## **C-8 Watercourse Crossing Management Plan**

### Aim and Objective

The purpose of C-8 Watercourse Crossing Management Plan (WCMP) is to set out the approach to manage and mitigate impacts of culvert installation on the Tina River and tributaries. Specifically, to ensure that culverts are correctly designed to allow water to flow freely beneath access roads, have headwalls installed to minimise erosion upstream and downstream, and to maintain fauna passage as much as possible.

This management plan specifically relates to culverts beneath Project roads. It does not apply to other in-stream works such as dam construction or aggregate extraction. It is noted that the culvert designs for the access roads have been approved previously as part of Lot 1, 2 and 3 ESMPs. No change to the proposed culvert design, mitigation or management is therefore proposed.

#### Summary of Impacts and Risks

A summary of impacts and risks from the installation of culverts on streams includes:

- Changing hydrological regime;
- Clearing of riparian habitat; ٠
- Obstruction of fauna (including fish) habitat and passage; •
- Contamination of water quality;

The underlying principles of watercourse crossing management are to:

- minimize impacts on the natural flow of the watercourse;
- minimize damage and changes to surrounding riparian vegetation;
- minimize obstructions to fauna passage through the habitat; and
- ٠ minimize potential contamination of the watercourse.

Mitigation, monitoring and management measures to address the objective and principles are detailed below, along with monitoring requirements to assess and audit potential impacts during the construction phase of the project. Refer to P-2 Biodiversity Management Plan (BMP) for the approach to avoid, minimise or mitigate adverse impacts during the construction and operation of the Project on terrestrial and aquatic biodiversity. The aims of the BMP are to achieve and maintain (1) no net loss of biodiversity values of natural lowland forest habitat and natural river habitat; and (2) net gains of critical primary lowland forest, riparian forest, cliff forest and critical river habitat.

