METROLINK

Integrated Transport. Integrated Life.

A5.10 Watercourse Diversion

Glossary

Term	Meaning
Debris	As trash, but also including non-buoyant material which may be rolled along the bed of a stream (e.g. boulders)
Freeboard	The difference between the culvert soffit level and the design flood level. Can also be defined as the distance between the culvert soffit level and the water surface.
Headwall	The retaining wall at an inlet or outlet (usually aligned at right angles to the culvert but can be skewed).
Inlet	Entry point to a culvert.
Invert	The lowest internal point of any cross section in a culvert.
Outlet	Exit point from a culvert.
Revetment	Material placed on the bed or banks to protect a structure or channel from scour.
Soffit	The highest internal point of any cross section in a culvert.
Wingwalls	The retaining walls which provide a transition from the culvert headwall to the channel.

List of Abbreviations

Acronym	Meaning
Ch	Chainage
EPA	Environmental Protection Agency
IFI	Inland Fisheries Ireland
NRA	National Road Authority
OPW	Office of Public Works
TII	Transport Infrastructure Ireland

1. Introduction

This appendix supports the EIAR Metrolink Construction Phase Chapter (Chapter 5). It should also be read in conjunction with Chapter 18 (Hydrology) and Chapter 15 (Biodiversity).

The proposed Project crosses five main waterbodies in the northern section where the alignment is above ground. These waterbodies include:

- Broadmeadow River;
- Ward River;
- Sluice River;
- Mayne River; and
- Santry River.

There are also minor streams crossed as part of the proposed Project.

This appendix sets out the construction options and methodologies for culverts and watercourses where they interface with the proposed Project.

It also covers the temporary diversions and crossings of culverts and watercourses, including methods used to install temporary measures and, where applicable, permanent construction.

2. Approach to Culvert and Watercourse Construction Works

2.1 General

This appendix outlines the approach and construction methods to be considered for the construction of culverts and diversion of watercourses.

In general, temporary diversion methods are used to re-route water from a watercourse or restrict flows to a designated portion of the watercourse channel to allow construction activities to take place in the existing stream or river, including along the banks or beneath the active channel. These methods generally require the placement of temporary bridging structures but would not preclude the appropriate use of minimum 900mm diameter concrete pipes, however clear span river and stream crossing structures are preferred.

Temporary diversion methods include temporary diversion channels, crossing of culverts, pump-arounds, piped diversions (or flumes), cofferdams and other similar practices as described in Section 2.6. The primary purpose of all temporary diversion methods is to protect water quality and preserve habitats by passing upstream flows around the active construction zone whilst minimising impacts on the environment.

2.2 Sources of Standards and Guidance

The main sources of relevant legislation, standards and guidance are as follows:

- TII Publication – Design of Outfall and Culvert Details (Doc Ref. DN-DNG-03071);
- A Guide to Applying for Consent under Section 50 of the Arterial Drainage Act, 1945;
- CIRIA Report 689 – Culvert Design and Operation Guide;
- NRA Guidelines for the Treatment of Otters Prior to the Construction of National Road Schemes;
- Inland Fisheries Ireland – Guidelines on protection of fisheries during construction works in and adjacent to waters, 2016;
- NRA Guidelines for the Crossing of Watercourses During the Construction of National Road Schemes (2008); and
- TII Publications - Drainage of Runoff from Natural Catchments (DN-DNG-03064).

Please refer to Section 3 for a full list of references.

Watercourse culverts are subject to regulation under Section 50 of the Arterial Drainage Act, 1945 as amended, and compliance is managed by the Office of Public Works (OPW). Requirements for watercourse culverts are stipulated by the OPW. Generally, ditches and earthworks drainage culverts are outside the scope of these requirements and are only subject to the requirements of TII's DN-DNG-03064. In addition, as a key stakeholder, Inland Fisheries Ireland (IFI) should be consulted and approval sought prior to any construction works starting adjacent to watercourses, and where temporary watercourse diversions are required.

2.3 Culvert and Watercourse Construction Locations

2.3.1 Culvert Works – Estuary Station and Park and Ride Facility

At present several ditches cross the station and P&R facility site. Diagram 2.1 indicates the extent of these ditches. The P&R facility will be built over the southern ditch which will be replaced by artificial drainage which will drain to a new attenuation pond at the southern end of the site. The western and eastern ditches will be diverted during site establishment and pre-earthworks.

The whole site has been subdivided into six sub-catchments, each one collecting rainwater drainage from the new impermeable areas (from the new roads, P&R building and track drainage) within the sub-catchment and conveying the water to a new attenuation pond. The attenuation ponds have been sized to contain the drainage from the sub-catchment for a design storm defined by 1% AEP (1:100-year annual chance) plus climate change and a freeboard. Drainage from the attenuation ponds is capped by a control structure to maintain discharges at greenfield rates, resulting in negligible change in flood risk. The attenuation pond at the southern end of the site will discharge to Broadmeadow River, while the other five ponds will drain to the western ditch on site. Assessment of the site drainage on flood risk is provided in Chapter 18 (Hydrology).

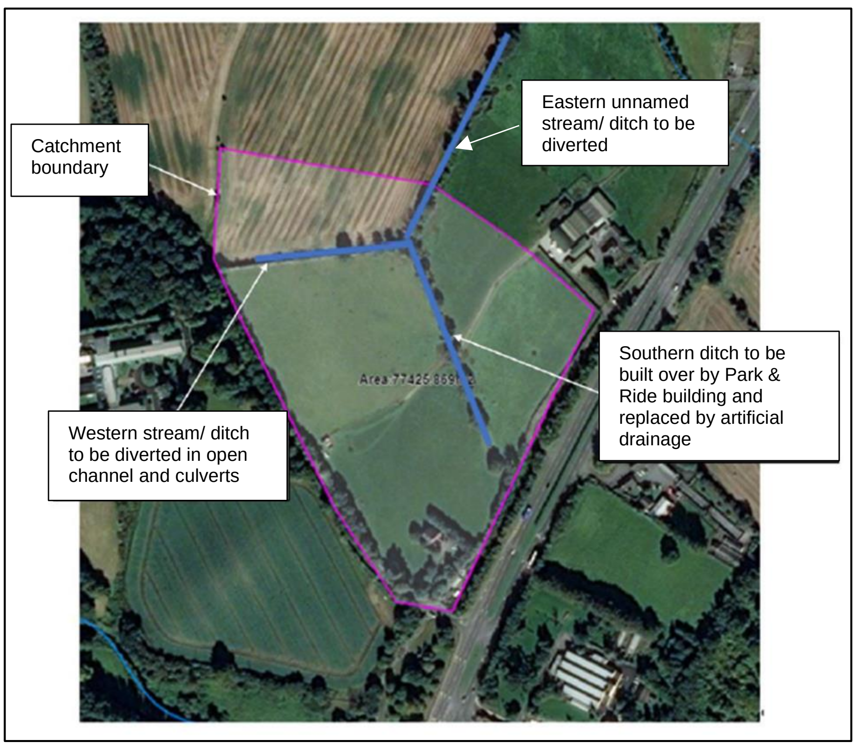

Diagram 2.1: Catchment Area of Stream/Ditch System Requiring Diversion

The existing stream/ditch system would be diverted as follows:

