ADDENDUM #2

REQUEST FOR PROPOSALS

RFP-03-24 Oyster River and Coastal Lands Floodplain Mapping

Issued April 15, 2024

The Strathcona Regional District (SRD) wishes to issue the following addendum to RFP 03-24 – Oyster River and Coastal Lands Floodplain Mapping.

New Reference Material

As noted in Addendum 1, the Comox Valley Regional District (CVRD) completed a flood risk assessment for the Oyster River and Saratoga Beach coastal area, including the northern shore within the jurisdictional boundaries of the SRD. Additionally, in 2021, the CVRD completed a Coast Flood Mapping project. These two projects cover a significant portion of the study area for this RFP and the resultant data is available from the SRD to serve as a foundation for this project.

Metadata pertaining to this data is now available as a reference for this RFP in the following documents, appended to Addendum #2:

- Metadata-BaseMapping-20210423
- Metadata-ClimateChangePlanningAreas-20210423
- Metadata-FloodHazardRating-20210423
- Metadata-MaximumFlowVelocity-20210423
- Metadata-MaximumWaterDepth-20210423
- Metadata-MaximumWaterLevel-20210423
- Metadata-MaximumWaveHeights-20210423
- Metadata-Regulatory_20210423
- Metadata-Setbacks-20210423

Question:

Will Flood Construction Levels (FCLs) be required for the coastline along the defined project boundary? Is the entire coastline shown in Appendix A subsequently within scope?

Response:

Yes and Yes. This RFP seeks FCLs for the entirety of the Flood Hazard DPA, shown in Appendix A of the RFP.

Question:
Will First Nations engagement be required as part of the project scope?

Response:
No. Engagement is not included as part of this project scope as the SRD will directly carry out all engagement that may be required; however, if engagement activities are included as part of a proposal, a summary of these activities must be provided as a deliverable of this project (as noted in the RFP).

Please sign below, acknowledging receipt of this Addendum and return this document with your submission to the RFP.

________________________	________________________
Signature	Name of Firm
________________________	________________________
Name and Title (Print)	Date

Base Mapping Products – 2021/04/23

Description

1. Processed GeoBC LiDAR: LiDAR topography for the study area collected in 2018/2019 obtained from GeoBC and processed by KWL**. It should be noted that the ocean water surface has not been removed from the dataset.**
2. Oyster River Model Base Mapping: Base mapping for the Oyster River prepared by integrating GeoBC and Strathcona Regional District LiDAR topographic datasets with the bathymetric mapping obtained through ground survey in 2019. This mapping was used for 2D modelling of the Lower Oyster River.
3. Bathymetric Digital Elevation Model (DEM): DEM prepared by integrating various CHS bathymetric data sets. This base mapping was used for deep water wave modelling.
4. Shoreline Transects: Cross sections through the shoreline at various locations (transects) prepared by integrating the GeoBC LiDAR and the Bathymetric DEM. These transects were used for the nearshore wave modelling. Transect location coordinates are also included.
5. Upper Oyster River Cross Sections from Bathymetric Survey: Cross sections from the bathymetric survey in 2019 used for 1D modelling of the Upper Oyster River. Transect location coordinates are also included.
6. Oyster River Alluvial Fan Boundary: Boundary of the Oyster River Alluvial Fan as per Technical Memorandum #2 – Fluvial and Coastal Geomorphology.
7. Normal Water Surface Boundary: As shown on the regulatory mapping. Equal to an elevation on 2.3 m CGVD2013 (nominally higher-high water level large-tide at Little River)

The mapping used to develop the model of the Courtenay River system was prepared under a separate project; reference should be made to the KWL memorandum *City of Courtenay, Integrated Flood Management Study, Hydrodynamic Model Development and Flood Management Options Evaluation, November 29, 2013* prepared for McElhanney Engineering for further details on the base mapping used for model development (KWL, 2013).

File Names and Formats

1. Processed GeoBC LiDAR: Model Key Points (*.dxf and *.xyz) and Rasters (*.tif)
2. Oyster River Bathymetric Survey: OysterRiverBathymetricSurvey.zip
3. Bathymetric DEM: 2019-1127_CCR_DataRequest_Combine_10m_Extract.csar.txt, 2019-1127_CCR_Metadata.docx (metadata)
4. Shoreline Transects: Basemapping.gdb [ArcGIS File Geodatabase Feature Class *CoastalTransects* (polyline)]
5. Oyster River Alluvial Fan Boundary: Basemapping.gdb [ArcGIS File Geodatabase Feature Class *OysterRiverAlluvialFanBound* (polyline)]
6. Normal Water Surface Boundary: Basemapping.gdb [ArcGIS File Geodatabase Feature Class *NormalWaterSurfaceBound* (polygon)]
7. Coastal Zone Boundary: Basemapping.gdb [ArcGIS File Geodatabase Feature Class *CoastalZone* (polyline)]

Datum

Processed GeoBC LiDAR, Oyster River Model Base Mapping, Shoreline Transects, Upper Oyster River Cross Sections from Bathymetric Survey, Normal Water Surface Boundary:
Horizontal Datum: NAD83(CSRS), UTM Zone 10
Vertical Datum: CGVD2013

Bathymetric DEM:
Horizontal Datum: NAD83(CSRS), UTM Zone 10
Vertical Datum: Low Water Datum

Oyster River Alluvial Fan Boundary *Horizontal Datum: NAD83(CSRS), UTM Zone 10* *Vertical Datum: N/A*	
Quality Control	
Mapping prepared by:	Ryan Taylor, GISP
Mapping checked by:	Eric Morris, P.Eng.
Mapping Product Development	
Refer to Technical Memorandum #1 – Coastal and River Base Map Development. The various topographic and bathymetric data sources used for the project base mapping, with the exception of the Bathymetric DEM, were collected in or adjusted to the project datum (CGVD2013)	
Notes and Limitations	
The following limitations should be considered when interpreting and using the maps: 1. Multiple data sources with different datums were integrated to create the base mapping. Some approximations were made when shifting the base mapping to a common datum and vertical errors of as much as approximately 4 cm related to conversion are present in the Shoreline Transects. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for details related to the datum shifts made during base mapping integration. 2. The LiDAR data sets used to create the base mapping were collected in 2016, 2018 and 2019. Changes in topography due to land development and erosion which affect the accuracy of this base mapping can be expected in the future and this should be considered when using the mapping. 3. Refer to Technical Memorandum #2 – Fluvial and Coastal Geomorphology for details regarding the development of the Oyster River Alluvial Fan Boundary mapping. The mapped extent of the fan has been truncated at the study area boundary at the northern end. The southern extent of the fan and the apex of the fan (upriver extent) have been determined through desktop study and should be considered approximate.	

