Assessing and managing risks with transitions in flood defence infrastructure

Framework for onsite inspection and evaluation of asset transitions

Date: July 2023

Version: FRS17181/R1

We are the Environment Agency. We protect and improve the environment.

We help people and wildlife adapt to climate change and reduce its impacts, including flooding, drought, sea level rise and coastal erosion.

We improve the quality of our water, land and air by tackling pollution. We work with businesses to help them comply with environmental regulations. A healthy and diverse environment enhances people's lives and contributes to economic growth.

We can't do this alone. We work as part of the Defra group (Department for Environment, Food & Rural Affairs), with the rest of government, local councils, businesses, civil society groups and local communities to create a better place for people and wildlife.

Published by:

Environment Agency
Horizon House, Deanery Road,
Bristol BS1 5AH

www.gov.uk/environment-agency

Further copies of this report are available from our publications catalogue: www.gov.uk/government/publications or our

National Customer Contact Centre: 03708 506 506

Email: enquiries@environment-agency.gov.uk

Author(s):
Jaap Flikweert, Eva van Maren

Keywords:
Transitions, inspection, prioritisation, asset management, flooding, embankment

Research contractor:
Royal Haskoning DHV

Research collaborator(s):
HR Wallingford, Deltares, IRSTEA, US Army Corps Engineers (USACE), Electricité de France (EDF)

Environment Agency Project Manager:
Dr Sarah Twohig

Environment Agency Project Executive:
Matthew Arthur

Project number:
FRS17181

Research at the Environment Agency

Scientific research and analysis underpins everything the Environment Agency does. It helps us to understand and manage the environment effectively. Our own experts work with leading scientific organisations, universities and other parts of the Defra group to bring the best knowledge to bear on the environmental problems that we face now and in the future. Our scientific work is published as summaries and reports, freely available to all.

This report is the result of research commissioned by the Environment Agency's Chief Scientist's Group.

You can find out more about our current science programmes at https://www.gov.uk/government/organisations/environment-agency/about/research

If you have any comments or questions about this report or the Environment Agency's other scientific work, please contact research@environment-agency.gov.uk.

Dr Robert Bradburne
Chief Scientist

Foreword

This report signposts potentially relevant considerations for practitioners when managing portfolios of flood risk assets with transitions. It is not intended to be, and should not be read as, prescriptive, exhaustive, or a statement of best practice.

The research findings presented in this report were commissioned by the Environment Agency for this project. This document is one of four outputs from this project and must be read alongside those other research outputs, rather than considered in isolation. There are also four appendices published in a separate document.

The outputs from this project are being used by the Environment Agency to review and improve our internal management processes. We apply a risk-based approach to all our activities, ensuring public money is targeted in a way to achieve the most benefit. This means that we may conclude that some of the techniques set out in this document are not appropriate for the Environment Agency to use.