- Diverted via open channel (intercepting ditch) to the north side of the proposed Estuary Park and Ride site with 500mm diameter concrete pipes under the new Estuary Station access roads;
- Diverted below the Estuary Station Turnback area and tracks via a 500mm diameter concrete pipe. From there it would be fed into new attenuation ponds north-east of the Estuary Park and Ride structure; and

- Diverted within the site along the eastern boundary of the Estuary Park and Ride structure with an outfall into the existing watercourse adjacent to the R132.

The proposed diversion of the existing ditches would mainly comprise of 300mm to 500mm diameter concrete piped surface water culverts excavated to gradient and bedded/surrounded in approved bedding material. In addition, open/intercepting channels and attenuation ponds also form part of this diverted surface water system in order to re-direct the existing ditches around to the north-east and south of the Estuary Park and Ride building.

When the earthworks progress far enough, some or all of the culvert diversion works would be included with the pre-earthworks site drainage measures. It is likely that additional temporary piped culverts or open channels would be constructed to accommodate completion of permanent culvert diversions and necessary haul roads within the Estuary Station site. This would require approval from the OPW.

Diagram 2.2 illustrates two types of temporary channels that would likely be constructed in this area to facilitate the permanent works.

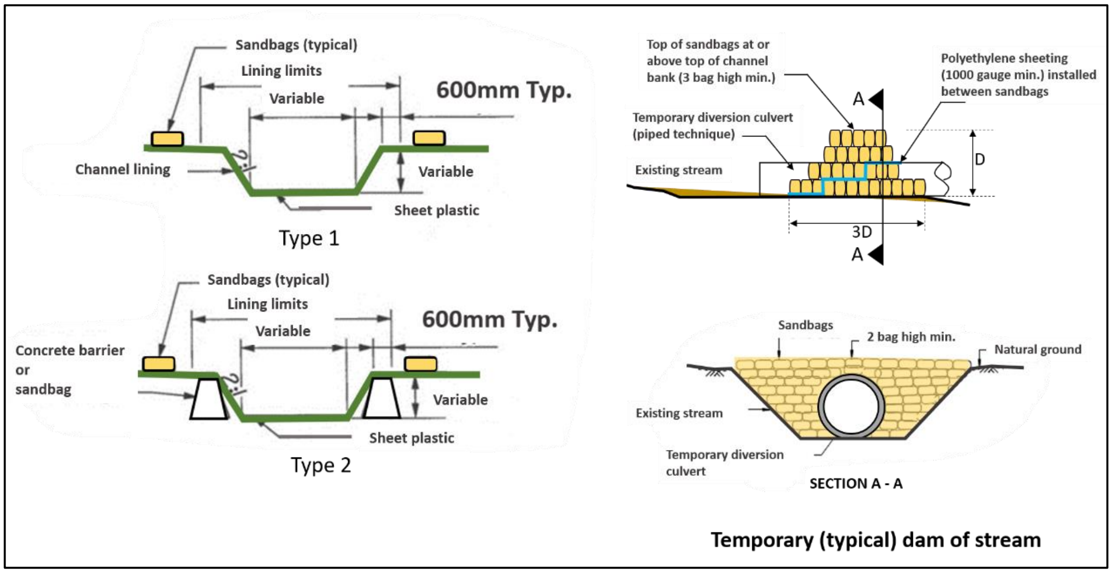

Diagram 2.2: Temporary Culvert/Stream Options

The permanent culvert works will involve either temporary diversion and culverting for the watercourse or constructing a temporary dam upstream of the works and pumping the water to the downstream side of the works. This will depend on the sensitivity of the watercourse and method statements would be agreed with OPW.

In general, various types of temporary culverts could be used by the contractor(s) as follows:

- Circular piped culverts;
- Precast box culverts;
- In situ box culverts; or
- Corrugated steel pipes.

Circular piped culverts and precast box culverts are constructed in a similar manner. Material, including gravel for bedding and culvert surrounds, and concrete culvert sections or pipes, would be delivered to the site via access from the R132 and haul road system throughout the works.

The line of the culvert would be excavated to bedding level with material taken away by dump truck for reuse or disposal. The gravel bedding material would be placed, followed by the culvert sections. Culvert sections would be treated with a waterproof membrane to faces retaining soil fill – the waterproof membrane would typically be a bitumen coating applied by brush or spray. Following this, the gravel culvert surround would be placed and compacted.

The above culvert types would also likely require the construction of headwalls. Headwalls would be constructed of concrete although they may have a stone facing or other finish applied following the main headwall works.

Plant likely to be involved in culvert construction includes:

- Excavators with long-arm booms;
- Pumps;
- Tracked vehicles, dump trucks, lorries;
- Delivery wagons; and
- Compacting plant.

2.3.2 Culvert Works – Sluice River and Forrest Little Stream Crossings

The proposed Project alignment crosses the Sluice River and the Forrest Little Stream, in the agricultural land to the north of the Naul Road. These watercourses are contained in bank with very little natural floodplain. Consequently, both watercourses will be culverted under the railway. The culvert for the Sluice River will incorporate a farm underpass in order to prevent severance of the farming unit. The locations of the culverts are shown on Figure 4.1, Chapter 4 (Description of the MetroLink Project).

