10. **Construction water management**

10.1 **Water-related assessments**

The Project’s water-associated assessments of effects are presented in four key reports:

- Construction Water Assessment Report
- Operational Water Assessment Report (see Section 21)
- Freshwater Ecology Assessment Report (see Section 11)
- Marine Ecology Assessment Report (see Section 13)

The Construction Water and Operational Water Assessment Reports are co-authored by the Project’s specialists to provide a comprehensive, integrated assessment for each phase of the Project.

The Construction Water Assessment Report contains:

- Erosion and Sediment Control (ESC); and
- Construction Water Management (for temporary structures).

The Operational Water Assessment Report, which is discussed in Section 21 below, contains:

- Hydrology;
- Stormwater Quality and Quantity; and
- Flood Modelling.

The freshwater and marine ecologists have also contributed to the assessment reports listed above by identifying sensitive environments and mitigation or management requirements for their own assessments.

10.2 **Construction Water Assessment**

The Construction Water Assessment Report provides an assessment of the environmental effects of construction-related water on the receiving environment during the construction stage of the Project.

The Construction Water Assessment Report describes the methods and practices that will be implemented to minimise environmental effects. The assessment has been undertaken based on the identification of construction-related water issues and principles, the development of methodologies for key construction activities, and the assessment of environmental risks associated with sediment yield and the eventual sediment loads in the receiving environment.

The following is a summary of the issues and potential effects identified in the Construction Water Assessment Report. This summary and the Report subsequently inform the recommended mitigation contained in Section 28 and will inform the Project conditions.
10.3 Assessment framework

10.3.1 Erosion and sediment control Focus Areas

The Project crosses two distinct types of terrain:

- Hill Country – including the prominent landforms of Pūhoi, Schedewys Hill and Moirs Hill; and
- Flat Country – including the relatively flat areas from Perry Road to Warkworth along the Mahurangi River Right Branch.

To assist with the assessment of effects relating to erosion and sedimentation, the Construction Water team selected two Focus Areas in the Moirs Hill Road Sector and the Perry Road Sector to represent the Hill Country and Flat Country terrain types respectively across the Project area. The locations of the Focus Areas are shown in Figure 10-1 below and further details are provided in Section 6.2 of the Construction Water Assessment Report.

Section 6.2 of the Construction Water Assessment Report and the associated assessment of effects (in Section 9 of that report) consider that the soil properties, geology, topography, ground slopes and climate in each of the Focus Areas are representative of those for the remainder of the Project area. The Construction Water team determined the effects for the total Project area by applying appropriate scaling factors to modelled results for these Focus Areas. The Construction Water team also applied learnings from other construction projects, including the NGTR and Long Bay.\(^{82}\)

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\(^{82}\) Refer to Section 5.4 of the Construction Water Assessment Report for further information on the Long Bay development.
Figure 10-1: Earthworks Focus Areas
10.3.2 Construction methodology and sequencing

The Construction Water Assessment Report uses the construction methodology developed for the Project (refer to Section 6 of this AEE). This construction methodology includes a mass haul calculation, which includes volumes and areas of earthworks likely to be required. It is a practical approach to achieving the associated bulk earthworks in these locations, and includes the disposal of surplus fill within the designation. Indicative spoil disposal sites are shown on the ESC Drawings 011-025 included in Volume 4.

The Construction Water team calculated sediment yields for a 5 and a 10 year construction scenario to provide options for the construction of the Project based on the recommended open area of earthworks limitations.

10.3.3 Discharge locations

The Construction Water team has developed conceptual Erosion and Sediment Control Plans (ESCPs) for the Focus Areas to demonstrate the ability to install appropriate ESC devices for the Project, and the team has investigated and reviewed the locations of the sediment retention devices as part of the development of the site specific construction erosion and sediment control design. Finalised CESC Ps will be developed during the detailed design phase.

From an overview perspective, all construction-related runoff discharges are either to a land environment or to a freshwater system after treatment. Discharge to land is considered by the Construction Water team to be beneficial in that a land-based buffer zone will provide a ‘polishing’ treatment for the discharged runoff. Where discharges are to freshwater systems, the outlet will be protected with geotextile and riprap material in the immediate vicinity of the outlet to minimise erosion of the stream bank and bed.

There are no specific freshwater environments within the Project area where ecological constraints preclude discharges. There will be no direct discharges from sediment retention devices into the CMA.

10.4 Existing water environment

The Project area is characterised by steep topography with 45% of the earthworks area having over 15 degrees in slope. The geology differs between the Hill Country and the Flat Country, and the dominance of the Pakiri Formation is noted within the Hill Country. While the geology across the Project area highly erodible, the underlying Pakiri Formation will allow the more competent rock to be worked over the winter period.

Both the Pūhoi and Mahurangi River catchments provide a range of ecological, recreational and resource functions and are suitable for a range of uses. They are sensitive to further additions of sediment and nutrients.

The Mahurangi Action Plan recognises sediment deposition as an environmental concern in the Mahurangi Estuary and Harbour, with existing pre-construction sediment deposition from catchment land uses currently impacting upon the estuary.
A more detailed description of the two catchments and the features of the existing environment that influence water management are provided in Section 3 of the Construction Water Assessment Report. Additional information regarding the existing environment in both of the catchments is provided in Sections 11.1 and 12.2 of this AEE, respectively.

### 10.4.1 Rainfall

Table 10-1 provides an overview of the rainfall data for the Project area. Rainfall in the Mahurangi River catchment typically exceeds that of the Pūhoi River catchment by 10%. This difference is not considered significant from an ESC perspective. All sediment yield modelling used the higher rainfall figures.