Climate Change Planning Area Mapping – 2021/04/23

Description	
Year 2100 and year 2200 Sea Level Rise Planning Areas as defined in the provincial guidelines (FLNR, 2018). Areas exposed to flood hazards from the Oyster and Courtenay River systems within the study area are also included in the mapping. A freeboard allowance is included.	
File Names and Formats	
List of geodatabase file(s): Planning.gdb [ArcGIS file geodatabase of sea level rise planning areas (polygon)] Feature classes of geodatabase includes the following: Year 2100 Climate Change Planning Area: AdmClimateChangePlanningArea_2100 Year 2200 Climate Change Planning Area: AdmClimateChangePlanningArea_2200	
Datum	
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: CGVD2013	
Contour Intervals	
Not applicable.	
Quality Control	
Coastal	
Mapping prepared by:	Max Scruton, P.Eng.
Mapping checked by:	Eric Morris, P.Eng.
Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.
Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.
Mapping Product Development	
Refer to: • Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions; • Technical Memorandum #3B – Courtenay River Modelling – Hydrology and Model Assumptions; and, • Technical Memorandum #4 – Coastal Modelling. The Year 2100 Climate Change Planning Area is depicted as the area between the existing floodplain limit and the Year 2100 floodplain limit. The Year 2200 Climate Change Planning Area is depicted as the area between the Year 2100 floodplain limit and the Year 2200 floodplain limit. The extents of the Climate Change Planning Areas in coastal areas are dictated by sea level rise, while the extents of the Climate Change Planning Areas bordering rivers are dictated by increases in river flow. For coastal areas, the Year 2100 scenario includes a 1 m SLR allowance, and the Year 2200 scenario includes a 2 m SLR allowance as per the provincial guidelines (FLNR, 2018). The floodplain limit is the elevation of the wave runup, $R_{2\%}$, and is calculated as the sum of: • The 0.5% AEP extreme static water level as determined by probabilistic analyses of tides and storm surge; • Allowance for future SLR (1 m for year 2100 and 2 m for year 2200); • Allowance for regional land uplift, or subsidence;	

- Estimated wave effects with a 0.5% AEP; and
- A freeboard of 0.6 metres.

As with the regulatory floodplain mapping, for the special case of topographic plateaus, the flood level has been established as the elevation of the seaward crest of the plateau plus freeboard, or the maximum elevation of the overland flooding zone plus freeboard, whichever is greater.

For river floodplain mapping along the Oyster River and the Courtenay River/Tsolum River/Puntledge River, the flood levels have been established as 0.5% AEP modelled flood profile plus 0.6 m of freeboard based on the following:

- 0.5% AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- An allowance added to the peak instantaneous flow to account for projected climate change impacts (+15% for Year 2100 and +30% for Year 2200);
- The 0.5% AEP extreme static ocean level plus allowance for Sea Level Rise (1 m for Year 2100 and 2 m for Year 2200); and,
- A freeboard of 0.6 metres.

Oyster River flood levels have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. The flood levels and floodplain limits depicted in the mapping are the maximum values of the two scenarios. The location and size of the hypothetical dike breach is based on recommendations provided in the Fraser Basin Council Floodplain Mapping Guidelines and Specifications (FBC, 2004). In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

For the Year 2100 Climate Change Planning Area boundary, Courtenay River flood levels have been modelled for two scenarios: existing conditions and a scenario with additional proposed flood protection works in place. The proposed flood protection alignment is based on the Flood Protection Option 2 ring dike presented in the City of Courtenay Integrated Flood Management Strategy, 2013. The flood levels and floodplain limits depicted on the map are the maximum values of the two scenarios. For the existing and Year 2200 Climate Change Planning Area boundaries, Courtenay River flood levels have been modelled for existing conditions without flood protection works in place.

Refer to the Technical Memorandum #5 - Section 3.2, Regulatory Floodplain Mapping, for information on how the coastal and river model results were converted into two-dimensional mapping and merged.

Notes and Limitations

1. Refer to Technical Memorandum #5 – Table 3 - Regulatory Floodplain Mapping Products for relevant notes and limitations.

Flood Hazard Rating Mapping – 2021/04/23

Description	
Raster GIS layer and contour polylines showing flood hazard rating (the product of water depth and velocity) for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Flood hazard ratings are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total. Flood hazard rating mapping is provided only for the Oyster River and the Courtenay River System.	
File Names and Formats	
List of geodatabase files: HR_Raster.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River flood hazard rating (raster)] HR_Contours.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River flood hazard rating contours (polyline)] HR_Extents.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River flood hazard extents (polygon). Note that the hazard map extent excludes the Courtenay River areas that were modelled in 1D (upper end of Puntledge River including adjacent floodplain, and top of bank to top of bank for all other rivers)] Feature classes of geodatabases follow the scenario naming convention of A_B_XXYYY_Z where A is the geodatabase name, B indicates the Oyster or Courtenay River and XX is the SLR scenario as follows: 00 = 0.0 m 05 = 0.5 m 10 = 1.0 m 20 = 2.0 m And YYY is the Annual Exceedance Probability as follows: 100 = 10% 050 = 5% 010 = 1% 005 = 0.5% 002 = 0.2% And _Z is a suffix indicating where a dike breach was modelled as follows: _breach = a breach of the Oyster River dike When reviewing flood hazard ratings along the Oyster River for a given AEP and SLR combination scenario, both the breach and no-breach flood levels and limits must be considered because the no-breach results will generally have higher flood hazard ratings within the diked river corridor.	
Datum	
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: N/A	
Contours	
Contour intervals have been selected to correspond to the hazard vulnerability classifications in the Australian flood hazard guidelines (AIDR, 2017) as follows: 0.3 m^2/s, 0.6 m^2/s, 1.0 m^2/s, 2.0 m^2/s, 4.0 m^2/s. It should be noted that the Australian flood hazard guidelines provide upper-bound water depths and velocities for each hazard classification and therefore cross-referencing with the depth and velocity mapping is required to perform a complete assessment.	
Quality Control	
Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.

Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.

Mapping Product Development

Refer to:

- Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions;
- Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions.

The flood hazard rating is the product of depth and velocity calculated using the hydraulic model output (AIDR, 2017).

The flood hazard ratings have been established based on the following:

- The appropriate AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- River flows have been increased over current (2020) extreme values to account for projected climate change impacts (+15% for year 2050 and 2100 and +30% for year 2200); and,
- Downstream boundary conditions assume the same ocean extreme static water level AEP as the river flow AEP and include an allowance for SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200).