The culverts are designed to comply with the hydraulic design contained in OPW Section 50 Consent Form. The permanent culverts for the proposed Project therefore have the following design parameters:

- The diameter is greater than 900mm for the passage of fish, operational purposes and reduce the risk of blockage;
- Constant slope, usually less than 1%;
- Water velocity is less than 1.2m/s at the discharge apron for three times the daily flow;
- The bottom (invert) is 500mm below the grade line of the natural stream bed, to permit fish passage;
- The width is similar to the natural low-flow channel;
- Is laid at a level and grade which allows the upstream invert to remain drowned (by back-watering) under low-flow conditions, to a depth suitable for the easy passage of the largest species frequenting the stream;
- Permit mammal passage; and
- Capacity shall be sufficient to ensure no risk of flooding to the line in the 0.1% AEP flood and no impact on flood risk to other properties.

Based on the criteria above a box culvert design at the Sluice River has been developed. A cross-section of the culvert can be seen in Diagram 4.52, Chapter 4 (Description of the MetroLink Project). This culvert includes a farm underpass that will be 3050m in length. A mammal ledge to allow for otter and badger passage across the alignment is also provided to mitigate severance. Further discussion on mitigation is provided in Chapter 15 (Biodiversity).

In the case of the culvert-underpass of the Forrest Little Stream, this structure will consist of single culvert which will be 2665m in length and includes a mammal ledge to allow for otter and badger passage across the alignment A cross-section of the culvert can be seen in Diagram 4.53, Chapter 4 (MetroLink Project Description).

Diagram 2.3 indicates the proposed temporary river diversions to be established prior to commencing the installation of the permanent box culvert structures, which would be subject to a Section 50 application and approval by the OPW. Local Authority approval may also be required. These would be executed based on the temporary diversion method outlined in Diagram 2.8.

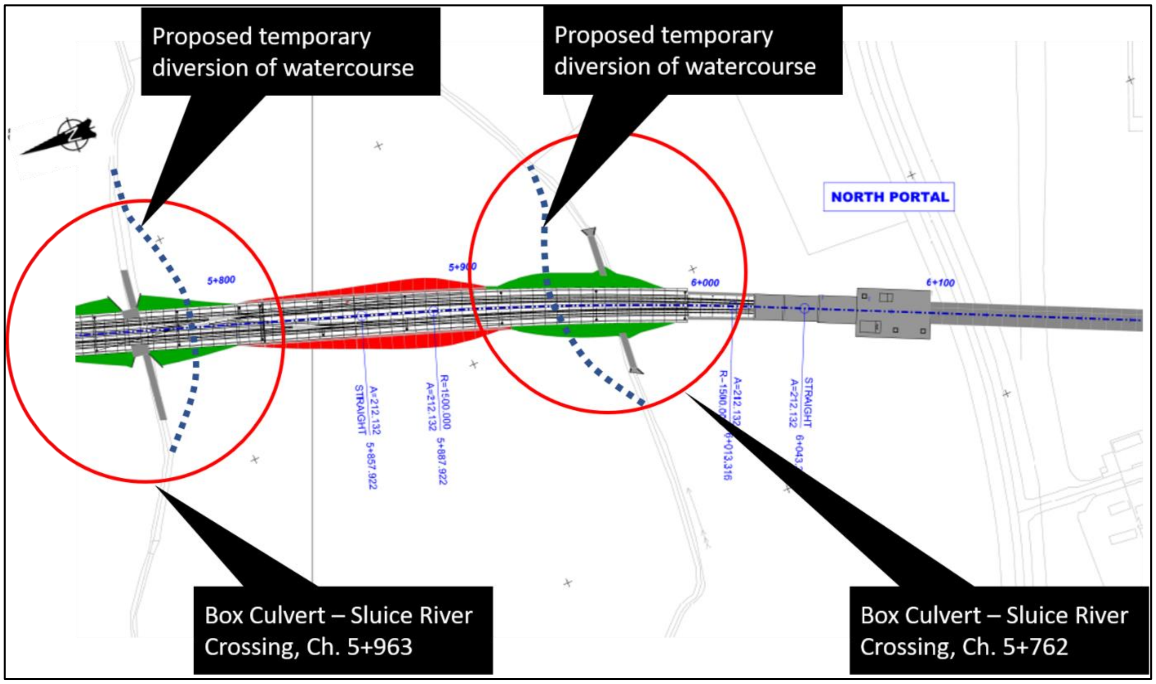

Diagram 2.3: Proposed Culvert Works – Sluice River Crossings

Given the proximity of these culvert crossings to one another, it is likely that an off-site build method would be used e.g. precast concrete sections delivered to site and installed sequentially using a 250-300T all-terrain mobile or tracked crane. The excavation and formation would be prepared in advance to expedite construction and minimise environmental impacts, as shown in Diagram 2.4.

Diagram 2.4: Typical Box Culvert Construction – Sluice River Crossings

2.3.3 Turnapin Stream (Mayne River) Diversion – Dardistown Depot

At the proposed Dardistown Depot, Turnapin Stream a tributary of the Mayne River, crosses the north-east corner of the site. Diversion of the Turnapin Stream will be required to maintain local drainage routes.