**Table 10-1: Comparison of 100 year ARI 24hr rainfall depths along the Project route**

<table>
<thead>
<tr>
<th>2013 (current climate)</th>
<th>Pūhoi rainfall (mm)</th>
<th>Mahurangi rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARI (year)</td>
<td>TP108</td>
<td>HIRDS V3</td>
</tr>
<tr>
<td>100</td>
<td>280</td>
<td>256</td>
</tr>
<tr>
<td>10</td>
<td>190</td>
<td>153</td>
</tr>
<tr>
<td>2</td>
<td>115</td>
<td>101</td>
</tr>
</tbody>
</table>

### 10.4.2 Geomorphology and erosion

Site visits have revealed evidence of existing erosion in the Project area, including mass movement and soil slip. The existing erosion forms part of the sediment yield that currently enters the receiving environments.

### 10.4.3 Water quality

Water quality sampling was undertaken for dry and wet weather conditions at 11 freshwater sites within the Project area (refer to Figure 8 in the Construction Water Assessment Report for locations). Results were compared with existing Auckland Council water quality monitoring data to develop a broad picture of freshwater quality throughout the Project area.

Overall, the existing Auckland Council data and the Project monitoring data identify that water quality is reasonably good across both freshwater catchments. The data did not indicate significant differences between the Mahurangi and Pūhoi River catchments.

In general, both catchments are characterised by elevated suspended solids and turbidity, which can reduce water clarity. Metals are generally in low concentrations and hydrocarbon concentrations are very low. Nutrients (nitrogen and phosphorous) are occasionally elevated above guideline levels.
Sediment quality is good in both the freshwater and marine environments of the Mahurangi and Pūhoi River catchments. Saline water quality is good in the Mahurangi Estuary with slight elevations of total suspended solids (TSS) and nutrients. No water quality data is available for the Pūhoi Estuary but it is anticipated to also have good water quality as the Project freshwater monitoring data indicates that both catchments are similar in water and sediment quality.

Water quality in the Mahurangi River is suitable for preservation of aquatic ecology values and suitable for stock watering, irrigation and fish farming uses. However, the catchment is sensitive to further increases in sediment and nutrients as these are already elevated and are causing concern in some areas.

### 10.4.4 Potential issues for construction water management

From a construction water management perspective, the potential environmental issues for the Project are considered to be:

- **Changes to water quality** – Assessments have been undertaken (refer to Section 6.1.3 of the Freshwater Ecology Assessment Report and Section 4.1 of the Marine Ecology Assessment Report) to identify changes in water quality that may potentially occur as a result of the Project construction. Such changes include the discharge of sediment from earthworks, discharge of other contaminants and the discharge of sediment from stream activities; and

- **Changes to ecology and habitat** – These changes have been assessed in the Freshwater Ecology Assessment Report and the Marine Ecology Assessment Report, and a summary of key issues and effects for each is presented in Sections 11 and 12 of this AEE. Key potential effects arise from changes to flora and fauna and changes to habitat.

Erosion occurs when the surface of the land is worn away by the action of water, wind or geological processes. Through the erosion process, soil particles are dislodged, generally by rainfall and surface water flow. As rain falls, water droplets concentrate and form small flows. As this flow moves down a slope, the combined energy of the rain droplets and the concentration of flows have the potential to dislodge soil particles from the surface of the land.

Sedimentation occurs when these soil particles are deposited. The amount of sediment generated depends on the erodibility of the soil, the energy created by the intensity of the rain event, the site conditions and the area of bare earth or unstable ground open to rainfall.

### 10.5 Project ESC

Erosion and sediment control measures will be implemented during the construction phase of the Project to manage the discharge of sediment from the Project and avoid, remedy or mitigate effects on the freshwater and coastal receiving environments.
10.5.1 ESC guidelines

Technical Publication 90 (TP90) provides information on the appropriate use, design and construction of ESC devices and practices. It represents the industry standard and provides the accepted design criteria for ESC measures.

The NZTA has developed an ESC standard for State highway infrastructure. This is a draft and is currently being finalised. The general principles of the standard have been incorporated into the Project ESC approach, which is based on TP90.

10.5.2 ESC principles and design criteria

The ESC for the Project has been described in Section 6 above and will be undertaken and implemented with a hierarchy and priority order as follows:

- Prevention;
- Capture;
- Minimisation; and
- Staging and Sequencing of Works.

Refer to Section 6.6 above for further information regarding the proposed ESC for the Project.

Table 10-2 summarises the principles and key design criteria developed for ESC for the Project (refer to Section 5 of the Construction Water Assessment Report).