Oyster River flood hazard ratings have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. Flood hazard ratings are provided for both scenarios independently. The location and size of the hypothetical dike breach is based on recommendations provided in the 2004 Fraser Basin Council Floodplain Mapping Guidelines and Specifications. In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

Courtenay River flood hazard ratings have been modelled for existing conditions.

Flood hazard rating mapping is only provided for areas in which 2-dimensional modelling has been performed (i.e., the Lower Oyster River and the Courtenay River.

The hydraulic model calculates the product of depth and velocity within each grid cell for each time step and the maximum value of the modelled depth-velocity product time series is then selected as the maximum flood hazard rating and plotted for mapping. Given that the depth-velocity product values are calculated at each time step throughout the modelled flood duration, the flood hazard rating may not necessarily occur at the time of maximum water depth or maximum flow velocity and may not be contemporaneous across the mapping (i.e.: maximum hazard ratings in different areas may occur at different times) The flood hazard rating data can be used for future quantitative flood risk and vulnerability assessments, multi-zone planning approaches (e.g., floodway and flood fringe) and for emergency preparedness planning.

Refer to the Technical Memorandum #5 - Section 3.3 Maximum Water Level Mapping, for information on how the river model results were converted into mapping; the flood hazard data was handled using similar techniques.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The maximum flood hazard rating mapping depicts the estimated flood hazard rating for various flood events within the map area where 2D modelling was performed. Flood hazard ratings greater than the estimated values may occur. The local government does not assume any liability for the accuracy of the estimated flood hazard ratings.

2. The flood hazard ratings correspond to the peak calculated values of the flood event and may not be contemporaneous across the mapping (i.e., maximum flood hazard ratings may occur in different areas at different times).
3. River flood hazard ratings are calculated using industry standard hydraulic modelling practices/software assuming open water flow conditions.
4. Flood hazard ratings shown in coastal areas are for river flow in isolation and effects of tidal and wave induced currents are not included.
5. The accuracy of the location of the flood limits as shown in the mapping are limited by the accuracy of the base topography. The flood limits are not established on the ground by legal survey.
6. This mapping does not provide information on the potential for site-specific flood-related hazards such as bank erosion, aggradation, debris accumulation or sudden shifts in river channel alignment. The mapping does not include all possible flood hazards which may include localized increases in flood levels due to groundwater, tributary streams, storm sewer systems or other phenomena and must be considered together with complementary studies including but not limited to Master Drainage Plans. Flood hazard ratings are not delineated for side streams or tributaries.
7. Users should note the dates of base mapping and ground and bathymetric surveys as well as the date of map publication. Subsequent developments or geomorphic changes may render map information obsolete. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for further information on the base mapping used for this project including dates of collection.

Maximum Flow Velocity Mapping – 2021/04/23

Description	
Raster GIS layer and polyline contours showing maximum flow velocities for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Maximum flow velocities are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total. Maximum flow velocity mapping is provided only for the Oyster River and the Courtenay River System.	
File Names and Formats	
List of geodatabase files: MaxVelocity_Raster.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River maximum flow velocity (raster)] MaxVelocity_Contours.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River maximum flow velocity contours (polyline)] MaxVelocity_Extents.gdb [ArcGIS file geodatabase of Oyster River and Courtenay River maximum flow velocity extents (polygon)] Feature classes of geodatabases follow the scenario naming convention of A_B_XXYYY_Z where A is the geodatabase name, B indicates the Oyster or Courtenay River and XX is the SLR scenario as follows: 00 = 0.0 m 05 = 0.5 m 10 = 1.0 m 20 = 2.0 m And YYY is the Annual Exceedance Probability as follows: 100 = 10% 050 = 5% 010 = 1% 005 = 0.5% 002 = 0.2% And _Z is a suffix indicating where a dike breach was modelled as follows: _breach = a breach of the Oyster River dike When reviewing flow velocities along the Oyster River for a given AEP and SLR combination scenario, both the breach and no-breach flood levels and limits must be considered because the no-breach results will generally have higher velocities within the diked river corridor.	
Datum	
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: N/A	
Contours	
Contours are provided at regular 0.5 m/s intervals as follows: 0.5 m/s, 1.0 m/s, 1.5 m/s, 2.0 m/s, 2.5 m/s, 3.0 m/s, 3.5 m/s, 4.0 m/s, 4.5 m/s, 5.0 m/s.	
Quality Control	
Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.
Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	

Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.

Mapping Product Development

Refer to:

- Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions;
- Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions.

The flow velocities have been established based on the following:

- The appropriate AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- River flows have been increased over current (2020) extreme values to account for projected climate change impacts (+15% for year 2050 and 2100 and +30% for year 2200); and,
- Downstream boundary conditions assume the same ocean extreme static water level AEP as the river flow AEP and include an allowance for SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200).

Oyster River flow velocities have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. Flow velocities are provided for both scenarios independently. The location and size of the hypothetical dike breach is based on recommendations provided in the 2004 Fraser Basin Council Floodplain Mapping Guidelines and Specifications. In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

Courtenay River flow velocities have been modelled for existing conditions.

Maximum flow velocity mapping is only provided for areas in which 2-dimensional modelling has been performed (i.e., the Lower Oyster River and the Courtenay River). Refer to the river modelling memorandum listed above for tabular maximum velocity data in areas where 1-Dimensional modelling has been performed.

The flow velocities correspond to the maximum for the entire storm event modelled across the full tidal range so may not correspond to the flow velocity at the maximum water level (i.e.: may occur during periods of high river flow and low tide) and may not be contemporaneous across the mapping (i.e.: maximum velocities in different areas may occur at different times).

Refer to the Technical Memorandum #5 - Section 3.3 Maximum Water Level Mapping, for information on how the river model results were converted into mapping. Flow velocity is a direct output from the modeling software and the data was handled using similar techniques.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The maximum flow velocity mapping depicts the estimated flow velocities for various flood events within the map area. Flow velocities greater than the estimated values may occur. The local government does not assume any liability for the accuracy of the estimated flow velocities.
2. The flow velocities correspond to the peak calculated values of the flood event and may not be contemporaneous across the mapping (i.e., maximum flow velocities may occur in different areas at different times).
3. River flow velocities are calculated using industry standard hydraulic modelling practices/software assuming open water flow conditions.
4. Flow velocities shown in coastal areas are for river flow in isolation and effects of tidal and wave induced currents are not included.