The location of the proposed stream to be diverted is shown in

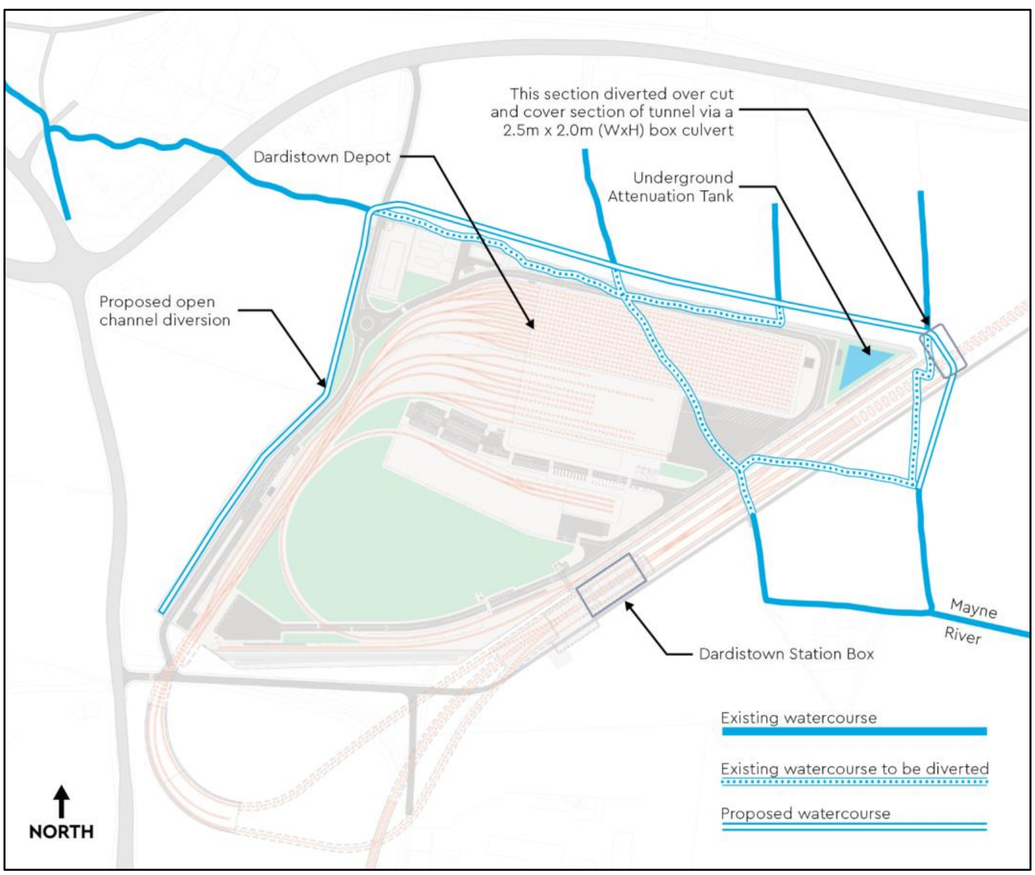

Diagram 2.5.

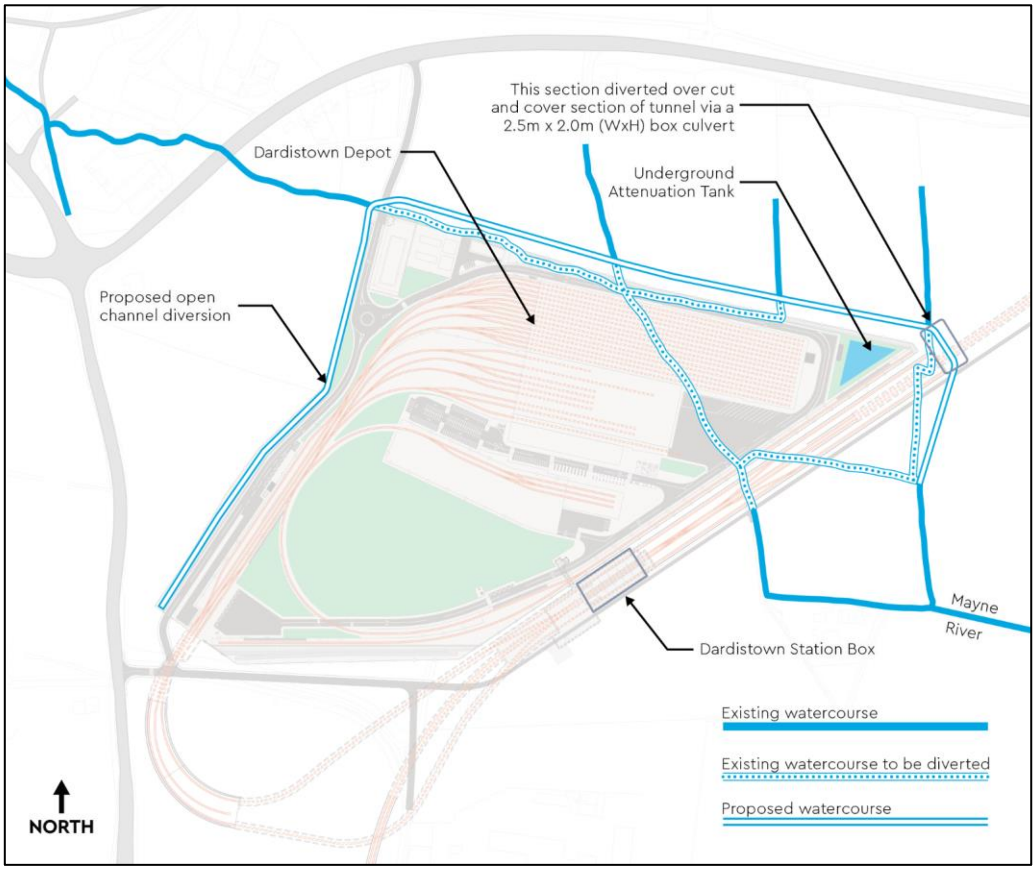

Diagram 2.5: Dardistown Depot Culvert Works – Turnapin Stream (Mayne River)

2.3.4 Santry River

In order to accommodate construction works at the Santry River crossing location, some minor alterations are proposed to the Santry River immediately downstream of the proposed Project's crossing. These works will comprise minor alterations to straighten the channel, including the addition of scour protection, immediately downstream of the culvert outlet. The location of the works is indicated on Figure 18.14 in the EIAR Book of Figures. These alterations have been assessed in the EIAR Chapter 15 (Biodiversity) and Chapter 18 (Hydrology).

These works would be undertaken in line with the general requirements of Section 2.6.

2.4 Construction Activities and Environmental Considerations

The effect of construction activities on the local environment during culvert diversion works should be carefully considered.

The key considerations would be:

- Fish: streams and rivers that support fish are generally too large to be culverted using pipes. Long culverts and changes of direction within the culvert should be avoided. Depressing the culvert invert and filling the void with gravel will aid fish passage by creating a natural bed.

- Mammals: Mammal runs are provided where the watercourse or ditch forms the natural passage from one side of the proposed Project's route to the other. Refer to the NRA's Guidelines for the Treatment of Otters Prior to the Construction of National Road Schemes. Culverts, the headwalls and adjacent vegetation can become roosts for bats. Culverts of diameter greater than 1.0m can become fly-through routes for bats if located adjacent to roosts or feeding areas.

- Habitats: Important habitats, including protected habitats and species, can be lost during the construction phase both through direct loss during site clearance (see Section 2.6 below) or indirectly due to loss through pollution and/or disruption. There is also the risk of spreading invasive non-native plants such as Japanese knotweed during construction. In the worst cases, long-term or even permanent damage may occur.