**Table 10-2: ESC principles and design criteria**

<table>
<thead>
<tr>
<th>Device / methodology</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erosion control measures</td>
<td></td>
</tr>
<tr>
<td>Clean water diversions (CWD)</td>
<td>Clean water diversion channels and bunds will be designed to cater for the 20 year ARI rain event.</td>
</tr>
<tr>
<td>Construction staging and sequencing</td>
<td>Staging and sequencing are both important non-structural measures and will be implemented within the open area limitations. Details of the staging and sequencing of works will be detailed within the CESCPs.</td>
</tr>
<tr>
<td>Contour drains</td>
<td>Contour drains will be designed and implemented in accordance with TP90.</td>
</tr>
<tr>
<td>Device location</td>
<td>All ESC devices should be located outside the 20 year ARI flood level unless no other viable alternative exists.</td>
</tr>
<tr>
<td>Dirty water diversions (DWD)</td>
<td>Dirty water runoff diversion channels will be sized to cater for the 20 year ARI rain event. Sediment sumps will be installed in all diversion channels</td>
</tr>
<tr>
<td>Pipe drop structures / Flumes</td>
<td>Flumes will be used in accordance with TP90 to safely transfer runoff from the top to the bottom of the batter slopes.</td>
</tr>
</tbody>
</table>

Refer to Section 2.2.1 and Appendix A of the Construction Water Assessment Report.
### Device / methodology

<table>
<thead>
<tr>
<th>Device / methodology</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock check dams</td>
<td>Rock check dams will be designed and implemented in accordance with TP90.</td>
</tr>
</tbody>
</table>
| Stabilisation for erosion and dust management purposes     | Progressive and rapid stabilisation of disturbed areas using top soil (where necessary) and seed, mulch and geotextiles will be ongoing throughout the Project. Stabilisation will be undertaken with three key purposes:  
  - To achieve the area of open earthwork limitations as specified within consent conditions for the project;  
  - To reduce the area of open earthworks within higher risk locations to assist with a reduction in sediment generation; and  
  - In response to the adaptive monitoring programme to address any potential effects or undesirable monitoring trends. |
| Stabilised entrance ways                                   | Stabilised entrance ways will be established at all ingress and egress points of the site from a public road network.                                                                                       |

### Sediment control measures

<table>
<thead>
<tr>
<th>Sediment control measures</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Container impoundment systems</td>
<td>Container Impoundment Systems will be implemented as per Drawing ES-155. They will be based a 3% volume criterion applied in relationship to catchment size and as such will apply to smaller catchment areas. Their primary purpose is for the initial earthworks in steep or “difficult” locations prior to the formation of a SRP or DEB structure.</td>
</tr>
<tr>
<td>Decanting earth bunds and decant systems</td>
<td>All DEBs established will be based on a volume of 2% of the contributing catchment area. All SRPs and DEBs will be fitted with floating decants. Decants have a mechanism to control (or cease) outflow during pumping activities to these structures.</td>
</tr>
</tbody>
</table>
| Flocculation                                               | Flocculation will be applied on all SRPs and DEBs based on an approved chemical treatment management plan and will be applied to all DEBs with a contributing area between 500m² and 3,000m² and all SRPs.  
  Manual batch dosing will be carried out as required.  
  Flocculant socks will be used as alternative and/or additional measures as required. |
| Sediment retention ponds                                   | All SRPs will be implemented based a 3% volume criterion applied in relationship to catchment size (ie 300m³ SRP volume per 10,000 m² of contributing catchment).  
  Baffles, decant pulleys and reverse slopes to be installed in all SRPs. |
| Super silt fences and silt fences                          | All super silt fences and silt fences will be based upon the design criteria within TP90.  
  SSF fabric will be installed with 200mm of fabric upslope at the base of the trench.  
  In high risk areas, as identified Figure 11 of the Construction Water Assessment Report, if a failure of the primary control measure occurs then the last line of defence, the SSF, will capture and treat any discharges. |

### Other measures / methodologies

<table>
<thead>
<tr>
<th>Other measures / methodologies</th>
<th></th>
</tr>
</thead>
</table>
| Construction stage erosion and sediment control Plans (CESCPs) | CESCPs will be submitted prior to commencement of work. CESCPs will likely include:  
  - Contour information;  
  - ESCS;  
  - Chemical treatment design and details; |
<table>
<thead>
<tr>
<th>Device / methodology</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>· Catchment boundaries;</td>
</tr>
<tr>
<td></td>
<td>· Location of the Work;</td>
</tr>
<tr>
<td></td>
<td>· Details of construction methods;</td>
</tr>
<tr>
<td></td>
<td>· Contingency measures;</td>
</tr>
<tr>
<td></td>
<td>· Design details;</td>
</tr>
<tr>
<td></td>
<td>· A programme for managing non-stabilised areas;</td>
</tr>
<tr>
<td></td>
<td>· The identification staff who will manage ESCs;</td>
</tr>
<tr>
<td></td>
<td>· The identification of staff who monitor compliance with conditions;</td>
</tr>
<tr>
<td></td>
<td>· A chain of responsibility for managing environmental issues;</td>
</tr>
<tr>
<td></td>
<td>· Methods and procedures for decommissioning measures; and</td>
</tr>
<tr>
<td></td>
<td>Design details for managing the discharge of contaminants.</td>
</tr>
</tbody>
</table>

**Decommissioning of devices**

Removal of devices will be in accordance with the CESCP.

**Non-structural measures**

These elements include:

- Manually raised decant devices on SRPs and DEBs;
- Batch dosing of SRPs and DEBs with chemical flocculant where required;
- Proactive monitoring and reporting programme (as per Section 8 of the Construction Water Assessment Report);
- Risk identification and management accordingly;
- Progressive stabilisation as works progress; and
- Weather response.

**Pumping activities**

Pumping of sediment laden runoff and groundwater during construction will be to SRPs, DEBs to grass buffer zones or to temporary sediment retention devices such as Container Impoundment Systems.

**Streamworks**

At all practical times these activities, and any associated works within these environments will be undertaken in an offline ‘dry’ environment. Fish spawning and migration periods will be avoided and managed accordingly.