Contents

Foreword ... 3

1. Introduction ... 8

1.1. Project overview ... 8

1.2. Scope of report ... 9

1.3. Who is this report for? ... 11

1.4. Report structure ... 11

1.4.1 By transition type and failure mode ... 11

1.4.2 Four tiers: simple where possible, advanced where needed ... 12

1.4.3 Assessment flowcharts and proformas ... 12

1.5. Using this report ... 13

1.5.1 Tier 0 and tier 1 for the Environment Agency ... 13

1.5.2 Tier 0 and tier 1 for other organisations than the Environment Agency ... 13

1.5.3 Tier 2 and tier 3 ... 14

2 Relevant failure modes per transition type ... 14

3 Tier 0: Identification ... 20

4 Tier 1: Inspection – Field Team ... 21

4.1 Aims ... 21

4.2 Approach ... 21

4.2.1 Step 1: Collect general transition asset information ... 21

4.2.2 Step 2: Collect information related to the ‘hidden’ failure modes ... 21

4.2.3 Step 3: Assess the transition for the ‘surface’ failure modes ... 22

4.2.3.1 Overall structure ... 23

4.2.3.2 Two types of indications for transition performance ... 23

4.2.4 Step 4: Collect information related to the 'surface' failure modes 24

4.2.5 Tips and tricks 24

4.2.5.1 Report everything you see 24

4.2.5.2 Judgement during the tier 1 site inspection 25

5 Tier 2: Assessment – senior engineer 26

5.1 Aims 26

5.2 Approach 26

5.2.1 Overall structure 27

5.2.2 Outcomes of tier 2 28

5.2.3 Tips and tricks 28

5.2.3.1 The need to consider a 'what if' scenario 28

5.2.3.2 Decision-making 29

6 Tier 3: Advanced assessment 30

6.1 Aim 30

6.2 Approach 30

6.2.1 Overall structure 31

6.2.2 Outcomes of tier 3 31

References 33

Tables

Table 2.1 Engineering integrity issues/failure modes for each transition type 18

Figures

Figure 1-1 project overview 9
Figure 1-2 Transition zone from different perspectives (for illustration only) 10
Figure 1-3 Types of transitions considered in this report 11
Figure 1-4 Assessment process 12
Figure 4-1 Overall set-up of tier 1 flowcharts 23

Figure 4-2 Poor maintenance regime causing vulnerability to surface erosion 25
Figure 5-1 Overall set-up of tier 2 flowcharts 27
Figure 6-1 Overall set-up of tier 3 flowcharts 31

Appendices A, B, C and D referred to in this report are published in a separate document.

1. Introduction

1.1. Project overview

Transitions between flood defence assets and components introduce irregularities which increase the chance of failure, as seen in many historic flood events. Current guidance in England and Wales on the visual inspection of flood defence assets to determine condition does not explicitly account for the potential effects of transitions on defence performance. As such, where transitions do increase the probability of defence failure above that of the adjoining defence assets, the associated risks are missed from local, regional and national flood risk assessments. This research supports identifying, prioritising and assessing flood defence asset transitions to determine if they form a weak spot compared to the neighbouring assets and therefore could lead to increased flood risk. Quantifying the increased failure risk due to the transitions then feeds into a next step of prioritisation for improvement works.

The aims of the project are to:

- consider the presence of transitions when assessing flood defence condition assessment
- quantify the effects of transitions on defence performance (fragility) and flood risk
- manage the risk of transitions with improved design and retrofitted solutions for existing defences

The research outputs have been divided into 4 reports. Each report focuses on a different stage of managing assets at transitions (Figure 1-1). This report focuses on inspection and post inspection and prioritisation of transitions