- Temporary river crossings: The same principles of good practice apply to permanent and temporary river crossings. All construction activities should be carried out from the banks where possible. Where rivers are required to be crossed, existing bridges would be used where possible. Where there is no existing permanent bridge, a temporary crossing should be constructed, as shown in Diagram 2.8.

- Temporary haul routes: temporary haul routes / road bridges should be provided with splash plates to prevent vehicular traffic from pushing debris over the edge and into watercourses. The river should not be forded as this poses a high risk of sediment getting into the river.

2.5 Culvert Alignment Options

Poor alignment of the culvert is frequently problematic, and sometimes the ideal arrangement of a 90º crossing of the obstruction is not always practicable. Diagram 2.6 2.6 illustrates the issues. Options (a) and (c) are both preferred, having good alignment of the flow at the inlet and outlet, and option (c) accommodates allowing construction in the dry.

The alignment of the culverts relative to crossings by the proposed Project should aim to minimise their lengths. Ideally, new crossings should follow as direct an alignment as possible. However, there are a number of factors to be considered during extension and, or construction:

- Maintenance of channel flows during construction;

- Effects on the watercourse or ditch of realignment;

- Scour or sedimentation problems;

- Design and cost of river training works;

- Maintenance access and working area; and

- Environmental constraints, e.g. habitats and mammals.

A culvert diversion constructed along the line of the existing watercourse or ditch is the better option for maintaining existing hydraulic conditions. However, the problems associated with on-line construction must be addressed during the design stage, and these are, briefly:

- Pumping or temporary channeling of the watercourse; and

- Removal of the channel bed and infilling of soft spots. Care should be taken during construction to ensure that there is no localised settlement of the proposed culvert (Refer to Diagram 2.10 for box culvert transition arrangement).

Off-line construction is the preferred approach generally and has advantages of maintaining the existing channel flows and working in the dry, which also reduces risk of debris or any discharge into the watercourse. Diversions of the watercourses or ditches through the new culvert may require the introduction of temporary short radius bends, particularly where these culvert crossings are close to 90º to the proposed Project, as indicated in Diagram 2.3above.

The introduction of sharp bends should be avoided to avoid possible erosion of the bank on the outside of the bend or silt deposition on the inside. Where necessary the guidance given in the NRA's Guidelines and guidance presented in Section 2.2 should be followed.

Option (c) or (d) shown in Diagram 2.6 probably offers the optimum methods to be adopted, being predominantly constructed off-line whilst minimising the deviation of the channel alignment.

Fundamentally there are four culvert alignment/construction methodology options (Diagram 2.6) that would likely be encountered where the proposed Project intersects an existing stream/watercourse. The final choice of which methodology is adopted would be subject to conclusion of the detailed design, any environmental constraints, in conjunction with the safe means and methods chosen by the contractor(s).

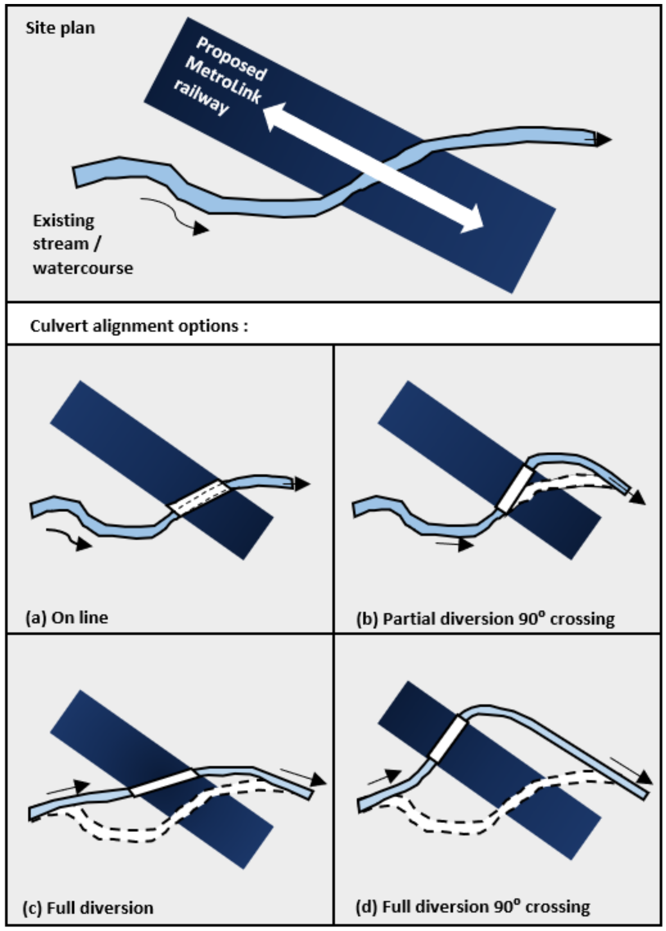

Diagram 2.6: Typical culvert alignment and diversion options (Source: CIRIA 689)

2.6 2Culvert and Watercourse Diversion Methodology

2.6.1 Constraints

The appropriate 'window' for instream works can vary depending on the nature of the fishery resource concerned and the existence of other factors such as catchment or sub catchment specific Bye Laws and Regulations.

To minimise adverse impacts on the fisheries resource, works in rivers, streams, watercourses etc. should normally (except in exceptional circumstances and with the agreement of IFI) be carried out during the period July-September.

2.6.2. Typical Construction – Precast Box Culvert Design

The typical construction sequence for a precast box culvert design, as shown in Diagram 2.44, would be as follows:

- Site and vegetation clearance including protection measures e.g. tree crown protection, silt screens, bunded areas, booms, traffic mats where required;
- Construct temporary channel, and temporarily divert the existing watercourse off-line in phases and dam upstream as required to allow work in the dry to be undertaken;

- Excavate and replace/prepare the existing ground;
- Install and grade to level, lean mix (semi-dry) concrete;
- Lift and position precast culvert sections until all sections have been installed;
- Complete internal components e.g. mammal shelves etc.;
- Install inlet and outlet headwalls;
- Seal and waterproof culvert sections and lay protection board over prior to backfilling as required;
- Backfill with either suitable granular fill or cement-bound granular fill to form transition; and
- Remove temporary diversion and reinstate natural watercourse flow through new culvert.