### 10.5.3 Integrated management system

An integrated management system will be established by the contractor. This system will ensure that appropriate resources, commitment and expertise are provided for the ESC aspects of the Project from the planning, design and construction phases. The contractor will ensure that relevant key stakeholders are involved in the development of the ESC measures and practices on site and the objectives are communicated to the relevant parties. The integrated management system is a process-based approach which will follow the principles outlined in Section 5 of the Construction Water Assessment Report and will include:

- Education and training of all site staff - all staff working on site, or with site responsibilities, shall undertake a formal site induction which will include an ESC module to ensure familiarisation with the requirements of TP90, the principles of the Draft (and
subsequently final) NZTA Standard and the content of the Construction Water Assessment Report. No person will be permitted to work on the site until they have completed the site induction process;

- Implementation of an adaptive monitoring programme (explained in Section 8 of the Construction Water Assessment Report) to inform the extent of construction activity on site and to influence and reduce the direct effect of construction works on the sediment yield into the receiving environment;
- Development of CESCPs;
- Adoption of a Quality Assurance / Management System to:
  - Provide written records of the management and maintenance programme for ESC devices;
  - Ensure awareness of the reporting procedure in the event of defects being discovered; and
  - Fix defects;
- Proactive and reactive ESC maintenance
  - Proactive maintenance:
    - Undertake regular – daily, weekly and long-range – weather monitoring;
    - Programme construction works and stabilisation works in response to weather forecasts;
    - Remove accumulated sediment from ESC devices and make necessary repairs to ESC devices prior to forecast rain events; and
    - Undertake pre and post rain event inspections of ESC measures.
  - Reactive maintenance
    - Repair any defective or damaged ESC measures following rain events;
    - Record the location of any sediment laden discharges to the receiving environment during a rain event; and
    - Develop a coordinated response plan in the event of unplanned sediment laden discharges to the receiving environment including:
      - Cessation or reduction of work activity in a particular area until accumulated or deposited sediment can be removed and the ESC measures can be repaired or replaced;
      - Remedy the effects of any sediment laden discharges, if required; and
      - Monitor the effects of any sediment laden discharges.

10.5.4 Construction activity management

The overall approach to ESC for the Project includes a number of specific construction water management techniques to address discharges, including sediment, from a number of activities. Activity-specific ESC methodologies have been developed for:

- Vegetation removal;
- Acid sulphate soils (if working in them);
- Stockpile and spoil site establishment;
Temporary and permanent stream diversions;
- Pumping activities;
- Culvert installation;
- Bridges and viaducts;
- Concrete work;
- Chemical treatment;
- Rip rap placement;
- Stormwater wetland establishment;
- Haul road establishment;
- Monoslope development; and
- Construction yards.

The innovations, devices and measures applied in these methodologies are described in detail in Section 6 of the Construction Water Assessment Report. These measures are based on the conceptual construction methodology and illustrate that the controls and methodologies can be implemented successfully within the Project footprint and proposed designation.

### 10.6 Sediment modelling

The Construction Water team identifies key erosion control risks as those works within and adjacent to watercourses, steep slopes and spoil site establishment.

Groundwater Loading Effects of Agricultural Management Systems (GLEAMS)\(^{84}\) modelling has been carried out to assess sediment yields from proposed earthworks activity while also determining the background sediment loads from the existing land use within the proposed earthworks footprint. Note that existing erosion in the Project area due to mass movement and soil slip is not included in the sediment yield calculations.

To provide a comparative analysis to the GLEAMS results, Universal Soil Loss Equation (USLE) calculations (refer to Section 7 of the Construction Water Assessment Report) have also been carried out to determine the construction sediment yields. There is a correlation of the results and a consistent comparative analysis. Based on the conceptual construction programme and associated erosion and sediment control plans development, the mean annual sediment yields have been calculated for the two Focus Areas.

The slope of the existing topography is identified as a key factor in the calculation of sediment yields. The modelling demonstrates that with a 50% reduction in the existing slope angle, (which is considered realistic for many of the proposed earthworks operations within the Project) it is expected that there will be a corresponding 67% reduction in sediment yield.

Through the results of the sediment modelling, other key risks are identified that relate to areas of higher sediment yield, typically within the Hill Country. These higher risk areas will be a specific point of focus and will attract attention from the contractor with rainfall monitoring and forecasting, structural controls and a range of non-structural control measures being implemented during construction.

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\(^{84}\) Excluding Te Muri Beach sub-catchment.
10.6.1 Background sediment loads

Background sediment loads were calculated based on Basin New Zealand modelling for the Mahurangi catchment and Catchment Landuse for Environmental Sustainability model for the Pūhoi catchment. This calculation represents the expected sediment loads from existing catchments. The annual background sediment loads for the Pūhoi Estuary and the Mahurangi Harbour (excluding Te Muri Beach sub-catchment) are 18,311 tonnes and 45,931 tonnes, respectively. These figures do not take into account forestry activity, such as harvesting, which can contribute significantly to sediment yields, producing peak loads and creating major deposition.

10.6.2 GLEAMS modelling

The GLEAMS model was used to estimate construction phase sediment yields based on a number of assumptions, including:

- Soil texture;
- Land cover;
- Slope classes;
- Areas of exposed ground; and
- Sediment yield reduction factors, including the efficiency of sediment control devices, as shown in Table 10-3.