Mitigation and Management Actions						
#	Issue or Risk	Action			Timing	Responsibility
C-8-1.	Culvert capacity	<ul> <li>A baseline survey of existing streams and drainage shall be undertaken to inform the detailed design.</li> <li>Culverts beneath access roads shall be sized to take 1:25 year Annual Return Interval (ARI) storm events.</li> <li>Culverts shall be designed with headwalls and riprap protection at the upstream and downstream ends to ensure bank stability and minimise erosion.</li> </ul>			Design Phase	HEC Engineering Team
C-8-2.	Fauna passage	<ul> <li>All culverts shall be designed and installed as low gradient as possible beneath the road to facilitate fish passage.</li> <li>At least one culvert shall be designed to allow for fauna passage beneath the road.<sup>1</sup></li> </ul>			Design and construction	HEC Engineering Team
C-8-3.	Construction management	<ul> <li>Excavation within flowing water shall be minimised to the extent possible to install the culverts.</li> <li>Flowing water shall be diverted around the zone of works during construction.</li> <li>Erosion and sediment control shall be installed, such as sumps, geotextile and/or silt fences, to minimise sediment generation during earthworks.</li> <li>Earth-worked areas shall be stabilised and planted with vetiver grass at the completion of construction.</li> <li>All other environmental controls shall be implemented during culvert installation, as detailed in the C-3 Forest Clearance Plan, P-13 Hazardous Materials Management, spill evention and Emergency Response Plan etc.</li> </ul>			Weekly inspections (summarise in monthly reports) As required after any spill event	HEC HSE Manager
Monitoring	Requirements					-
Monitoring #	Requirements Title	Description		Target / Performance Indicator	Timing / Frequency	Responsibility
Monitoring # C-8-A.	Requirements Title Culvert design completed	Description         • Baseline survey of existing drainage completed         • Proposed drainage design completed and approved.		Target / Performance Indicator Refer plans in Annex C-8-I and Annex C-8-II.	Timing / Frequency         Prior to constriction	Responsibility HEC Engineering Team
Monitoring           #           C-8-A.           C-8-B.	Title         Culvert design         completed         Road maintenance	Description         • Baseline survey of existing drainage completed         • Proposed drainage design completed and approved.         • Access roads and culverts monitored as part of weekly site inspections and cleared of Cleared material deposited in-situ or transported to spoil disposal areas.	of any blockages.	Target / Performance IndicatorRefer plans in Annex C-8-I and Annex C-8-II.No ponding or otherwise flooding of the access road	Timing / Frequency         Prior to constriction         Throughout construction	Responsibility         HEC Engineering Team         HEC Construction Team
Monitoring           #           C-8-A.           C-8-B.           C-8-C.	Requirements         Title         Culvert design         completed         Road maintenance         Water quality monitoring	Description         • Baseline survey of existing drainage completed         • Proposed drainage design completed and approved.         • Access roads and culverts monitored as part of weekly site inspections and cleared of Cleared material deposited in-situ or transported to spoil disposal areas.         • Water quality monitoring undertaken as detailed in M-1 Suspended Sediment Monitor Plan (WQMP).	of any blockages. Dring Plan and M-2 Water Quality Monitoring	Target / Performance IndicatorRefer plans in Annex C-8-I and Annex C-8-II.No ponding or otherwise flooding of the access roadRefer details in M-2 Water Quality Materia	Timing / Frequency         Prior to constriction         Throughout construction         Introing Plan	ResponsibilityHEC Engineering TeamHEC Construction Team
Monitoring           #           C-8-A.           C-8-B.           C-8-C.           Supporting	Requirements         Title         Culvert design completed         Road maintenance         Water quality monitoring         Documents - Annexes	Description         • Baseline survey of existing drainage completed         • Proposed drainage design completed and approved.         • Access roads and culverts monitored as part of weekly site inspections and cleared of Cleared material deposited in-situ or transported to spoil disposal areas.         • Water quality monitoring undertaken as detailed in M-1 Suspended Sediment Monitor Plan (WQMP).	of any blockages. Dring Plan and M-2 Water Quality Monitoring	Target / Performance IndicatorRefer plans in Annex C-8-I and Annex C-8-II.No ponding or otherwise flooding of the access roadRefer details in M-2 Water Quality Mater	Timing / Frequency         Prior to constriction         Throughout construction         Initoring Plan	Responsibility         HEC Engineering Team         HEC Construction Team
Monitoring # C-8-A. C-8-B. C-8-C. Supporting Annex	Requirements         Title         Culvert design completed         Road maintenance         Water quality monitoring         Documents - Annexes         Name	Description         • Baseline survey of existing drainage completed         • Proposed drainage design completed and approved.         • Access roads and culverts monitored as part of weekly site inspections and cleared of Cleared material deposited in-situ or transported to spoil disposal areas.         • Water quality monitoring undertaken as detailed in M-1 Suspended Sediment Monitor Plan (WQMP).	of any blockages. Dring Plan and M-2 Water Quality Monitoring Description	Target / Performance IndicatorRefer plans in Annex C-8-I and Annex C-8-II.No ponding or otherwise flooding of the access roadRefer details in M-2 Water Quality Materia	Timing / Frequency         Prior to constriction         Throughout construction         onitoring Plan	Responsibility         HEC Engineering Team         HEC Construction Team
Monitoring           #           C-8-A.           C-8-B.           C-8-C.           Supporting           Annex           C-8-I.	Requirements         Title         Culvert design completed         Road maintenance         Water quality monitoring         Documents - Annexes         Name         Existing Drainage Facility	Description         • Baseline survey of existing drainage completed         • Proposed drainage design completed and approved.         • Access roads and culverts monitored as part of weekly site inspections and cleared of         • Cleared material deposited in-situ or transported to spoil disposal areas.         • Water quality monitoring undertaken as detailed in M-1 Suspended Sediment Monitor Plan (WQMP).	of any blockages. oring Plan and M-2 Water Quality Monitoring Description Survey plan of streams and road drainage b	Target / Performance Indicator         Refer plans in Annex C-8-I and         Annex C-8-II.         No ponding or otherwise flooding of the access road         Refer details in M-2 Water Quality Materia Access Road,	Timing / Frequency         Prior to constriction         Throughout construction         onitoring Plan         with proposed road realigner	Responsibility         HEC Engineering Team         HEC Construction Team         ment overlaid.