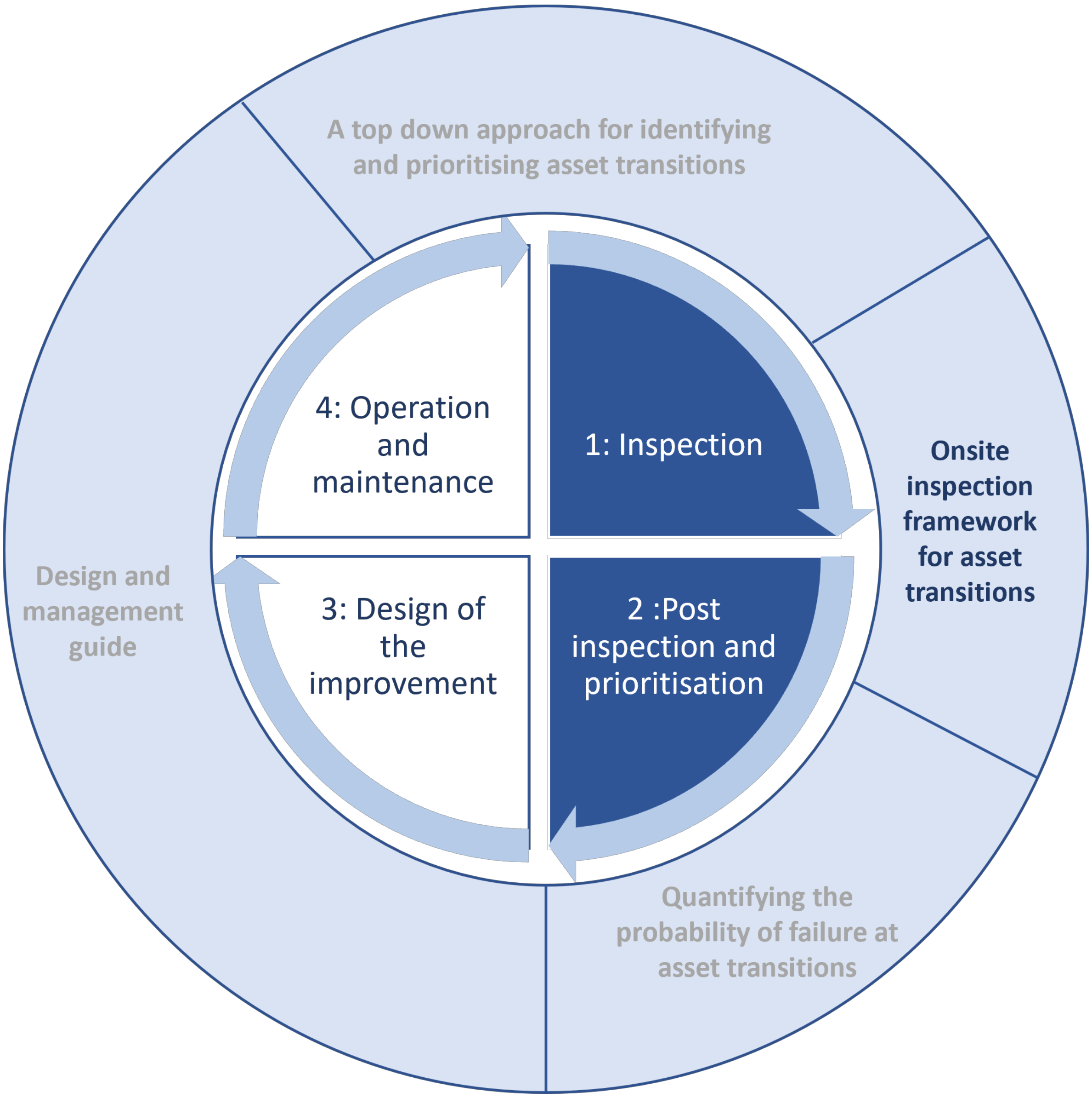


Figure 1-1: project overview

1.2. Scope of report

This report supports the assessment of flood defence asset transitions to determine if they form a weak spot compared to the neighbouring assets and could lead to unacceptable flood risk. The resulting weak spot transitions then feed into a next step of prioritisation for improvement works.

A transition is a single point or a zone in a flood defence structure where characteristics such as structure type, material, geometry, subsoil or orientation change in a way that can materially affect the performance or integrity of the structure during a flood. Examples are connections between structural flood walls and earthen embankments and crossings of utility infrastructure such as culverts or pipes through or under a flood defence. Changes of construction characteristics at transitions can have an impact on flood defence performance by locally reducing resistance (strength) or by attracting increased loading.

The size of a transition zone cannot easily be defined in general terms. It extends as far as the potential impact of the transition on the performance of the flood defence, that is, the full zone where the transition reduces strength below that of the main assets and/or increases the loading. This is sometimes called the ‘influence zone’ and is illustrated in Figure 1-2.

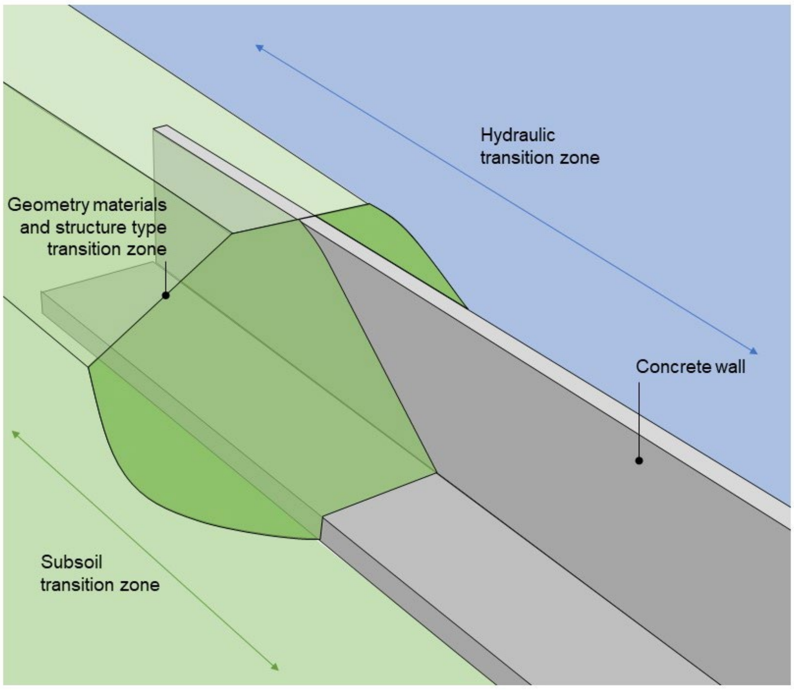


Figure 1-2: Transition zone from different perspectives (for illustration only)