**Table 10-3: Sediment control device efficiencies**

<table>
<thead>
<tr>
<th>Sediment control device type</th>
<th>Sediment removal efficiency (%)</th>
<th>2 year ARI</th>
<th>10 year ARI</th>
<th>50 year ARI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super silt fence</td>
<td></td>
<td>80%</td>
<td>65%</td>
<td>50%</td>
</tr>
<tr>
<td>Decanting earth bund (DEB) – Chemically Treated</td>
<td></td>
<td>90%</td>
<td>80%</td>
<td>60%</td>
</tr>
<tr>
<td>Sediment retention pond (SRP) – Chemically Treated</td>
<td></td>
<td>95%</td>
<td>85%</td>
<td>65%</td>
</tr>
</tbody>
</table>

Comparative analyses of the predicted sediment yields from the Focus Areas (outputs of the GLEAMS model) against the existing sediment loads for the Mahurangi River and Harbour are summarised in Table 10-4 and Table 10-5.
Table 10-4: GLEAMS sediment load results for Focus Areas and the Mahurangi River

<table>
<thead>
<tr>
<th></th>
<th>Background load Mahurangi River</th>
<th>FASY plus background load</th>
<th>Percentage increase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5 year conceptual programme</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sediment load (t)</td>
<td>60965</td>
<td>65361</td>
<td>7%</td>
</tr>
<tr>
<td>Mean annual load (t)</td>
<td>12193</td>
<td>13072</td>
<td>7%</td>
</tr>
<tr>
<td><strong>10 year conceptual programme</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sediment load (t)</td>
<td>121930</td>
<td>128846</td>
<td>6%</td>
</tr>
<tr>
<td>Mean annual load (t)</td>
<td>12193</td>
<td>12885</td>
<td>6%</td>
</tr>
</tbody>
</table>

Table 10-5: GLEAMS sediment load results for Focus Areas and the Mahurangi Harbour

<table>
<thead>
<tr>
<th></th>
<th>Background load Mahurangi River</th>
<th>FASY plus background load</th>
<th>Percentage increase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5 year conceptual programme</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sediment load (t)</td>
<td>229655</td>
<td>234050</td>
<td>2%</td>
</tr>
<tr>
<td>Mean annual load (t)</td>
<td>45931</td>
<td>46810</td>
<td>2%</td>
</tr>
<tr>
<td><strong>10 year conceptual programme</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sediment load (t)</td>
<td>459310</td>
<td>466226</td>
<td>1.5%</td>
</tr>
<tr>
<td>Mean annual yield (t)</td>
<td>45931</td>
<td>46623</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

For the Pūhoi River, the predicted sediment yields for a five year construction programme are compared with the existing sediment load for the River in Table 10-6.

Table 10-6: GLEAMS sediment load for the Pūhoi River

<table>
<thead>
<tr>
<th></th>
<th>Background load Pūhoi River</th>
<th>FASY plus background load</th>
<th>Percentage Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5 year conceptual programme</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sediment load (t)</td>
<td>91555</td>
<td>95545</td>
<td>4.4%</td>
</tr>
<tr>
<td>Mean annual load (t)</td>
<td>18311</td>
<td>19109</td>
<td>4.4%</td>
</tr>
</tbody>
</table>

Corresponding discharge total suspended solids concentrations have been calculated and are shown in Figure 10-2 to Figure 10-6 below.

---

85 Refer to Section 7.3.2 of the Construction Water Assessment Report.
Figure 10-2: AC-FHQ hourly TSS and turbidity concentrations five year construction of a 2 year ARI event

Site AC-FHQ is an upper Mahurangi catchment tributary. The site is likely to receive runoff from most of the Hill Focus Area. At this site, the peak construction activity in the Hill Focus Area is predicted to form approximately 10% of the overall Mahurangi catchment. A large increase in TSS concentrations and turbidity levels relative to background levels is predicted at this site.

Figure 10-3: MW site hourly TSS and turbidity concentrations five year construction of a 2 year ARI event

Site MW Mahurangi is a mid-Mahurangi catchment tributary and receives flow from both the Mahurangi Left and Right Branches. It is likely to receive runoff from all of the Hill Focus Area and
the majority of the Flat Focus Area. The predicted construction TSS concentrations and turbidity levels in this part of the catchment are a smaller proportion of the background levels.

Figure 10-4: Mahurangi mouth site hourly TSS and turbidity concentrations five year construction of a 2 year ARI event

The Mahurangi River mouth is likely to receive the construction runoff from the coincident works in both the Hill and Flat Focus Areas. The predicted construction TSS concentrations and turbidity levels in this part of the catchment are a smaller proportion of the background levels.
Figure 10-5: P10 site hourly TSS and turbidity concentrations five year construction of a 2 year ARI event

The P10 site is likely to receive the construction runoff from the Hill Focus Area. The predicted sediment yield TSS concentrations and turbidity levels in this part of the catchment are a relatively large proportion of the background loads.

Figure 10-6: Pūhoi mouth site hourly TSS and turbidity concentrations five year construction of a 2 year ARI event

The Pūhoi River mouth is likely to receive construction runoff extrapolated from the Hill Focus Area. Predicted TSS concentrations and turbidity levels in this part of the catchment are a smaller proportion of the background loads.
10.6.3 Universal Soil Loss Equation

The Construction Water team undertook universal soil loss equation (USLE) calculations to provide a level of confidence and check on the results of the GLEAMS model. The USLE calculations largely adopted the same input parameters used for the GLEAMS model, but use a two year six hour duration storm event instead of an historic 50 year rainfall record to represent normal erosive force and rain intensity. A specific slope length factor, vegetative cover factor and erosion control factor have also been applied.

