka and Tathra
- Figure 5.7: Candelo Village
- Figure 6.1: Locations of Rainfall Stations
- Figure 6.2: Flow and Water Level Gauges Map
- Figure 6.3: DTM Representation of the Confluence of Brogo and Bega Rivers North of Bega Based on the Council's LIDAR Survey

 Data
- Figure 6.4: Surveyed Control Cross-Sections Along Bega and Brogo Rivers
- Figure 6.5: Candelo Creek Surveyed Cross Sections
- Figure 6.6: Example where LIDAR Adequately Represented Channel
- Figure 6.7: Example where LIDAR did not Adequately Represent Channel
- Figure 6.8: Schematic of Cochrane Dam Weir Plan and Section Views
- Figure 6.9: Historic Aerial Photographs near Mogareeka (Source OEH)
- Figure 6.10: 2010 Aerial Photograph near Mogareeka (Source Council)
- Figure 7.1: Flood Extent Map by WRC, 1979
- Figure 7.2: Flood Extent Map from Council's GIS
- Figure 7.3: River Styles in Bega/Brogo Catchment
- Figure 8.1: Floods Greater than 4.6m by WRC Bega River at North Bega (WRC, 1979)
- Figure 8.2: Significant Floods at North Bega Gauge Since 1971
- Figure 11.1: Flood Frequency Curve by WRC Bega River at North Bega (WRC, 1979)
- Figure 11.2: Flood Frequency Curve at Bega River Annual Series Analysis
- Figure 11.3: Flood Frequency Curve at Bega River Partial Series Analysis
- Figure 11.4: Flood Frequency Curve at Station 219025 Brogo River @ Angledale
- Figure 11.5: Flood Frequency Curve at Station 219003 Bemboka River @ Morans Crossing
- Figure 11.6: Flood Frequency Curve at Station 219017 Double Creek near Brogo
- Figure 11.7: Flood Frequency Curve at Station 219006 Tantawangalo Creek @ Tantawangalo
- Figure 11.8: Flood Frequency Curve at Station 219022 Tantawangalo Creek @ Candelo Dam Site
- Figure 11.9: Flood Frequency Curve at Station 219001 Rutherford Creek @ Brown Mountain
- Figure 12.1: Catchment Delineation
- Figure 12.2a: Cleared and Natural Land Types within the catchment
- Figure 12.2b: Cleared and Natural Land Types within the catchment
- Figure 12.3: Land Zoning within the Catchment
- Figure 13.1: Components of Elevated Water Levels on the Coast
- Figure 13.2: Layout at Candelo Creek
- Figure 14.1: Isohyetal Map showing Spatial Distribution of Rainfall for Feb 1971 Event
- Figure 14.2: Isohyetal Map showing Spatial Distribution of Rainfall for Mar 2011 Event ALL DATA
- Figure 14.3: Isohyetal Map showing Spatial Distribution of Rainfall for Mar 2011 Event FOR MODELLING
- Figure 14.4: Isohyetal Map showing Spatial Distribution of Rainfall for Mar 1983 Event
- Figure 14.5: Isohyetal Map showing Spatial Distribution of Rainfall for Feb 2010 Event