2.6.3. Site Clearance and Protection Measures

For any stream/river/ditch diversion, it is important to avoid unnecessary vegetation clearance, keep damage or construction impacts to a minimum and so avoid sediment pollution from runoff. Site clearance for these works should only commence and be undertaken when works are required, adopting a planned approach to avoid clearing the whole site at once, and leaving exposed ground for long periods of time.

Prior to works commencing, buffer zones around watercourses and protected habitats/species should be established and suitably isolated from works using fences, barriers, screens and signage.

Invasive or noxious plants (e.g. Japanese knotweed, giant hogweed, ragwort etc.) should be removed before works commence.

The timing of vegetation removal should be considered carefully to avoid particularly sensitive periods of the year (e.g. bird nesting season).

The watercourses should be protected to prevent debris from vegetation removal operations from falling into the water. This would be normally undertaken by removing vegetation from behind the bank and pulling it away from the water, or by placing screens or nets between the vegetation and the water. If this is impractical, the use of booms or temporary screens to collect any floating debris would be installed so that it can then be easily removed. This type of recovery should cause as little disruption to the watercourse as possible.

During site clearance operations it is important to take measures to ensure the stability of the bank, particularly where there is a risk of raised water levels (high flows) until the vegetation is re-established. Biodegradable textiles would be used to protect areas of bare soil, as shown in Diagram 2.7.

Diagram 2.7: Typical River/Stream Bank Protection Measures

Other protection measures for example mammal-resistant fencing, as indicated in Diagram 2.88, should be erected as required.

2.6.4. Watercourse Temporary Diversion and Options

There are a number of options to divert a watercourse temporarily. The optimum solution is dependent upon the site conditions, habitat, design, flood, stream or river flow parameters and final construction stage design solution. The range of diversion options are:

- Channel diversion: for smaller streams, construction of dams and detention basins, or as the site allows, a channel diversion may divert the entire waterway as illustrated in Diagram 2.88 below.
- Berm or coffer dam: appropriate for streams of all sizes to confine flow to one side of the stream.
- Piped diversion: a bypass pipe is generally appropriate for short-duration projects with low baseflows; and
- Pumped diversion: may be appropriate for short-duration projects with low baseflows. It may also be the only option where space for the diversion is restricted.

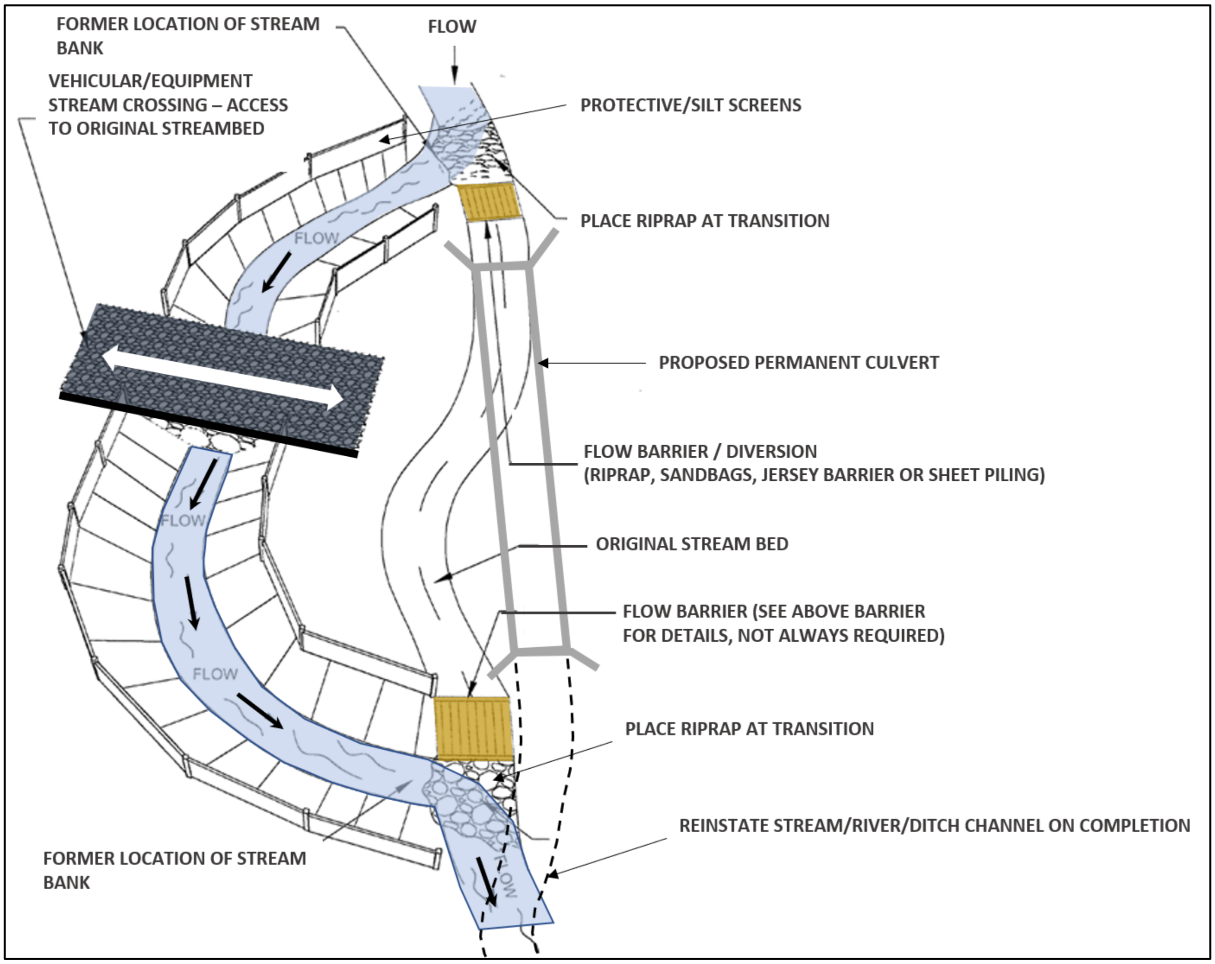

Diagram 2.8: Typical Temporary Diversion Channel

This stage would require the isolation and de-watering of the works area to create dry working conditions. Isolation of the works area reduces the risk of sediment entering the stream/ditch or river.

A berm or cofferdam is usually installed at the stream head to be diverted and confine flow to one side of the stream into a piped or open channel. A number of other damming techniques could be used e.g. sandbags/polythene, Jersey barriers etc. Where the works area remains wet, a silt curtain would be placed around the works area to minimise sediment being transferred downstream.