5. The accuracy of the location of the flood limits as shown in the mapping are limited by the accuracy of the base topography. The flood limits are not established on the ground by legal survey.
6. This mapping does not provide information on the potential for site-specific flood-related hazards such as bank erosion, aggradation, debris accumulation or sudden shifts in river channel alignment. The mapping does not include all possible flood hazards which may include localized increases in flood levels due to groundwater, tributary streams, storm sewer systems or other phenomena and must be considered together with complementary studies including but not limited to Master Drainage Plans. Flow velocities are not delineated for side streams or tributaries.
7. Users should note the dates of base mapping and ground and bathymetric surveys as well as the date of map publication. Subsequent developments or geomorphic changes may render map information obsolete. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for further information on the base mapping used for this project including dates of collection.

Maximum Water Depth Mapping – 2021/04/23

Description	
Raster GIS layer and polyline contours showing maximum water depths for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Maximum water depths are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total. **No freeboard allowance is included**.	
File Names and Formats	
List of geodatabase files: MaxDepth_Raster.gdb [ArcGIS file geodatabase of maximum water depths (raster)] MaxDepth_Contours.gdb [ArcGIS file geodatabase of maximum water depth contours (polyline)] MaxDepth_Extents.gdb [ArcGIS file geodatabase of maximum water depth flood extents (polygon)] Feature classes of geodatabases follow the scenario naming convention of A_XXYYY_Z where A is the geodatabase name and XX is the SLR scenario as follows: 00 = 0.0 m 05 = 0.5 m 10 = 1.0 m 20 = 2.0 m And YYY is the Annual Exceedance Probability as follows: 100 = 10% 050 = 5% 010 = 1% 005 = 0.5% 002 = 0.2% And _Z is a suffix indicating where a dike breach was modelled as follows: _breach = a breach of the Oyster River dike When reviewing water depths along the Oyster River for a given AEP and SLR combination scenario, both the breach and no-breach flood levels and limits must be considered because the no-breach results will generally have higher water depths within the diked river corridor.	
Datum	
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: N/A	
Contours	
Contour intervals have been selected to provide higher resolution in shallow water areas and to provide a distinction between nuisance flooding events (nominally < 0.3 m water depth) and more damaging and hazardous flooding events. Contours are provided for the following depths: 0.1 m, 0.3 m, 1 m, 2 m, 3 m. Contours for water depths greater than 3 m are not provided because water depths greater than 3 m are outside the coastal floodplain (i.e., they are flooded under existing conditions).	
Quality Control	
Coastal	
Mapping prepared by:	Max Scruton, P.Eng.
Mapping checked by:	Eric Morris, P.Eng.
Oyster River	

Mapping prepared by:	Yannic Brugman, P.Eng.
Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.

Mapping Product Development

Refer to:

- Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions;
- Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions; and,
- Technical Memorandum #4 – Coastal Modelling.

For coastal flood hazard mapping, the maximum water depths are depicted as the extreme static water level plus an allowance for future SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200); and an allowance for regional land uplift, or subsidence as appropriate minus the ground surface elevation at any point. Water depths do not include wave effects, including wave setup. Water depths are not depicted for overland flow/flooding due to waves.

For river floodplain mapping along the Oyster River and the Courtenay River/Tsolum River/Puntledge River, the water depths have been established based on the following:

- The appropriate AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- River flows have been increased over current (2020) extreme values to account for projected climate change impacts (+15% for year 2050 and 2100 and +30% for year 2200); and,
- Downstream boundary conditions assume the same ocean extreme static water level AEP as the river flow AEP and include an allowance for SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200).

Oyster River water depths have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. Water depths are provided for both scenarios independently. The location and size of the hypothetical dike breach is based on recommendations provided in the 2004 Fraser Basin Council Floodplain Mapping Guidelines and Specifications. In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

Courtenay River water depths have been modelled for existing conditions.

Refer to the Technical Memorandum #5 - Section 3.3, Maximum Water Level Mapping, for information on how the coastal and river model results were converted into mapping and merged. Note that the Maximum Water Depth Mapping as described in this section **does not include a freeboard allowance**.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The maximum water depth mapping depicts the estimated water depths for various flood events within the map area **WITHOUT freeboard allowance**. Flooding may occur to depths greater than the estimated water depths. The local government does not assume any liability for the accuracy of the estimated water depths.
2. The water depths correspond to the peak calculated values of the flood event and may not be contemporaneous across the mapping (i.e., maximum water depths may occur in different areas at different times).
3. River water depths are calculated using industry standard hydraulic modelling practices/software assuming open water flow conditions.

4. The accuracy of the location of the flood limits as shown in the mapping are limited by the accuracy of the base topography. The flood limits are not established on the ground by legal survey.
5. This mapping does not provide information on the potential for site-specific flood-related hazards such as bank erosion, aggradation, debris accumulation or sudden shifts in river channel alignment. The mapping does not include all possible flood hazards which may include localized increases in flood levels due to groundwater, tributary streams, storm sewer systems or other phenomena and must be considered together with complementary studies including but not limited to Master Drainage Plans. Water depths are not delineated for side streams or tributaries. Water depths due to tsunami are not depicted in the mapping.
6. Users should note the dates of base mapping and ground and bathymetric surveys as well as the date of map publication. Subsequent developments or geomorphic changes may render map information obsolete. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for further information on the base mapping used for this project including dates of collection.

Maximum Water Level Mapping – 2021/04/23

Description	
Maximum water level raster and polyline contours and point file of the Limit of the Wave Action Zone for 4 sea level rise (SLR) scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5%, 0.2%). Maximum water levels are also provided for two different flood protection scenarios for the Oyster River (dike breach and no dike breach) for the 1%, 0.5% and 0.2% annual exceedance probability events; 32 scenarios total. **No freeboard allowance is included**.	
File Names and Formats	
List of geodatabase files: MaxWL_Raster.gdb [ArcGIS file geodatabase of maximum water levels (raster)] MaxWL_Contours.gdb [ArcGIS file geodatabase of maximum water level contours (polyline)] MaxWL_Extents.gdb [ArcGIS file geodatabase of maximum water level flood extents (polygon)] MaxWL_LoWAZ.gdb [ArcGIS file geodatabase of limit of wave action zone (points)] Feature classes of geodatabases follow the scenario naming convention of A_XXYYY_Z where A is the geodatabase name and XX is the SLR scenario as follows: 00 = 0.0 m 05 = 0.5 m 10 = 1.0 m 20 = 2.0 m And YYY is the Annual Exceedance Probability as follows: 100 = 10% 050 = 5% 010 = 1% 005 = 0.5% 002 = 0.2% And _Z is a suffix indicating where a dike breach was modelled as follows: _breach = a breach of the Oyster River dike When reviewing water levels along the Oyster River for a given AEP and SLR combination scenario, both the breach and no-breach flood levels and extents must be considered because the no-breach results will generally have higher water levels within the diked river corridor.	
Datum	
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: CGVD2013	
Contour Intervals	
• 0.5 m intervals for Water Levels < 8.0 m Elevation • 1.0 m intervals for Water Levels > 8.0 m Elevation	
Quality Control	
Coastal	
Mapping prepared by:	Max Scruton, P.Eng.
Mapping checked by:	Eric Morris, P.Eng.
Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.

Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.
Mapping Product Development	

Refer to:

- Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions;
- Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions; and,
- Technical Memorandum #4 – Coastal Modelling.

For coastal mapping, the water level is calculated as the sum of:

- The appropriate annual exceedance probability extreme water static level as determined by probabilistic analyses of tides and storm surge;
- Allowance for future SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200);
- Allowance for regional land uplift, or subsidence; and,
- Estimated wave effects with an annual exceedance probability matching the annual exceedance probability of the extreme water level.

In the special case of topographic plateaus, the Limit of the Wave Action Zone is also provided in the mapping as a point. The limit of the Wave Action Zone is the location (distance along transect) of the transition between impulsive wave run-up on the foreshore and the overland flow on the topographic plateau.

For river floodplain mapping along the Oyster River and the Courtenay River/Tsolum River/Puntledge River, the water levels have been established based on the following:

- The appropriate AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- River flows have been increased over current (2020) extreme values to account for projected climate change impacts (+15% for year 2050 and 2100 and +30% for year 2200); and
- Downstream boundary conditions assume the same ocean extreme static water level AEP as the river flow AEP and include an allowance for SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200).

Oyster River flood levels have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. The flood levels and floodplain limit mapping is provided for both scenarios independently. The location and size of the hypothetical dike breach is based on recommendations provided in the Fraser Basin Council Floodplain Mapping Guidelines and Specifications (FBC, 2004). In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

Courtenay River flood levels have been modelled for existing conditions.

Refer to the Technical Memorandum #5 - Section 3.2, Regulatory Floodplain Mapping, for information on how the coastal and river model results were converted into two-dimensional mapping, post-processed and merged. Note, however, the following differences regarding how the maximum water level mapping has been processed:

- The Maximum Water Level Mapping as described in this section **does not include a freeboard allowance;**
- “Islands” within the floodplain have not been removed from the raster dataset but have been removed from the “limit” polyline using the same techniques used for post-processing the regulatory floodplain mapping; and
- Water level contours have not been smoothed.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The maximum water level mapping depicts the estimated water levels for various flood events within the map area **WITHOUT freeboard allowance**. Flooding may occur to levels above the estimated water levels. The local government does not assume any liability for the accuracy of the estimated water levels.
2. The water levels correspond to the peak calculated values of the flood event and may not be contemporaneous across the mapping (i.e., maximum water levels may occur in different areas at different times).
3. River water levels are calculated using industry standard hydraulic modelling practices/software assuming open water flow conditions.
4. The accuracy of the location of the flood limits as shown in the mapping is limited by the accuracy of the base topography. The flood limits are not established on the ground by legal survey.
5. This mapping does not provide information on the potential for site-specific flood-related hazards such as bank erosion, aggradation, debris accumulation or sudden shifts in river channel alignment. The mapping does not include all possible flood hazards which may include localized increases in flood levels due to groundwater, tributary streams, storm sewer systems or other phenomena and must be considered together with complementary studies including but not limited to Master Drainage Plans. Water levels are not delineated for side streams or tributaries. Water levels due to tsunami are not depicted in the mapping.
6. Users should note the dates of base mapping and ground and bathymetric surveys as well as the date of map publication. Subsequent developments or geomorphic changes may render map information obsolete. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for further information on the base mapping used for this project including dates of collection.

Maximum Wave Heights in Coastal Floodplain Mapping – 2021/04/23

Description

Polyline contours of significant wave height in the coastal floodplain for 4 SLR scenarios (0 m, 0.5 m, 1.0 m, 2.0 m) and 5 annual exceedance probabilities (10%, 5%, 1%, 0.5% and 0.2%); 20 scenarios total. Maximum Wave Height in the Coastal Floodplain Mapping is provided for coastal areas only.

File Names and Formats

List of geodatabase files:

MaxWV_Contours.gdb [ArcGIS file geodatabase of maximum wave height contours (polyline)]

Feature class of geodatabase follows the scenario naming convention of MaxWV_XXYYY where XX is the SLR scenario as follows:

00 = 0.0 m
05 = 0.5 m
10 = 1.0 m
20 = 2.0 m

And YYY is the Annual Exceedance Probability as follows:

100 = 10%
050 = 5%
010 = 1%
005 = 0.5%
002 = 0.2%

Datum

Horizontal Datum: NAD83(CSRS), UTM Zone 10

Vertical Datum: N/A

Contour Intervals

Various. Wave heights have been calculated for water depths at nominal 0.1 m increments which results in variable intervals between wave height contours.

Quality Control

Mapping prepared by:	Max Scruton, P.Eng.
Mapping checked by:	Eric Morris, P.Eng.

Mapping Product Development

Refer to:

- Technical Memorandum #4 – Coastal Modelling

Wave height contours have been provided in the coastal floodplain, which is the flooded area shoreward of the existing normal highest tide (higher-high water large tide, HHWLT). Wave heights are not depicted for overland flooding areas at topographic plateaus.

The water levels used for the modelling of the maximum wave heights in the coastal floodplain are the extreme static water level plus an allowance for future SLR as appropriate (+0.5 m for the year 2050, +1.0 m for the year 2100 and +2.0 m for the year 2200); and an allowance for regional land uplift, or subsidence as appropriate. Wave heights in the floodplain have been estimated based on the formulas developed by Goda (Goda, 2010). These formulas account for the effects of wave shoaling and breaking on wave heights.

The maximum wave heights in the coastal floodplain have been calculated using one-dimensional modelling techniques using the same transects used for wave effect (nearshore wave) modelling. The calculated wave heights are only considered to be accurate on the transect and have been extrapolated to other areas within each coastal zone using an algorithm based on water depth. In this algorithm, each water depth contour (at nominal 0.1 m increments) is assigned a wave height based on the value of the wave height on the transect where the water depth contour crosses the transect. In cases where a water depth contour crosses a transect several times, the water depth contour is conservatively assigned a wave height at the most seaward crossing location on the transect.