- Figure 14.6: Pluviograph Stations Map
- Figure 14.7: Pluviograph for the February 1971 Event Station 70199
- Figure 14.8: Pluviograph for the March 2011 Event Station 219033
- Figure 14.9: Pluviograph for the February 2010 Event Station 219032
- Figure 14.10: Revised Temporal Pattern for March 1983 Event
- Figure 14.11: Example of Separation of Baseflow from Total Observed Flow (Feb 1971 Flood Event, Station 219003)
- Figure 14.12: Effect of Stopboard Collapse at Cochrane Dam 10%AEP36 hour flood event
- Figure 14.13: Effect of Stopboard Collapse at Cochrane Dam 1%AEP36 hour flood event
- Figure 14.14: Flood Frequency Curve St 219025 Brogo River
- Figure 14:15: Flood Frequency Curve St 219022 Tantawangalo Creek
- Figure 14:16: Flood Frequency Curve St 219003 Bemboka/ Bega River
- Figure 14:17: Frequency distribution of individual loss rates from values across Australia
- Figure 14.18: March 2011 Event Flood Debris Tarraganda Lane
- Figure 14.19: February 1971 Event Flood Map with Locations of Floodmarks
- Figure 14.20: March 2011 Event Flood Map with Locations of Floodmarks
- Figure 14.21: March 1983 Event Flood Map with Locations of Floodmarks
- Figure 14.22: February 2010 Event Flood Map with Locations of Floodmarks
- Figure 15.1: Design Rainfall Relationship Intensity Duration Frequency
- Figure 15.2: Site Specific Analysis 1%AEP event
- Figure 15.3: Default Ocean Level 1%AEP event
- Figure 15.4: Measurements of Global Mean Sea Level from Satellites from Jan 1993 to Dec 2012, source: CSIRO (BoM, 2012)
- Figure 15.5: Temporal Distribution of Annual Rainfall
- Figure 15.6: Average Annual Rainfall across NSW
- Figure 15.7: Debris and Blockages at Bridges
- Figure 15.8: Water Surface Profiles along Bega River
- Figure 15.9: Approximate Location of Proposed Upgrade
- Figure 16.1: Check Locations Used in the Sensitivity Analysis
- Figure 18.1: 1% AEP Flood Levels vs Time
- Figure 18.2: Extent of inundation, Bega River upstream of Bega Map 1
- Figure 18.3: Extent of inundation, Bega River upstream of Bega Map 2
- Figure 18.4: Extent of inundation, Bega River upstream of Bega Map 3
- Figure 18.5: Extent of inundation, Brogo River upstream of Bega Map 1
- Figure 18.6: Extent of inundation, Brogo River upstream of Bega Map 2
- Figure 18.7: Extent of inundation, Bega Township Map 1
- Figure 18.8: Extent of inundation, Bega Township Map 2
- Figure 18.9: Example of communities accessing Tathra Road that may become isolated
- Figure 18.10: Vulnerable communities north side of Tathra Rd
- Figure 18.11: Reedy Swamp Road isolated communities
- Figure 18.12: Extent of inundation, western edge of Betunga Swamp showing Wallagoot Lane submerged in 5% AEP
- Figure 18.13: Extent of inundation, Blackfellows Lagoon Area
- Figure 18.14: Extent of inundation, Mogareeka Area



List of Tables

- Table 6.1: Years of Continuous Water level Records
- Table 8.1: Recorded Flood Depths at gauging station Bega River at Bega (North Bye)
- Table 10.1: Summary Responses for February 1971 Event
- Table 10.2: Summary Responses for March 1983 Event
- Table 10.3: Summary Responses for February 2010 Event
- Table 10.4: Summary Responses for February 2011 Event
- Table 10.5: Summary Responses for March 2011 Event
- Table 10.6: Summary Responses for March 2012 Event
- Table 11.1: Estimate of ARI of Recent Major Flood Events from Flood Frequency Analysis
- Table 11.2: Estimate of ARI Flood Level Based on Results from Flood Frequency Analysis
- Table 11.3: Estimate of ARI for Historic Floods from Flood Frequency Analyses Using Annual Series Analyses
- Table 11.4: Estimate of Design ARI Gauge Flood Level Based on Results from Flood Frequency Analysis
- Table 11.5: Top Ranked Historic Events recorded at Station 219900 Bega River at Bega (North Bye)
- Table 12.1: Percentage Imperviousness Applied Individual Land Zones
- Table 14.1: Availability of Pluviograph Data for Calibration/ Validation Events
- Table 14.2: Revised Rainfall Totals for March 1983 Event
- Table 14.3: Availability of Data at Adopted Streamflow Gauging Stations
- Table 14.4: Water Level Recording Stations
- Table 14.5: Water Level Recording Stations Dam Sites
- Table 14.6: Rating Curve Extrapolation
- Table 14.7: Rainfall Losses from Calibration and Validation Runs
- Table 14.8: Manning's Roughness Coefficients from Calibration and Validation Runs
- Table 14.9: Comparison with Documented Roughnesses
- Table 14.10: Recommended Rainfall Loss Parameters for use in Design Events up to 1%AEP Event
- Table 14:11: Recommended Basic Model Parameters
- Table 14.12: Manning's Roughness Coefficients for Modelling of Design Events
- Table 14.13a: Calibration Results February 1971 Event
- Table 14.13b: Additional Calibration Results February 1971 Event
- Table 14.14: Calibration Results March 2011 Event
- Table 14.15a: Validation Results March 1983 Event
- Table 14.15b: Additional Validation Results March 1983 Event
- Table 14.16: Validation Results February 2010 Event
- Table 14.17: 2D Modelling Surface Roughness Coefficients from Calibration and Validation Runs
- Table 14.18: Modelling Surface Roughness Coefficients for Design Event Runs
- Table 14.19: Modelling Bridge Entry/Exit Losses for Design Event Runs
- Table 14:20: Entrance Conditions for use in Design Events
- Table 15.1: Geographic Rainfall Factors for Bega and Brogo Rivers Catchment
- Table 15.2: Log Normal Intensities for Bega and Brogo Rivers Catchment
- Table 15.3: Critical Durations for Various Design Flood Events based on Bega/ Brogo Rivers Junction
- Table 15.4: Coincidental Flooding of Bega River from Catchment and Ocean flooding
- Table 15.5: Catchment and Ocean Flooding Combinations
- Table 15.6: Most Likely Block Levels (based on Debris Potential Alone)
- Table 15.7: Block Levels (based on Likelihood and Consequences)
- Table 15.8: Adopted Blockage Factors for Bridges within the Modelling Area
- Table 15.9: Design Flood Levels at Flood Gauges within the Modelling Area