The focus of this report is on embankment-related transitions: and it covers the 4 transition types in Figure 1-3:

1. longitudinal transitions
2. cross-sectional transitions
3. crossing infrastructure
4. revetments

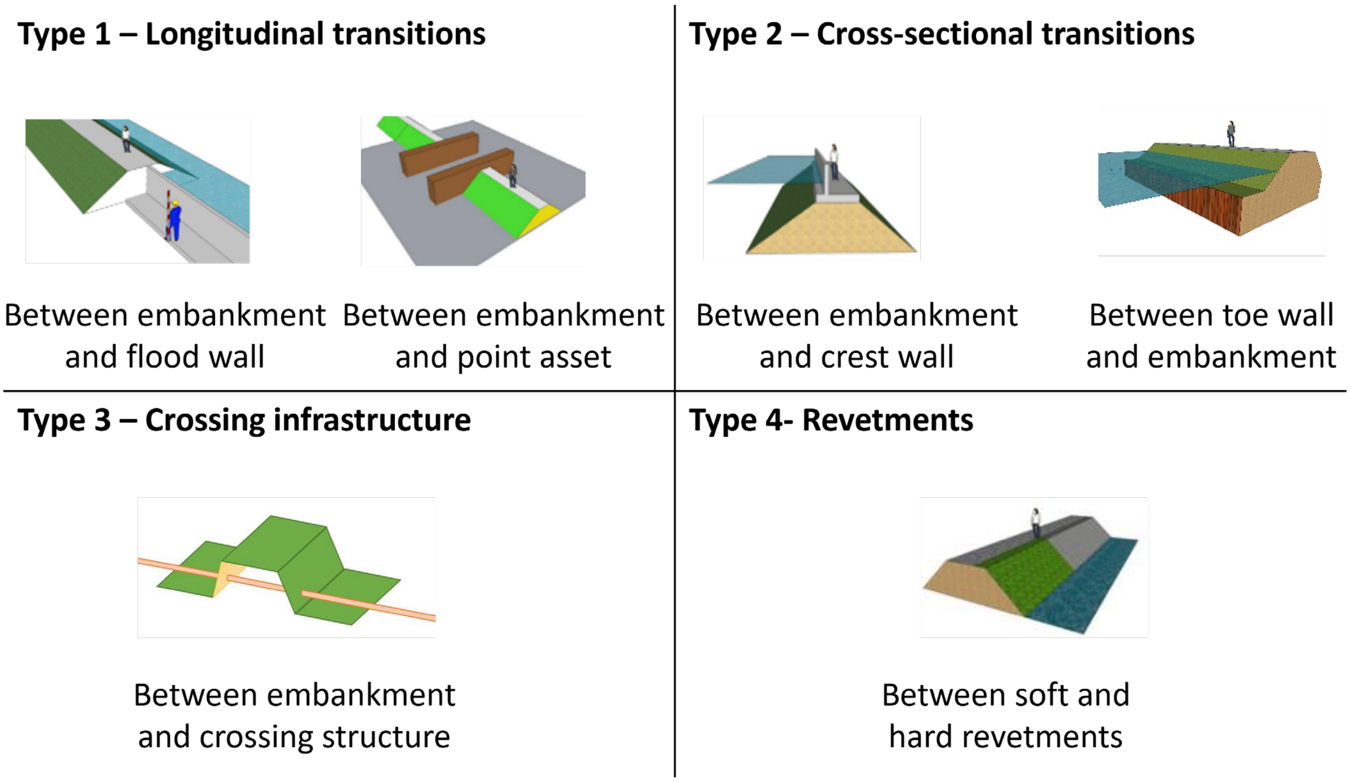


Figure 1-3: Types of transitions considered in this Report

1.3. Who is this report for?

The envisaged users are the teams responsible for identifying the need for asset improvement, in particular those involved in scoping and instructing asset inspection. The Report is set up to make the best use of different skillsets, from inspectors (such as the Environment Agency’s Field Teams), engineering staff (such as the Environment Agency’s catchment engineers) and specialists (within or outside the organisation).