Notes and Limitations

The following limitations should be considered when interpreting and using the mapping:

1. The maximum wave heights in the coastal floodplain mapping depicts the estimated wave heights for various flood events within the map area. Wave heights greater than the estimated values may occur. The local government does not assume any liability for the accuracy of the wave heights.
2. As noted in Goda (2010), a feature of the formulas is a prediction of wave heights at the shoreline where the water depth, as per the water depth mapping, is zero. To quote Goda: *The presence of finite wave heights there (at the shoreline) is due to the increase in actual water depth due to wave setup and surf beats. The motion of water around the shoreline, however, is more intensive than that of ordinary wave motion corresponding to the height estimated because of the up-rushing and down-rushing surging motion of water there. Therefore, the estimated wave height at [the shoreline] should be regarded as an apparent one which does not adequately represent the magnitude of the wave action*. The estimated wave heights in the mapping should therefore not be used for design of coastal structures or other works and are considered to be suitable only for hazard assessment or other uses where an indication of relative wave action is needed.
3. Wave heights are maximum significant wave heights as per Goda ($H_{1/3}$) corresponding to the peak of the storm event for the ensemble of storm directions modelled and may not be contemporaneous across the mapping (i.e., maximum wave heights may occur in different areas at different times).
4. The accuracy of the wave heights as shown on the mapping is limited by the base topography and the 1D to 2D conversion algorithm as described in “Mapping Product Development”.
5. The wave height in the coastal floodplain modelling and mapping have been prepared at a regional scale, and do not resolve small-scale variations in shoreline exposure, topography, and bathymetry. Wave heights in the coastal floodplain have been calculated based on one-dimensional modelling in which the shoreline is divided into "Coastal Zones" and wave heights are calculated at discrete locations (transects) within each Coastal Zone. When preparing two-dimensional mapping based on the coastal model results, it is assumed that the results at these transect locations are representative of the adjacent locations within the zone and wave heights are proportional to water depth. Wave heights calculated at locations other than the transect locations may differ from those depicted on the map due to the effects of refraction, diffraction, and varying bathymetry which are not accounted for in the one-dimensional modelling.
6. Wave heights as a result of tsunami are not included.
7. Users must note the dates of base mapping, ground or bathymetric surveys and issue of mapping relevant to dates of development in the map area. Changes within the floodplain or in offshore areas will affect wave heights and render site-specific map information obsolete.

Regulatory Floodplain Mapping Products – 2021/04/23

Description
Set of 163 regulatory floodplain maps at 1:4000 scale on 11"X17" paper. The regulatory floodplain maps show: • Floodplain Limits • Flood Levels (labelled) • River Flood Elevation Contour The maps also include a "hillshade" background generated from the LiDAR that gives an indication of the topography, and road and parcel boundaries. The maps were prepared in general conformance with the provincial guidelines (FLNR, 2018).
File Names and Formats
Regulatory Coastal Flood Maps.pdf (Adobe Portable Document Format) List of geodatabase files: RegCoastalFloodExtents.gdb [ArcGIS File Geodatabase Feature Class including features for flood extents (polygon)] RegCoastalFloodLimit.gdb [ArcGIS File Geodatabase Feature Class including features for Floodplain Limit (polyline)] RegCoastalFloodContours.gdb [ArcGIS File Geodatabase Feature Class including features for River Flood Elevation Contours (polylines)] RegCoastalZones.gdb [ArcGIS File Geodatabase Feature Class including features for Coastal Zone Boundaries (polylines)]
Datum
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: CGVD2013
Notes on Map Data, Data Sources and Dates:
The following additional mapping data is shown on the regulatory floodplain mapping: 1. Cadastral information supplied by ParcelMap BC / Land Title and Survey Authority of British Columbia (accessed September 30, 2020). 2. Property addressing and landmarks supplied by Comox Valley Regional District (accessed April 9, 2020). 3. Hydrology features supplied by National Hydrology Network (accessed June 29, 2017). 4. Parks, Ecological Reserves and Protected areas supplied by DataBC and Comox Valley Regional District (accessed May 16, 2019). 5. Road features supplied by Digital Road Atlas (accessed March 4, 2020). 6. Building footprints in the City of Courtenay supplied by the City of Courtenay (accessed June 4, 2020). 7. Building footprints outside the City of Courtenay derived from 2018 Orthophoto (CVRD). 8. Topography collected by LiDAR. Sources and dates as follows: • South of Oyster River: GeoBC (2018/2019) • North of Oyster River: Strathcona Regional District (2016)
Contour Intervals
• 0.5 m water level intervals for Water Levels < 8.0 m Elevation • 1.0 m water level intervals for Water Levels > 8.0 m Elevation
Quality Control

Coastal	
Mapping prepared by:	Max Scruton, P.Eng.
Mapping checked by:	Eric Morris, P.Eng.
Oyster River	
Mapping prepared by:	Yannic Brugman, P.Eng.
Mapping checked by:	Dave Zabil, P.Eng.
Courtenay River	
Mapping prepared by:	Alisson Seuarz, P.Eng.
Mapping checked by:	Craig Sutherland, P.Eng.

Mapping Product Development

Refer to:

- Technical Memorandum #3A – Fluvial Modelling – Oyster River Hydrology and Model Assumptions;
- Technical Memorandum #3B – Fluvial Modelling – Courtenay River Hydrology and Model Assumptions; and,
- Technical Memorandum #4 – Coastal Modelling.

Coastal Floodplain Mapping

For the coastal floodplain mapping, the flood levels have been established using the "probabilistic method" in the provincial guidelines (FLNR, 2018) as the sum of:

- The 0.5% AEP extreme static water level as determined by probabilistic analysis of tides and storm surge;
- Allowance for future Sea Level Rise to the year 2100 (+1.0 m);
- Allowance for regional land uplift, or subsidence to the year 2100;
- Estimated wave effects in the Designated Storm with a 0.5% AEP; and
- A freeboard of 0.6 metres.

For the special case of topographic plateaus, the flood level has been established as the elevation of the seaward crest of the plateau plus freeboard, or the maximum elevation of the overland flooding zone plus freeboard, whichever is greater.

Flood levels have been established based on one-dimensional modelling in which wave effects are calculated at discrete locations (transects) along the shoreline. In this modelling approach, the shoreline is divided into a series of "coastal zones" with similar topography, bathymetry, and wave exposure. A single transect location is then defined within each coastal zone. The transect location is selected to be representative of the topography, bathymetry, and wave exposure of the zone. The one-dimensional modelling results have been converted into two-dimensional mapping as follows:

- Each coastal zone is assigned a flood level based on the flood level calculated at the representative transect. This approach, relative to interpolation of flood levels between transects, allows for explicit definition of the flood level selected for a given area;
- Inland coastal zone boundaries are mapped to ensure that the floodplains within each coastal zone are contiguous with the sea. In practice, this means that the zone boundaries follow the topography so that flooded areas are connected to the source of flooding.