- Table 15.10: Design Flood Levels at Hydraulic Structures
- Table 15.11: Freeboard at Hydraulic Structures
- Table 15.12: Duration of Bridge Overtopping in Design Events
- Table 16.1: Scenarios Used in Sensitivity Analysis
- Table 16.2: Peak Flowrates from Sensitivity Analysis of Rainfall Intensities
- Table 16.3: Peak Flowrates from Sensitivity Analysis of Rainfall Losses
- Table 16.4: Peak Flowrates from Sensitivity Analysis of Catchment Roughness (PERN)
- Table 16.5: Sensitivity Analysis Results for Blockage Through Bridges Velocities
- Table 16.6: Sensitivity Analysis Results for Blockage Through Bridges Upstream Water Levels
- Table 16.7: Water Levels at Control Locations Used in Sensitivity Analysis
- Table 16.8: Change in Water Levels at Control Locations Used in Sensitivity Analysis
- Table 16.9: Velocities at Control Locations Used in Sensitivity Analysis
- Table 16.10: Change in Velocities at Control Locations Used in Sensitivity Analysis
- Table 17.1: Provisional Hazard Categories for People
- Table 17.2: Provisional Hazard Categories for Vehicles
- Table 18.1: Response Required for Different ERP Classifications (Source: OEH)



List of Appendices

APPENDIX A - DAM RATING CURVES

APPENDIX B - COMPONENTS IN SITE SPECIFIC ANALYSIS

APPENDIX C - DETAILED BLOCKAGE FACTORS AT BRIDGES

APPENDIX D - GENERAL CATCHMENT AND MODELLING INFORMATION

- Figure D1 Modelling Area
- Figure D2 Catchment Topography
- Figure D3 Hydraulic Structures

APPENDIX E – CALIBRATION AND VALIDATION

- Figure E1 Rainfall and Flow Gauging Stations
- Figure E2 Simulated Versus Gauged Hydrographs
- Figure E3 Modelling Surface Roughness Coefficients Design Events

APPENDIX F - DESIGN FLOOD MAPPING

- Figure F1A 10%AEP Flood Depths and Levels
- Figure F1B 5% AEP Flood Depths and Levels
- Figure F1C 2% AEP Flood Depths and Levels
- Figure F1D 1% AEP Flood Depths and Levels
- Figure F1E 0.2% AEP Flood Depths and Levels
- Figure F1F Probable Maximum Flood (PMF) Flood Depths and Levels
- Figure F2A 10% AEP Water Velocities
- Figure F2B 5% AEP Water Velocities
- Figure F2C 2% AEP Water Velocities
- Figure F2D 1% AEP Water Velocities
- Figure F2E 0.2% AEP Water Velocities
- Figure F2F Probable Maximum Flood (PMF) Water Velocities

APPENDIX G - HYDRAULIC AND HAZARD CATEGORISATION

- Figure G1A 10% AEP Hydraulic Categories
- Figure G1B 5% AEP Hydraulic Categories
- Figure G1C 2% AEP Hydraulic Categories
- Figure G1D 1% AEP Hydraulic Categories
- Figure G1E 0.2% AEP Hydraulic Categories
- Figure G1F Probable Maximum Flood (PMF) Hydraulic Categories



Figure G2A - 10% AEP Flow Hazard

Figure G2B - 5% AEP Flow Hazard

Figure G2C - 2% AEP Flow Hazard

Figure G2D - 1% AEP Flow Hazard

Figure G2E - 0.2% AEP Flow Hazard

Figure G2F - Probable Maximum Flood (PMF) Flow Hazard

APPENDIX H - IMPACT OF SEA LEVEL RISE ON PRELIMINARY FLOOD PLANNING LEVELS

Figure H1 – Preliminary Flood Planning Levels under Existing Sea Levels (1% AEP+0.5m freeboard)

Figure H2 – Preliminary Flood Planning Levels under 2050 Sea Level Rise Projections (0.4m SLR)

Figure H3 – Preliminary Flood Planning Levels under 2100 Sea Level Rise Projections (0.9m SLR)

APPENDIX I – LIDAR SURVEY METADATA

APPENDIX J - CANDELO CREEK RESULTS

APPENDIX K - CANDELO CREEK MAPS (Depths, Velocities, Hydraulic Categories, Flow Hazard)