The USLE calculations are based on the 5 and 10 year construction scenarios for each of the Focus Areas. The comparative sediment yields between the GLEAMS and USLE results are shown in Table 10-7. This comparative assessment provides confidence that the models are an appropriate base for risk assessment and sensitivity analysis for Project construction, and that the calculations can be used to refine ESC measures for the Project.

Table 10-7: Sediment yield estimates from GLEAMS and USLE

<table>
<thead>
<tr>
<th>5 year construction programme</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hill Focus Area</td>
<td>USLE - Focus Area sediment yields</td>
<td>Year</td>
<td>GLEAMS - Focus Area sediment yields</td>
<td>USLE - Focus Area sediment yields</td>
</tr>
<tr>
<td>Year 1</td>
<td>563</td>
<td>670</td>
<td>Year 1</td>
<td>472</td>
<td>380</td>
</tr>
<tr>
<td>Year 2</td>
<td>853</td>
<td>1171</td>
<td>Year 2</td>
<td>532</td>
<td>483</td>
</tr>
<tr>
<td>Year 3</td>
<td>1413</td>
<td>1494</td>
<td>Year 3</td>
<td>533</td>
<td>558</td>
</tr>
<tr>
<td>Year 4</td>
<td>1953</td>
<td>1931</td>
<td>Year 4</td>
<td>560</td>
<td>586</td>
</tr>
<tr>
<td>Year 5</td>
<td>1598</td>
<td>2067</td>
<td>Year 5</td>
<td>483</td>
<td>662</td>
</tr>
<tr>
<td>Total (t of sediment)</td>
<td>6380</td>
<td>7333</td>
<td>Total (t of sediment)</td>
<td>2580</td>
<td>2669</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10 year construction programme</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hill Focus Area</td>
<td>USLE - Focus Area sediment yields</td>
<td>Year</td>
<td>GLEAMS - Focus Area sediment yields</td>
<td>USLE - Focus Area sediment yields</td>
</tr>
<tr>
<td>Year 1</td>
<td>525</td>
<td>648</td>
<td>Year 1</td>
<td>442</td>
<td>348</td>
</tr>
<tr>
<td>Year 2</td>
<td>642</td>
<td>980</td>
<td>Year 2</td>
<td>431</td>
<td>470</td>
</tr>
</tbody>
</table>
10.7 Sediment and water quality effects during construction

The Construction Water team used the USLE calculations to determine the annual average sediment yield for the Focus Areas over both a 5 year and 10 year construction scenario, and extrapolated them across the wider Project to provide average annual sediment yield for both terrain types, as shown in Table 10-8 and Table 10-9.

Table 10-8: Average annual sediment yield from USLE 5 year scenario

<table>
<thead>
<tr>
<th>Hills – 5 year construction period</th>
<th>Contributing exposed earthworks area (ha)</th>
<th>Focus Area sediment yield (t)</th>
<th>Flat – 5 year construction period</th>
<th>Contributing area (ha)</th>
<th>Focus Area sediment yield (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>16.84</td>
<td>670</td>
<td>2016</td>
<td>22.96</td>
<td>380</td>
</tr>
<tr>
<td>2017</td>
<td>26.04</td>
<td>1171</td>
<td>2017</td>
<td>31.84</td>
<td>483</td>
</tr>
<tr>
<td>2018</td>
<td>44.54</td>
<td>1494</td>
<td>2018</td>
<td>22.19</td>
<td>558</td>
</tr>
<tr>
<td>2019</td>
<td>44.18</td>
<td>1931</td>
<td>2019</td>
<td>16.07</td>
<td>586</td>
</tr>
<tr>
<td>2020</td>
<td>22.59</td>
<td>2067</td>
<td>2020</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total</td>
<td>154.2</td>
<td>7333</td>
<td>Total</td>
<td>93.06</td>
<td>2007</td>
</tr>
<tr>
<td>Average annual sediment yield</td>
<td>47.6 t/ha/year</td>
<td>Average annual sediment yield</td>
<td>21.6 t/ha/year</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 10-9: Average annual sediment yield from USLE 10 year scenario

<table>
<thead>
<tr>
<th>Hills – 10 year construction period</th>
<th>Contributing exposed earthworks area (ha)</th>
<th>Sediment Yield (t)</th>
<th>Flat – 10 year construction period</th>
<th>Contributing area (ha)</th>
<th>Sediment yield (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>16.84</td>
<td>648</td>
<td>2016</td>
<td>22.96</td>
<td>348</td>
</tr>
<tr>
<td>2017</td>
<td>16.84</td>
<td>980</td>
<td>2017</td>
<td>22.96</td>
<td>470</td>
</tr>
<tr>
<td>2018</td>
<td>26.04</td>
<td>997</td>
<td>2018</td>
<td>31.84</td>
<td>399</td>
</tr>
<tr>
<td>2019</td>
<td>31.79</td>
<td>979</td>
<td>2019</td>
<td>13.08</td>
<td>630</td>
</tr>
<tr>
<td>2020</td>
<td>31.79</td>
<td>1139</td>
<td>2020</td>
<td>22.19</td>
<td>482</td>
</tr>
<tr>
<td>2021</td>
<td>44.18</td>
<td>1330</td>
<td>2021</td>
<td>16.07</td>
<td>677</td>
</tr>
<tr>
<td>2022</td>
<td>12.75</td>
<td>1950</td>
<td>2022</td>
<td>16.07</td>
<td>512</td>
</tr>
<tr>
<td>2023</td>
<td>12.75</td>
<td>1730</td>
<td>2023</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total</td>
<td>192.9</td>
<td>9753</td>
<td>Total</td>
<td>145.2</td>
<td>3518</td>
</tr>
</tbody>
</table>

Average annual sediment yield: 50.6 t/ha/year
Average annual sediment yield: 24.2 t/ha/year

The Construction Water team then averaged these results across the construction scenarios to provide representative annual sediment yields for both terrain types, as follows:

- Hill Country: 49.1 t/ha per year
- Flat Country: 22.9 t/ha per year

An extrapolation of these yields over each of the construction zone earthwork areas, based on the open area of earthworks, is provided in Table 31 of the Construction Water Assessment Report.