1.4. Report structure

1.4.1 **By transition type and failure mode**

The method of assessment depends on the type of transition (Type 1 to 4 from Figure 1-3) and on the failure mode being considered. The Report provides an assessment method for each relevant combination of transition type and failure mode.

1.4.2 **Four tiers: simple where possible, advanced where needed**

The Report follows a tiered process as illustrated in (Figure 1-4). Each tier is described in a separate section:

- tier 0 - prioritising assets (section 3)
- tier 1 - inspection by field inspectors (such as the Environment Agency's Asset Performance (AP) Team) (section 4)
- tier 2 - assessment by senior engineers (such as the Environment Agency's catchment engineers) (section 5)
- tier 3 - advanced analysis by a specialist (section 6)

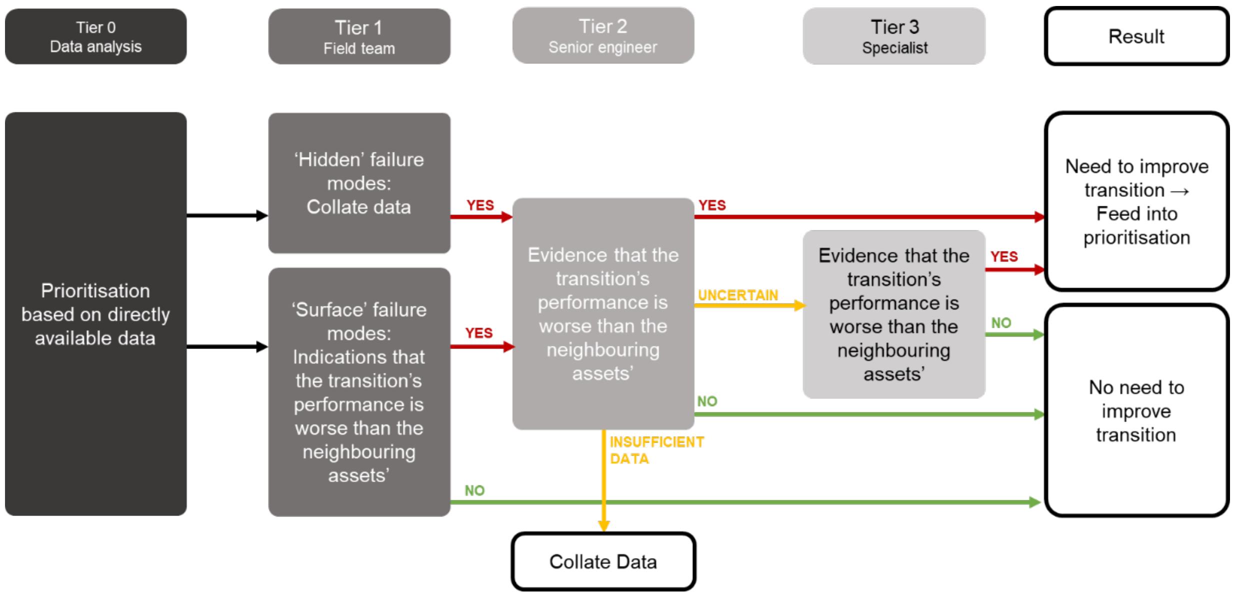


Figure 1-4: Assessment process

1.4.3 **Assessment flowcharts and proformas**

This report provides a method for each of the 3 tiers, 1, 2 and 3, for each relevant transition type/failure mode combination.

The method consists of a linked set of 3 flowcharts, one for each tier, which set out the step-wise approach, the possible outcomes of each tier and the information to be collated. The methods and their flowcharts have a consistent structure for each tier. This is explained in more detail in sections 4,5 and 6.

In addition, the report provides a set of proformas for use during tier 1 inspections, to collect data that can support the tier 2 assessments and wider performance analysis. There is a proforma for each of the 4 transition types shown in Figure 1-2. The proformas consist of 3 parts, each with a slightly different purpose and usage. This is explained in detail in section 4.

As shown in Figure 1-4, the method at tier 1 (Field inspection) is different for 2 groups of failure mode, ‘hidden’ and ‘surface’. This is explained further in section 2.