Depending on the stream/river flows, a full isolation or over-pumping/siphon technique could also be used, which requires pumping water (Diagram 2.9) from upstream of the barrier to downstream of the works area, maintaining 'normal' flow in the watercourse either side of the isolated reach. Depending on the gradient of the watercourse, it may also be necessary to install a full-width barrier downstream of the work area to prevent ingress of water.

Diagram 2.9: Typical Arrangement for Full Isolation Over-pumping

2.6.5. Excavation and Formation Preparation

For the excavation of the culvert, it is recommended that a large excavator bucket is used. Each time a bucket of soil is placed in the stream, a portion is suspended. Therefore, using a large excavator bucket instead of a small one would be beneficial, and would reduce the total amount of soil that washes downstream.

2.6.6. Earthworks Transitions

There are situations where the formation and its supporting elements can be expected to change and at such locations earthworks transitions will be required at box culvert locations.

Transitions generally comprise structural wedges usually formed in embankments from cement bound well graded granular fill material such to provide a zone of near zero internal settlement.

The function of an earthworks transition is to maintain the ride quality of the track by smoothing the change in formation properties and dynamic response to ensure that both repeated loading across a discontinuity does not result in a progressive degradation of support, and long-term differential movements due to gravity loading do not compromise performance.

Typically, transitions are installed at the interface with and over culverts where differential settlement, differential heave and/or differential longitudinal earthwork's dynamic stiffness may result in conditions in the short or long term that do not meet the quality requirements of the works. Diagram 2.10 refers to and illustrates a typical transition arrangement over a box culvert.

In some instances, improvement of the embankment foundation may be required. Excavation of the embankment foundation could be considered and backfilling with a regulating course. The regulating course may need to be stabilised or reinforced to span across the replaced strata.

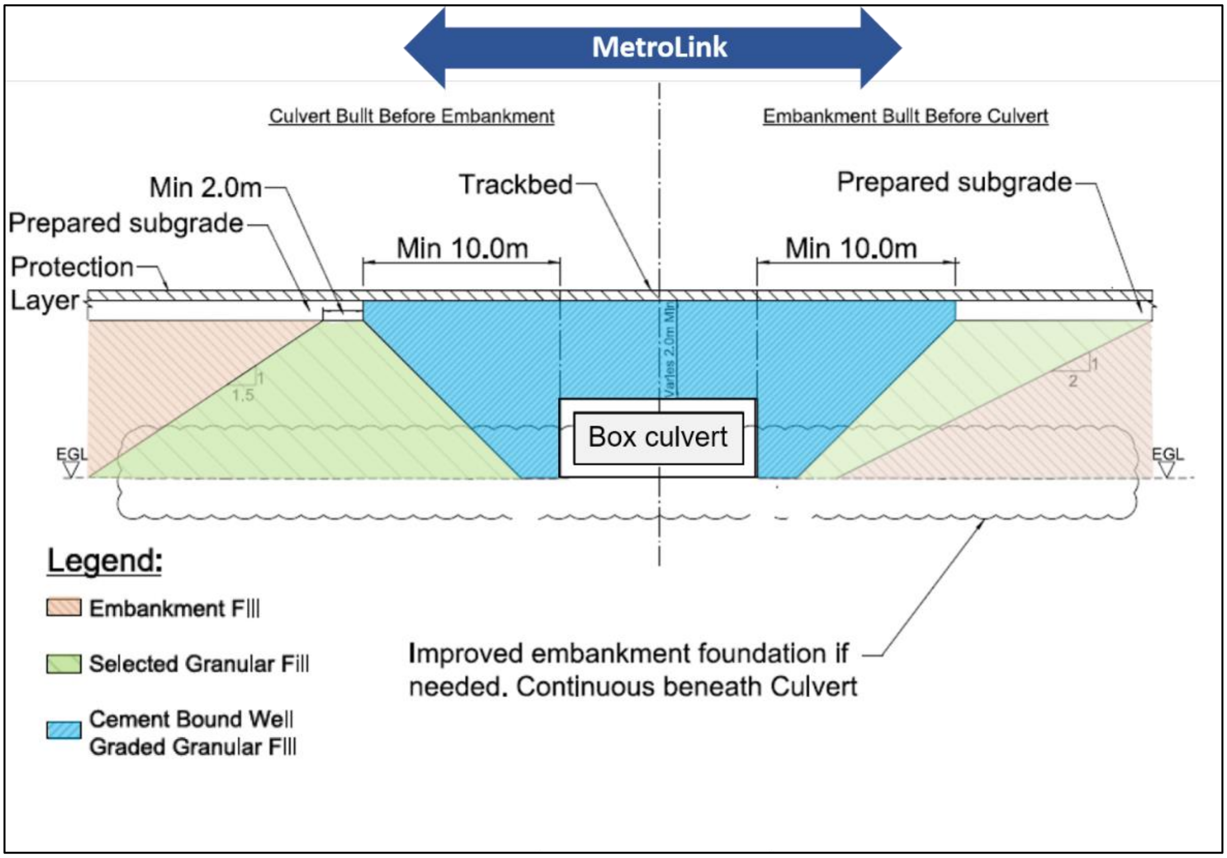

Diagram 2.10: Typical Transition Arrangement, Box Culvert Crossings

2.6.2 Temporary Sediment Basin

After the flow barrier (e.g. cofferdams, sandbags etc) have been installed, it is necessary to dewater the work area. This water would then be pumped into a temporary sediment basin for filtration as follows.

- The temporary sediment basin or tanks would be installed, typically as shown in Diagram 2.11 and Diagram 2.12.
- The sediment basin could also comprise hay bales and non-woven geotextile filter fabric. Filter fabric is used to line the inside of the hay bale basin to filter sediment. Sediments accumulated inside the basin will be disposed of at a location away from the stream to prevent future erosion and transport of the sediments back into the stream.
- The sediment basin will be located close to the work site with adequate vegetation between it and the stream to provide additional filtration.
- Pumping any heavily silted water to the sediment basin.
- Once fish are evacuated from the work area, it will be pumped as dry as possible.