The total estimated sediment yield from the Project over a five year earthworks period is approximately 14,075t. Of this total, 6307t are within the Pūhoi River catchment and 7,767t within the Mahurangi River catchment.

GLEAMS and USLE calculations show a relatively low percentage increase in sediment yields for the Project from the background loads. The specific increase from the overall Project on the wider receiving environment based on a mean annual sediment load is shown in Table 10-10.

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86 Refer to Section 7.6 of the Construction Water Assessment Report.
Table 10-10: Mean annual sediment loads in the Mahurangi and Pūhoi Catchments for a 5 year construction programme

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Background mean annual sediment load (t/year)</th>
<th>Additional mean annual sediment load (t/year)</th>
<th>Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahurangi River catchment</td>
<td>12193</td>
<td>1553</td>
<td>12.7%</td>
</tr>
<tr>
<td>Mahurangi Harbour catchment</td>
<td>45931</td>
<td>1553</td>
<td>3.4%</td>
</tr>
<tr>
<td>Pūhoi River catchment</td>
<td>18311</td>
<td>1261</td>
<td>6.9%</td>
</tr>
</tbody>
</table>

It is clear that those works associated with the steep topography of the Project are of higher risk than the Flat areas and need careful and proactive management and monitoring to ensure that the effects will be minor.

10.7.1 Sediment transport and distribution modelling

Coastal process models were developed to model sediment transport and distribution in coastal areas for the purpose of assessing effects. These models and the results of the modelling exercises are summarised in Section 7 of the Construction Water Assessment Report and Section 12 of this AEE.

eCoast developed coastal process models for the Pūhoi and Mahurangi estuaries. The estuary models predict sediment transportation and deposition from each of the catchments to the respective estuarine receiving environments during the 10 year ARI rain event and 50 year ARI rain events, which, while a lower probability, are considered a higher risk than the two year ARI rain event.

Coastal modelling has been used to predict the sediment retained within the estuaries and the quantity of sediment transported into the open sea, beyond the heads of the harbours. The model predicts the change in TSS in the estuary after events and the duration of this change, and provides information on the flushing rate of marine waters within the estuaries. Refer to Section 4.1 of the Marine Ecology Assessment Report for information on sediment distribution to coastal areas.

Further information regarding the transport and deposition of sediment, including volumes and anticipated depths, is provided in Section 7.9 of the Construction Water Assessment Report.

10.7.2 Maximum open areas of earthworks

Based on the sediment yield modelling undertaken for the Project, the Construction Water team considers that the following maximum open areas of earthworks are appropriate:

- Pūhoi River catchment: 41ha
Mahurangi River catchment (Hill Country): 41 ha
Mahurangi River catchment (Flat Country): 21.5 ha

The maximum open earthworks period for each year will not take place during a full calendar year but only during the summer periods (October to April).

In order to provide the contractor with flexibility during construction, the combinations of maximum open areas across Hill and Flat Country in the Mahurangi River catchment can be changed without affecting the combined sediment yield.

The maximum open areas of earthworks allow the practical completion of the earthworks for the Project construction to be carried out within the 5 year programme, while generating a minor effect on the receiving environment. Section 10 of the Construction Water Assessment Report recommends a limit on the maximum open area of earthworks that reflects the modelled results. An adaptive monitoring programme to monitor the effectiveness of ESC measures implemented on the Project is also proposed that would provide information regarding the actual effects and environmental outcomes associated with earthworks and allow adjustment of the open area limits depending on the monitoring results.

10.7.3 Water quality assessment

The design of the Project, including the water management measures proposed to reduce the effects of discharges of sediment and contaminants during construction, has been considered in the context of the existing water quality environment and is discussed in Section 10.5 of this AEE.

The changes to water quality as a result of construction activities were ascertained using results from the GLEAMS model and a harbour sediment and transport modelling exercise. The changes have been used to assess the effects of Project construction on the existing water quality within the two catchments, particularly in relation to change in water quality, aesthetics and odour, human health and water users.

Section 9 of the Construction Water Assessment Report also considers the potential changes in nutrient loads arising from nutrients bound in sediment entering the watercourses. Experience from similar projects (NGTR and Long Bay) has been used to assess the potential effects of contaminants from other discharges during construction on water quality, including:

- Discharges of flocculants that may affect pH or have a direct effect on water quality;
- Clean water discharges from cut off drains and diversions;
- Dewatering from deeper cut earthworks; and
- Accidental discharges such as spills of fuels, oils, cement etc.

(a) Aesthetics and odour

Oil and grease may be released from the Project in very small amounts due to accidental spills. Any impact associated with such an event would be temporary and managed through the CESCPs so that the effects are minor.
Increases in sediment nitrogen and phosphorus loads are expected to occur in relation to the increase in sediment yields. The receiving environment is not likely to develop nuisance algal growths as a result of these predicted increases.