1.5. Using this report

The methods can be used in principle for any flood defence asset management organisation, but they were developed primarily in the context of the Environment Agency. As a result, some parts of the method, in particular tier 0 and tier 1, are set up so that they can be supported by the Environment Agency’s Asset Information Management System (AIMS) and associated tools. This section explains how to use this report within and outside of the Environment Agency.

In general, the different failure modes can be assessed in any order. The worst result determines the answer. This means it can be worthwhile starting with the failure mode that is most likely to be a cause for weakness, based on local knowledge.

1.5.1 Tier 0 and tier 1 for the Environment Agency

In the case of the Environment Agency, the tier 0 method presented in section 3 will identify the transition assets to be inspected. The method will automatically assign a transition type to the asset.

For tier 1, the Environment Agency has incorporated the process for ‘surface’ failure modes (the flowcharts and the relevant part of the data collection proformas) into the AIMS app that it uses for its asset management processes. The Field Teams will use the AIMS app, with the flowcharts from Appendix A as a back-up. For the ‘hidden’ failure modes and general transition asset data, the Environment Agency will still use the proformas for data collection in Appendix B.

1.5.2 Tier 0 and tier 1 for other organisations than the Environment Agency

At tier 0, the bespoke data analysis method described in section 3 will not be directly applicable for other organisations. The method’s background information (referenced in section 3) may be useful for developing their own approach for identifying and prioritising the transitions that need to be inspected.

For tier 1, the AIMS app will not be directly applicable for other organisations, but the flow charts (Appendix A) and data collection proformas (Appendix B) are fully independent of Environment Agency systems.

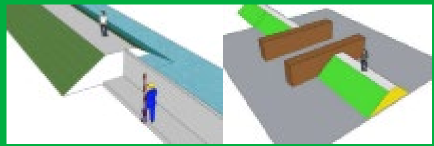
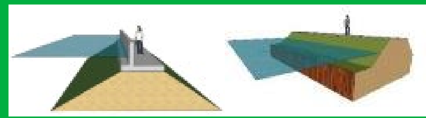
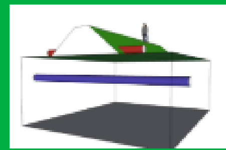
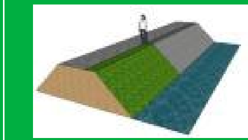
1.5.3 Tier 2 and tier 3

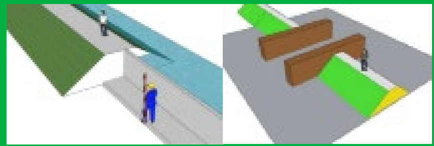
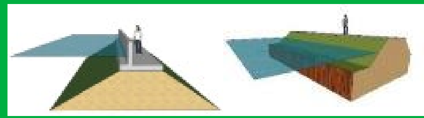
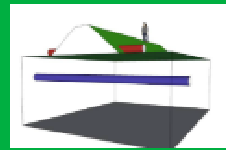
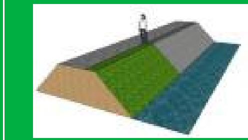
For any transitions identified as needing tier 2 assessment, the senior engineer takes the tier 2 flowcharts relevant for the transition type and only for the failure modes identified as a cause for concern in tier 1, while taking account of the overall defence and its performance. This is discussed further in section 5, and the flowcharts and proformas are provided in Appendix C.

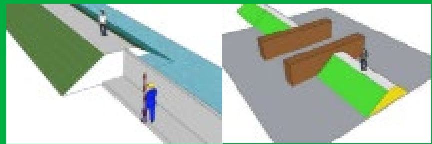
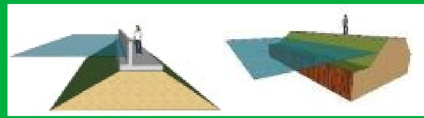
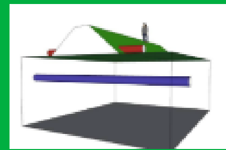
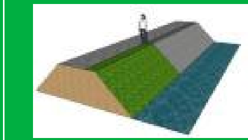
For any transitions identified as needing tier 3 assessment, the specialist again takes only the flowcharts for the relevant failure modes, while taking account of the overall defence and its performance. This is discussed further in section 6, and the flowcharts and proformas are provided in Appendix D.