<sup>&</sup>lt;sup>1</sup> The approved plans have one culvert with fauna passage.

ANNEX C-8-II PROPOSED DRAINAGE DESIGNS

## EXISTING DRAINAGE FACILITY















# EXISTING DRAINAGE FACILITY (7/14) 24) f fo Photo 24 a a 4 r101'-IIP.1"-l'-P









TIN/1.D/I.M





TINA DAM



## EXISTING DRAINAGE FACILITY (13/14) 20 D Na r1ol'III'-I''- $\Box$ T 35 CPO LE DP 0 d D' Photo 3500 Photo 34 Photo 36 Photo 37 MANAGRIK



## EXISTING DRAINAGE FACILITY (14/14)



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ANNEX C-8-II PROPOSED DRAINAGE DESIGNS

## Drainage Design

## 1. Summary

- The road drainage system is divided into road drainage, side opening, surface drainage, and underground drainage. Considering the existing drainage conditions and road size, the drainage plan was established by hydraulic calculation so that the function of the road would not be degraded due to rainwater.
- The drainage system crossing the roads was roughly planned through field surveys and the technical and economic factors to be reflected in the design were comprehensively reviewed.
- In designing the drainage system, it was planned to consider the local situation, especially the topography, weather, and geology, and to facilitate maintenance such as cleaning and inspection after use.
- The location, extension, and waterway direction of the facility can be changed during construction, so this can be applied with the approval of the director.

## <Table 1> Drainage System Design Procedure



## 2. Drain Pipe and Drainage Culvert Design

- Culverts and drains are facilities for small rivers or waterways that cross roads, the plays an important role in preventing damage to the preservation side of the road body and heavy rains in the road adjacent ground.
- The method applied in this design is as follows.
- 1) Design flow rate determination
- Since the drainage area is less than 25km<sup>2</sup>, the rational equation is applied and the related equation is as follows.

Qd : 0.2778. C. I. A

Where,

 $Q_d$ : peak flow in drainage area (m<sup>3</sup>/sec) C : run-off coefficient

- I : Rainfall intensity with rainfall duration for Tc (mm/hr)
- A : drainage area (km<sup>2</sup>)
- The rainfall intensity applied the Tc=0.1HR(6min) and the values follows 2.3.4 clause

2) Selection of culvert size

- Determination of pipe and box culvert size is given in the separate rCalculation ReportJ, the main considerations follow.
- The slope of the culvert should be a natural slope but planned to be 0.5% or more (min 0.25%)
- In the case of transverse drainage pipes, considering the sedimentation and maintenance, the minimum pipe diameter of the mains transverse drainage pipe is not less than 0900mm and the structural safety of the transverse drainage pipes is reviewed.
- If the design flow rate is increased, the channel guards are reflected in the design to prevent scour and erosion at the outlet.
- Culvert's highest water level is planned to be lower than pavement.

3) Cross drainage pipe design

• The drainage pipe was installed on the road drainage and valley section or on the road cross section of the existing waterway, and the minimum size of the cross drainage pipe was applied to more than 0900mm, so that there was no problem in securing and maintaining the cross section for water flow conveyance.















AREA					
	AREA(km²)		·		
D900	0.0044	12.82	LOT 3-1		
D900	0.0059	9.80	LOT 3-1		
D900	0.0087	7.96	LOT 3-1		
D900	0.0045	6.10	LOT 3-2		

N		LENGTH (m)	REMARKS	
E.P	TION	TYPE - 4(B,H=0.4m)		
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+255.0	L	135	"	
+495.0	L	110	"	
+935.0	L	245	// //	
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+480.0	L	345	"	
+509.4	L	30	"	
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