Some examples of coastal zones and coastal zone boundaries are provided in Figure 1B of Appendix B; the examples are described as follows:

Example A – Coastal Zone 11: This is an example of a coastal zone where the zone boundaries have been dictated mostly by topography since the offshore wave conditions are reasonably uniform along this stretch of shoreline. The boundaries have been placed at a road right-of-way to the west and a property boundary to the east. The zone boundaries extend inland beyond the floodplain limit.

Example B – Coastal Zone 4: This is an example of a coastal zone where the inland alignment of the western zone boundary has been selected such that the flooding from adjacent Coastal Zone 3 is contiguous with the sea. The zone boundary has been selected to follow road rights-of-way and property boundaries.

Example C – Coastal Zones 95, 96 and 97: This is an example of a series of coastal zones where the zone boundaries have been dictated by both topography and wave exposure. Coastal Zone 95 is more sheltered from waves than the other two zones and has the flattest topography. Coastal Zone 97 has the steepest shoreline topography. As with the other examples, the zone boundaries have been selected to follow road rights-of-way and property boundaries.

Some limitations with respect to the coastal modelling and mapping approach are as follows:

- The modelling and mapping have been performed at a regional scale, and do not resolve small-scale variations in shoreline topography. Flood levels calculated at locations other than the transect locations may differ from those depicted in the mapping.
- The modelling and mapping techniques do not account for wave overtopping and the relative conveyance capacity and storage volume of inland water courses and drainage systems. Instead, inland areas are assumed to flood to the flood level of the coastal zone. As a result, the inland flood levels and floodplain limits associated with coastal flooding depicted in the mapping are considered to be conservative values.

River Floodplain Mapping

For river floodplain mapping along the Oyster River and the Courtenay River/Tsolum River/Puntledge River, the flood levels have been established as 0.5% AEP modelled flood profile plus 0.6 m of freeboard based on the following:

- 0.5% AEP peak instantaneous flow from flood frequency analysis using historical data recorded by Water Survey of Canada;
- An allowance of +15% added to the peak instantaneous flow to account for projected climate change impacts to the year 2100;
- The 0.5% AEP extreme static water level plus allowance for Sea Level Rise to the year 2100 at the estuary (+1.0 m); and
- A freeboard of 0.6 metres.

Oyster River flood levels have been modelled for two scenarios: a scenario in which dikes are intact and do not overtop and a scenario in which a hypothetical dike breach occurs. The flood levels and floodplain limits depicted in the mapping are the maximum values of the two scenarios. The location and size of the hypothetical dike breach is based on recommendations provided in the Fraser Basin Council Floodplain Mapping Guidelines and Specifications (FBC, 2004). In the no-breach scenario, it is assumed that the Glenmore Dike is sufficient to contain the river flow on the river side of the dike, and also that the Glenmore Road Embankment will act as a dike, resulting in maximum flood levels on the river side of the dike and road. In the breach scenario, it is assumed that the Glenmore Dike and the Glenmore Road Embankment would prevent flow from returning to the river, resulting in maximum flood levels in the floodplain to the north of the dike and road.

Courtenay River flood levels have been modelled for two scenarios: existing conditions and a scenario with additional proposed flood protection works in place. The proposed flood protection alignment is based on the Flood Protection Option 2 ring dike presented in the City of Courtenay Integrated Flood Management Strategy (KWL, 2013). The flood levels and floodplain limits depicted on the map are the maximum values of the two scenarios.

The river mapping was created as follows:

- For the Lower Oyster River, the two-dimensional output from the river modelling software package (HEC-RAS) was imported into GIS software and the freeboard allowance was added. In order to confirm that the flood extents with the freeboard allowance added were reasonable from a hydraulic perspective, a model run was conducted at a higher flow level which resulted in a river flood level which approximately matched the level with freeboard; the floodplain limits obtained from both techniques where then compared to confirm they are similar;
- For the Upper Oyster River, the flood extent in the 1D model area was created using the following procedure:
    1. Visually delineated the full width of the valley bottom based on the topography showing the location higher ground.
    2. Manually created a flood contour polyline at each cross-section location, extending the full width of the valley.

3. Assigned the 1D modelled water level plus freeboard value to each polyline.
4. Created a flood level surface raster from the polyline locations with elevations.
5. Created 0.5 m flood contour isolines throughout the surface.
6. Intersected flood level raster with topography raster to create a flooded areas with freeboard polygon.
7. Visually reviewed flood polygon and noted locations of what appear to be backwatered low spots separated by high ground from the river. Revised the alignment of the 0.5 m flood contour polylines to reflect the backwatering condition (by extending 0.5 m polylines from the location where the backwatered area is connected to main channel up and around the backwatered area).
8. Repeated Steps 3, 4, and 5 with updated 0.5 m flood contour isolines to create the updated flooded raster with lower water levels in the backwatered areas.
9. Intersected the updated flood level raster with the topography raster to create an updated flooded areas with freeboard raster. Removed floodplain flooded areas that are disconnected from the river flooded area (isolated pools of water).
10. From the raster created in Step 9, generated 1m flood contours with freeboard.

- For the Courtenay River system, the one-dimensional/two-dimensional maximum water level output from the river modelling software package (MIKE Flood) developed in 2013 for the City of Courtenay Integrated Flood Management Study (KWL, 2013) was imported into GIS software, adjusted to CVGD 2013 datum and then the freeboard allowance was added.

Post-Processing and Mapping Integration

The flood extents and limits were post-processed to remove small "islands" within the floodplain and flooded areas that are disconnected from the coastal and river flooded areas. Islands were removed using an algorithm based on the elevation of the island above the flood level and the size of the island. Any islands that are less than 3 m above the surrounding flood level on average or are less than 1000 m^2 in area were removed and the area is depicted as flooded.

Once the coastal and river floodplain limit lines, floodplain surfaces and extents were established, the datasets were merged using GIS software to create seamless floodplain mapping in coastal and river areas. This involved selecting the governing (highest) flood levels in areas where the coastal and river modelling overlap.

Water level contours (isolines) have been smoothed based on engineering judgement.