2 Relevant failure modes per transition type

Table 2.1 provides an overview of the transition impacts: the ways in which transitions could reduce performance of flood defences. The table is structured by the 4 transition types and by failure mode. Each cell contains a short description of the transition impact: how the transition could reduce flood defence strength or increase the loading on the flood defence.

Failure mode	Hard to soft longitudinal 	Hard to soft cross-sectional 	Crossing infrastructure 	Revetments 
Global instability	Transition geometry too steep Soil disturbed/poorly compacted	N/A	Soil disturbed/poorly compacted Insufficient cover depth	N/A
Seepage and piping	Reduced seepage path length Preferential seepage between soil and hard structure	Reduced seepage path length Preferential seepage between soil and hard structure	Reduced seepage path length Preferential seepage between soil and hard structure	N/A
Backfill washout	N/A	N/A	N/A	Gaps, interruptions in filter structure

Failure mode	Hard to soft longitudinal 	Hard to soft cross-sectional 	Crossing infrastructure 	Revetments 
Crest height degradation	Differential settlement due to animal action (animal burrows) Rutting/furrows due to vehicles, preferential paths Differential settlement due to poorly compacted or disturbed soil	N/A	Differential settlement due to animal action (animal burrows) Differential settlement due to poorly compacted or disturbed soil	Differential settlement due to animal action (animal burrows) Rutting/furrows due to vehicles, preferential paths Differential settlement due to poorly compacted or disturbed soil
Surface erosion	Impeded root formation (poor grass cover) Reduced resistance due to poor ground compaction	Impeded root formation (poor grass cover) Reduced resistance due to poor ground compaction	Impeded root formation (poor grass cover)	Impeded root formation (poor grass cover)

Failure mode	Hard to soft longitudinal 	Hard to soft cross-sectional 	Crossing infrastructure 	Revetments 
	Reduced resistance due to erosion (wear and tear from animals, people, concentrated rainfall), rutting/furrows due to vehicles, preferential paths Increased turbulence of local wave/flow action due to irregular geometry	Reduced resistance due to erosion (wear and tear from animals, people, concentrated rainfall), rutting/furrows due to vehicles, preferential paths Increased turbulence of local wave/flow action due to irregular geometry	Reduced resistance due to poor ground compaction Reduced resistance due to erosion (wear and tear from animals, people, concentrated rainfall), rutting/furrows due to vehicles, preferential paths Increased turbulence of local wave/flow action due to irregular geometry	Reduced resistance due to poor ground compaction Reduced resistance due to erosion (wear and tear from animals, people, concentrated rainfall), rutting/ furrows due to vehicles, preferential paths Increased turbulence of local wave/flow

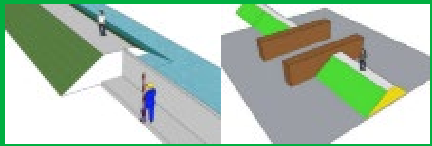
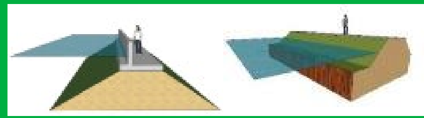
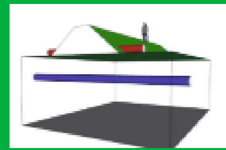
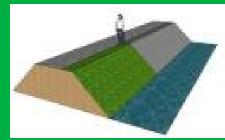
Failure mode	Hard to soft longitudinal 	Hard to soft cross-sectional 	Crossing infrastructure 	Revetments 
			Turbulence/scour around pipe perimeter or headwall structures due to irregular geometry	action due to irregular geometry

Table 2.1 Engineering integrity issues/failure modes for each transition type

The matrix in Table 2.1 forms the basis for the assessment flow charts in this report. The report provides a method for each of the relevant combinations (completed cells in Table 2.1), covering the transition impacts listed for each combination.

As indicated in Figure 1-4, the tier 1 method is different for 'hidden' and 'surface' failure modes. For 'surface' failure modes (crest height degradation and surface erosion; (Table 2.1), the defects or weaknesses are typically visible. This makes it worthwhile that the field team looks for indications of transition impacts, and uses a flowchart to assess these. However, for the other 'hidden' failure modes (Table 2.1), the focus of tier 1 is fully on collecting factual transition asset data for the tier 2 assessment, supported by the proformas. The tier 1 method for both types of failure mode is described in more detail in section 4.