Effects on aesthetics, including floatable or suspended materials and clarity, and odour will be minor and temporary.

(b) Human health

The increase in stream water nutrient levels during the construction period is not expected to alter the quality of Watercare’s Mahurangi River take when compared to New Zealand Drinking Water Standards 2008 (NZDWS) values for nitrite and nitrate. Neither nitrite nor nitrate is currently elevated at the source.

The increase in TSS concentrations, due to the construction of the Project, is likely to increase turbidity levels within the Mahurangi River. The Project sediment retention ponds will attenuate the construction sediment load. Sediment ponds will continue to discharge stormwater for a period of between 24-48 hours after streams have returned to baseflow. The effect of this attenuation on water quality in the lower Mahurangi River is likely to be small, due to the timing of inflows from other parts of the catchment and the relatively small component of the catchment represented by the Project.

In the context of the construction water management techniques to be used within the Project; including the open area limitations, the adaptive monitoring programme and the innovative practices proposed, the Construction Water team consider the effects of the Project on surface water drinking source in the Mahurangi River to be minor to moderate. The increase in sediment loads due to the Project may result in the duration and/or frequency of the closure of the Warkworth water treatment plant. Plant closures have been a relatively frequent occurrence, during which drinking water is supplied form storage or trucked in.

Watercare is currently developing a bore water supply that they propose to come on-line by 2016 and is likely to be the main water supply (refer to Section 9.4.2 of the Construction Water Assessment Report). If the bore is the main source of drinking water during construction, with the surface water as a back-up supply, the effects of the Project on the human drinking water source will be minor.

(c) Water users

After reasonable mixing, the effects of the Project on water quality for stock drinking purposes are expected to be minor. For other water users abstracting water under the permitted activity rules of the ARP:ALW, there may be minor to moderate effects. A potential moderate effect on the Genesis Aquaculture fish farm may occur with increased sediment loads and depositions during rainfall events. However, any such effect would be temporary.

Temporary changes in colour and clarity will have a minor effect on recreational users (swimmers and boats) in the freshwater and marine environments of the Pūhoi and Mahurangi catchments.
10.7.4 Overall water-related effects during construction

The above assessment is based on the effects of construction related discharges and in particular those associated with sediment yields from land disturbing activities, including earthworks.

The potential effects of Project construction on water quality were assessed by the Construction Water team to be moderate only in the case of a 50 year ARI rainfall event. However, the Construction Water team considers that the probability of such an event occurring during the construction period is very low.

The proposed earthworks open area limitations derived from the sediment modelling exercise and the proposed techniques to restrict or control sediment are important to ensure only minor effects are realised. An adaptive monitoring programme will use water quality monitoring to inform any changes to the earthworks open area limitations to ensure that effects are minor.

Subject to the confirmation of specific methodologies for undertaking streamworks and the imposition of proposed conditions, the effects of streamworks are considered to be minor.

Overall, the timing and duration of the works during the construction phase of the Project and the recommended conditions (refer to Section 10.8 below) will effectively avoid, remedy or mitigate any actual or potential water-related effects.

Specific effects on freshwater and marine ecology are assessed in Sections 5 and 6 of the Freshwater Ecology Assessment Report and in Sections 4 and 5 of the Marine Ecology Assessment Report. Summaries of the effects assessed in these reports are provided in Sections 11 and 12 of this AEE, and should be read in conjunction with the assessment of construction water effects.

10.8 Recommendations and mitigation

The following are noted in the Construction Water Assessment Report:

- The Consent Holder shall make all contractor staff aware of and ensure implementation of appropriate construction water management controls including construction and maintenance of these devices, in accordance with TP10 and NZTA draft guidelines;
- GLEAMS and USLE model calculations show a relatively low percentage increase in sediment yields for the Project from the background loads. However it is clear that those works associated with the steep topography of the Project are of higher risk than the Flat areas and need careful and pro-active management and monitoring to ensure that the construction effects are minor.
- A range of ESC measures are proposed for the Project. Where possible, these will be implemented at the same locations as the long-term stormwater structures, and will at all times achieve the requirements of TP90 as a minimum. ESCs will be based on both structural and non-structural measures with an emphasis placed on the non-structural management techniques; and
- The Project’s construction-related water management will rely on CESCPS to be submitted to Auckland Council at a later date, before any construction activity takes place, to allow for contractor input and review by the Council.
An adaptive monitoring programme will be implemented which will allow for ongoing water quality and ecological assessment of the construction programme. Continuous improvement of the construction water methodologies will form an integral part of this monitoring programme.

The adaptive monitoring programme will include meteorological, ecological and water quality monitoring during the construction phase of the Project and will include the following key components:

- Receiving environment visual assessments;
- Weather forecasting;
- On site monitoring of devices;
- Flocculation monitoring;
- Quantitative water quality and flow monitoring; and
- Habitat monitoring.

The results of the adaptive monitoring programme will be used to identify future risks to ecology based on pre-determined trigger levels. These triggers are not effects triggers, but rather act at an earlier stage to identify a point at which investigation, intervention and continuous improvement opportunities are to be considered appropriate. The adaptive monitoring programme will also inform the earthworks open area limitation and associated effects, and may lead to an increase in open earthworks areas over time. However, any such determination will be based on analysis of the water quality outcomes and associated assessment.

I accept that there are proven techniques, derived from the application of TP90, which will manage potential loss of sediment from the Project. Given the experience of the Construction Water team on other projects such as Long Bay and using the adaptive management techniques outlined by that Team, I support these recommendations.