Diagram 2.11: Typical Sediment Control Measures (Pond and Tanks)

Diagram 2.12: Typical Dirty Water Treatment System (Hay Bales and Geotextile Fabric)

2.6.3 Cofferdam Removal

After all diversion work requiring isolation from the stream/river environment is complete, the cofferdam can be removed to restore stream flow through the structure. Cofferdams that are placed across the entire stream are removed as follows:

- The diversion pump or dewatering system will be stopped, and the upstream cofferdam would be slowly breached. The first flush of dirty water will be captured by the downstream “dirty water pump”, which will then pump the water into the sediment treatment system;
- When the water behind the remaining intact cofferdam is visually similar, that dam will be breached as well;
- The remainder of the upstream cofferdam and the diversion pump system will then be removed; and
- Sandbag cofferdams will be removed by hand, if they are small, or by an excavator working from the stream banks if they are the large industrial-sized sandbags. See Diagram 2.13 and Diagram 2.14 for typical flow barriers.

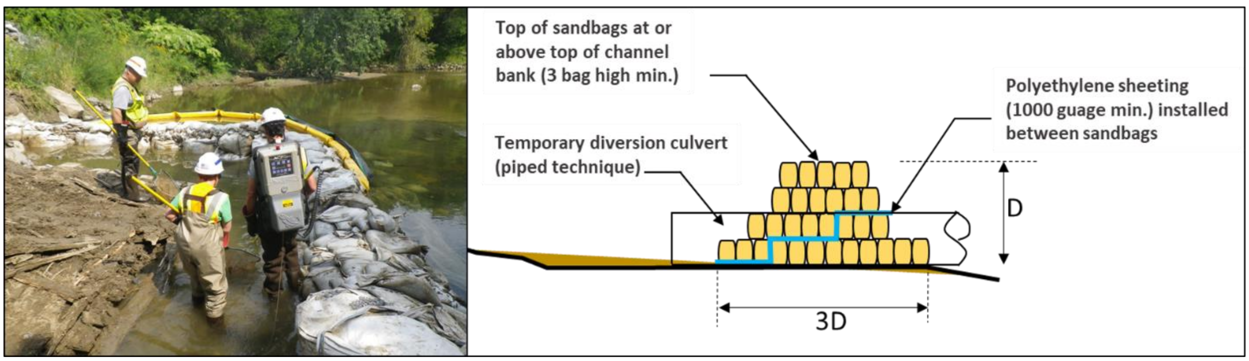

Diagram 2.13: Typical Cofferdam System (Small Sandbags)

Diagram 2.14: Typical Cofferdam System (Industrial Sandbags)

2.6.9. Temporary Crossing Structures on Waters

All watercourses which have to be traversed during construction projects should be effectively bridged prior to commencement of works. The design and choice of temporary crossing structures should provide for passage of fish and macroinvertebrates including the requirement to protect other important fish habitats e.g. spawning and overwintering area, as well as preventing erosion and sedimentation.

Temporary watercourse crossings should:

- Not impede fish passage through the system;
- Have access constructed of suitable material and in a manner that will not give rise to rutting, ponding and silt runoff; and
- Have silt-laden runoff directed to silt lagoons. Silt control measures should be increased with increasing gradient and buffer zones should be incorporated between the ponds and watercourse.

Fording of watercourses to gain access to the opposite bank should only be considered where no alternative option exists and under approval of the IFI, or the OPW where protected species occur in significant numbers.

Where required, access should be restricted to one crossing point and where feasible, traffic movements should be limited. In-stream and bank-side preparation and rehabilitation would likely be required.

Concrete should not be used for preventing erosion of stream beds and banks where a softer option is available, e.g. natural bank stabilisation techniques such as willow-faggoting, stone armour, logs, conifer tops or composite protection using products such as coir-matting or geo-web products with appropriate planting (reeds, willow, etc.).

Bank stabilisation, erosion protection and drainage outfalls, if required, should be designed in consultation with the IFI and OPW. These works should be designed to avoid downstream impacts and to promote natural re-colonisation of the original riparian and aquatic marginal vegetation.

2.6.10. Construction Haul Roads

Temporary haul roads and bridges would be provided with splash plates to prevent vehicular traffic from pushing debris over the edge and into watercourses.

Temporary haul roads would generally be constructed by laying clean graded stone material on a geotextile membrane, and where adjacent to watercourses, 'Jersey' type barriers would be strategically placed in conjunction with a polythene protective barrier to prevent material and any contaminants from entering the watercourse.

In some instances, and where practicable, heavy gauge rubber mats would be used to provide clean and stable temporary access routes as well as minimising construction impacts e.g. ground rutting, risk of silt contamination and, or runoff etc.

Particular attention and monitoring should be implemented to prevent silty or sediment laden runoff from temporary crossings or haul roads entering watercourses, for example:

- The deck or surface should be sealed or lined;
- The deck or surface should have an edge upstand (e.g. steel plate, timber, straw bales, sandbags, geotextile); and

- The road surface should be on a slight gradient or be graded to ensure that surface water is not shed into the watercourse but is routed beyond the top of the riverbank into site drainage which has the appropriate form of silt treatment.

2.6.11. Post Construction Site Reinstatement

Once water flow is restored to the area inside of the new box culvert or piped culvert and the in-water portion of stream crossing reinstatement is complete, restoration of the construction site will be undertaken.

The contractor(s) will complete any final stabilisation treatments, restoration of any temporary work areas, and build the trackbed or structure on top of the new watercourse crossing/structure.

2.7. Maintenance and Removal

Because temporary stream/river/ditch diversions are one of the most critical environmentally impacting elements of work in waterways, they must be inspected and maintained frequently to remain in effective operating condition.

During construction, it is highly recommended that flow barriers should be inspected at the start and end of each workday and at any time that excess water is noted in dry work areas. This would also require inspections to take place in advance of impending storms or forecasted heavy rainfall events.

For diversion of stream/ditch channels, the diversion channel itself should be inspected for signs of erosion, and the lining should be repaired or replaced if there are signs of deterioration or failure. Any armoring used in the diversion return points to the waterway should be checked as work progresses, and additional armoring should be added if erosion is noted.

During extending or diverting streams/rivers or ditches, water should not be allowed to flow back through the natural stream until all construction is completed. After redirecting the flow through the natural channel, temporary diversion measures should be removed. For temporary diversion channels, lining materials should be removed, and the diversion channel would then be backfilled and stabilised. Points of tie-in to the natural channel should be protected with riprap sized in accordance with TII Standard; Design of Outfall and Culvert Details, DN-DNG-03071.

3. References

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