Notes and Limitations

The following limitations should be considered when interpreting and using the maps:

1. Regulatory floodplain maps are administrative tools which depict the estimated flood levels and floodplain limits for a designated storm and flood events within the map area. Flooding may occur to levels above the estimated flood levels and outside the estimated floodplain limits. The local government does not assume any liability for the accuracy of the estimated flood levels and floodplain limits shown on this map. A site-specific analysis should be conducted to assess the potential for flooding in areas outside/near the mapped floodplain limits.
2. The flood levels and floodplain limits depicted on this map have been developed using a methodology which is consistent with the BC Flood Hazard Area Land Use Management Guides (FLNR, 2018 - the "provincial guidelines") for the development of flood construction levels, the Federal Flood Mapping Framework (NRC, 2018) including relevant guidelines, the Engineers and Geoscientists BC Flood Mapping Guidelines (EGBC, 2017) and the Fraser Basin Council Floodplain Mapping Guidelines and Specifications (FBC, 2004).
3. The flood levels and floodplain limits correspond to the peak calculated values of the flood event and may not be contemporaneous across the mapping (i.e., maximum flood levels may occur in different areas at different times).
4. River flood levels are calculated using industry standard hydraulic modelling practices/software assuming open water flow conditions. The river flooding events depicted on this map have a statistical annual exceedance probability of 0.5% (the flood which is estimated to be equalled or exceeded on average once every 200 years) and occur at an ocean still water level with an annual exceedance probability of 0.5%. River flows have been

increased by 15% over current (2020) extreme values to account for projected climate change impacts and ocean still water levels have been increased by 1.0 m over current extreme static water levels to account for the effects of sea level rise. River flood levels and floodplain limits include a freeboard allowance of 0.6 m.

5. The accuracy of the location of the floodplain limit as shown on this map is limited by the accuracy of the base topography and the scale at which the map is produced. The floodplain limits are not established on the ground by legal survey. Existing ground elevations, building and floodproofing elevations should be based on field survey using established benchmarks. The legal boundaries shown on this map are based on cadastral information and are for illustration only. A site-specific legal survey is required to reconcile property locations.
6. This flood map does not provide information on the potential for site-specific flood-related hazards such as bank erosion, aggradation, debris accumulation or sudden shifts in river channel alignment. The map does not include all possible flood hazards which may include localized increases in flood levels due to groundwater, tributary streams, storm sewer systems or other phenomena and must be considered together with complementary studies including but not limited to Master Drainage Plans. Flood levels and floodplain limits are not delineated for side streams or tributaries. Flood levels and floodplain limits due to tsunami are not depicted on the map.
7. Users should note the dates of base mapping and ground and bathymetric surveys as well as the date of map publication. Subsequent developments or geomorphic changes may render map information obsolete. Refer to Technical Memorandum #1 – Coastal and River Base Map Development for further information on the base mapping used for this project including dates of collection.

Setback Mapping – 2021/04/23

Description	
Coastal Setback polyline based on the provincial guidelines (FLNR, 2018). River Setbacks are not depicted. Potential Setback Reduction or Increase polyline which is intended to serve as a screening tool when making land use planning decisions. Field investigations by qualified professionals should be conducted to confirm local conditions and setback requirements.	
File Names and Formats	
List of geodatabase file(s): Coastal_Setbacks.gdb [ArcGIS file geodatabase of coastal setbacks (polyline)]	
Datum	
Horizontal Datum: NAD83(CSRS), UTM Zone 10 Vertical Datum: CGVD2013	
Contour Intervals	
Not applicable.	
Quality Control	
Mapping prepared by:	Jamie Rodstrom, EIT
Mapping checked by:	Eric Morris, P.Eng.
Mapping Product Development	
Refer to: • Technical Memorandum #2 – Fluvial and Coastal Geomorphology • Technical Memorandum #4 – Coastal Modelling. Coastal setbacks have been defined for the same sea level rise and storm scenario as depicted in the regulatory floodplain mapping: 1 m of SLR and 0.5% AEP water level and storm event. Setbacks are depicted as the greater of 15 m from the future estimated natural boundary of the sea with 1 m of SLR, or landward of the location where the natural ground elevation contour is equivalent to the floodplain limit with 1 m of SLR. A freeboard allowance of 0.6 m is included when estimating the floodplain limit with 1 m of SLR. For the special case of topographic plateaus, the floodplain limit has been established as the elevation of the seaward crest of the plateau plus freeboard, or the elevation of the shoreward extent of overland flooding plus freeboard, whichever is greater. The location of the future estimated natural boundary of the sea with 1 m of SLR is estimated as the elevation of the wave runup exceeded by 50% of the waves ($R_{50\%} = R_{2\%}/2.2$) for the 0.5% AEP storm event (Ausenco Sandwell, 2011). For areas with coastal bluffs that are steeper than 3 (Horizontal) to 1 (Vertical) and have a height in excess of 3 m, setbacks have been determined with the following criteria, illustrated in Figure 2B of Appendix B: • If the future estimated natural boundary is located at least 15 m seaward of the toe of the bluff, then no special bluff setback has been defined and the setback is defined as per above. • If the future estimated natural boundary is located 15m or less seaward of the toe of the bluff, then the setback from the future estimated natural boundary has been located at a horizontal distance of 3 times the height of the bluff, measured from 15 m landwards from the location of the future estimated natural boundary. Lengths of shoreline which may warrant a reduction or increase in setbacks have been identified in the mapping. Potential extraordinarily erodible or eroding areas have been identified as locations where setbacks could be increased while potential non-erodible areas have been identified as locations where setbacks could be reduced. Refer to Technical Memorandum #2 – Fluvial and Coastal Geomorphology for further information.	
Notes and Limitations	

The following limitations should be considered when interpreting and using the mapping:

1. The setback mapping has been performed entirely as a desktop exercise based on provincial guidelines for setback mapping (FLNR, 2018). No field investigations have been conducted to confirm local site conditions or the adequacy of the setbacks depicted in the mapping; larger setbacks may be needed due to local erosion hazards. Terrestrial cliff and slope stability hazards have not been reviewed when preparing the setback mapping. Field investigations by qualified professionals should be conducted to confirm local conditions and setback requirements.
2. The shoreline erodibility assessment which supported the identification of lengths of shoreline which may warrant potential setback increase or reduction was entirely a desktop exercise and relied on the interpretation of orthophotos, mapping and reports by others that provided only partial coverage of the study area. As such, the results should be viewed as indicative only. The assessment is intended to serve as a potential screening tool when making land use planning decisions. Field investigations by qualified professionals should be conducted to confirm local conditions and setback requirements.
3. Setbacks have not been defined for tsunami hazards.
4. Refer to Technical Memorandum #5 - Table 3 - Regulatory Floodplain Mapping Products for additional relevant notes and limitations.