Some of the flowcharts cover multiple cells where the assessment is identical; these are highlighted by coloured cell borders in Table 2.1. The resulting list of flow charts is as follows:

- Global instability:
  - Type 1
  - Type 3
- Seepage and piping
  - Type 1, 2 and 3
- Backfill washout
  - Type 4
- Crest height degradation
  - Type 1 and 4
  - Type 3
- Surface erosion
  - Type 1, 2, 3 and 4

The report assesses all these failure modes independently. In reality, failure processes are often more complex, with one process triggering another (for example, surface erosion causing instability), or different processes occurring at the same time. This needs to be considered in the tier 2 (and possibly tier 3) inspection when confirming whether a transition needs to be improved.

3 Tier 0: Identification

The tier 0 process, as reported in Development of top-down methods for identifying and prioritising asset transitions based on risk report (Environment Agency, 2022a) developed for the Environment Agency in the Transitions R&D project, is an automated method for initially prioritising transitions for tier 1 inspection. The aim is to take a risk-based approach: only invest time and resource of the tier 1 (and potentially subsequent tiers) inspection for those transitions where any increased likelihood of failure (resulting from transition impacts) would mean a significant increase in associated consequences.

The method developed for the Environment Agency is described in detail in Design and management guide for fixing transitions Environment Agency (2022d). The method is linked strongly to the specific asset management context of the Environment Agency and is not suitable for direct use by other flood risk asset management organisations. The principles behind the method can, however, be used to develop approaches for other organisations.

4 Tier 1: Inspection – Field Team

4.1 Aims

1. Collate site information about the transition to support tier 2 assessment – All failure modes.
2. Filter out sufficiently robust transitions that don't need tier 2 assessment – 'surface' failure modes only.

4.2 Approach

All transition types need to be inspected using a combination of flowcharts and proformas. The process on site consists of 4 steps:

1. Collect general transition asset information, using the first part of the proforma for the transition type.

2. Collect information relating to the 'hidden' failure modes, using the second part of the proforma.

3. Assess the transition for the relevant 'surface' failure modes, based on the flowcharts (using the AIMS app instead, if available).

4. Collect information relating to the 'surface' failure modes, using the third part of the proforma (using the AIMS app instead, if available).

These steps are described in more detail below.

4.2.1 Step 1: Collect general transition asset information

The proforma for each transition type starts with a section for collecting general transition asset information. This includes photographs, and concerns variables such as crest width, slope angle, local crest level difference and embedment length.

This information will support the tier 2 assessment, but also wider performance analysis, for example, for prioritising improvements.

4.2.2 Step 2: Collect information related to the 'hidden' failure modes

The second part of each proforma specifies information to be collected about the 'hidden' failure modes. As introduced in section 2, this concerns global instability, seepage and backfill washout, but not all of these need to be addressed for each transition type. In line with Table 2.1, the list is as follows:

- type 1: slope instability and seepage
- type 2: seepage
- type 3: slope instability and seepage
- type 4: backfill washout

The questions mainly concern whether the inspector sees any indications of damage or weakness around the transition that may be related to the failure mode, and the requested evidence concerns photos, sketches and descriptions. Due to the ‘hidden’ nature of these failure modes, these indications will not be conclusive, but they will be very important for informing tier 2 and Tier 3 assessments.

4.2.3 Step 3: Assess the transition for the ‘surface’ failure modes

The aim of this step is to filter out transitions that are so robust that they do not need to be assessed against these failure modes at tier 2. This can improve the efficiency of the overall process.

The method consists of flowcharts for each relevant combination of transition type and failure mode, provided in Appendix A. At tier 1, this concerns only the following 3 flowcharts (as introduced in section 2):

- crest height degradation for type 1 and 4
- crest height degradation for type 3
- surface erosion for type 1, 2, 3 and 4

The flowcharts report the inspector through a set of questions, aiming to determine if there is any indication that the transition’s performance is worse than the neighbouring assets. The tier 1 flowcharts are designed to feed into the tier 2 flowcharts for the senior engineer to use, as discussed in Section 5.

The flowcharts are provided in Appendix A and explained in this section.

Each tier 1 flowchart has a similar set-up, (see Figure 4-1). The text in yellow is generic in this figure, but is made specific in the flowcharts for each transition type and failure mode.

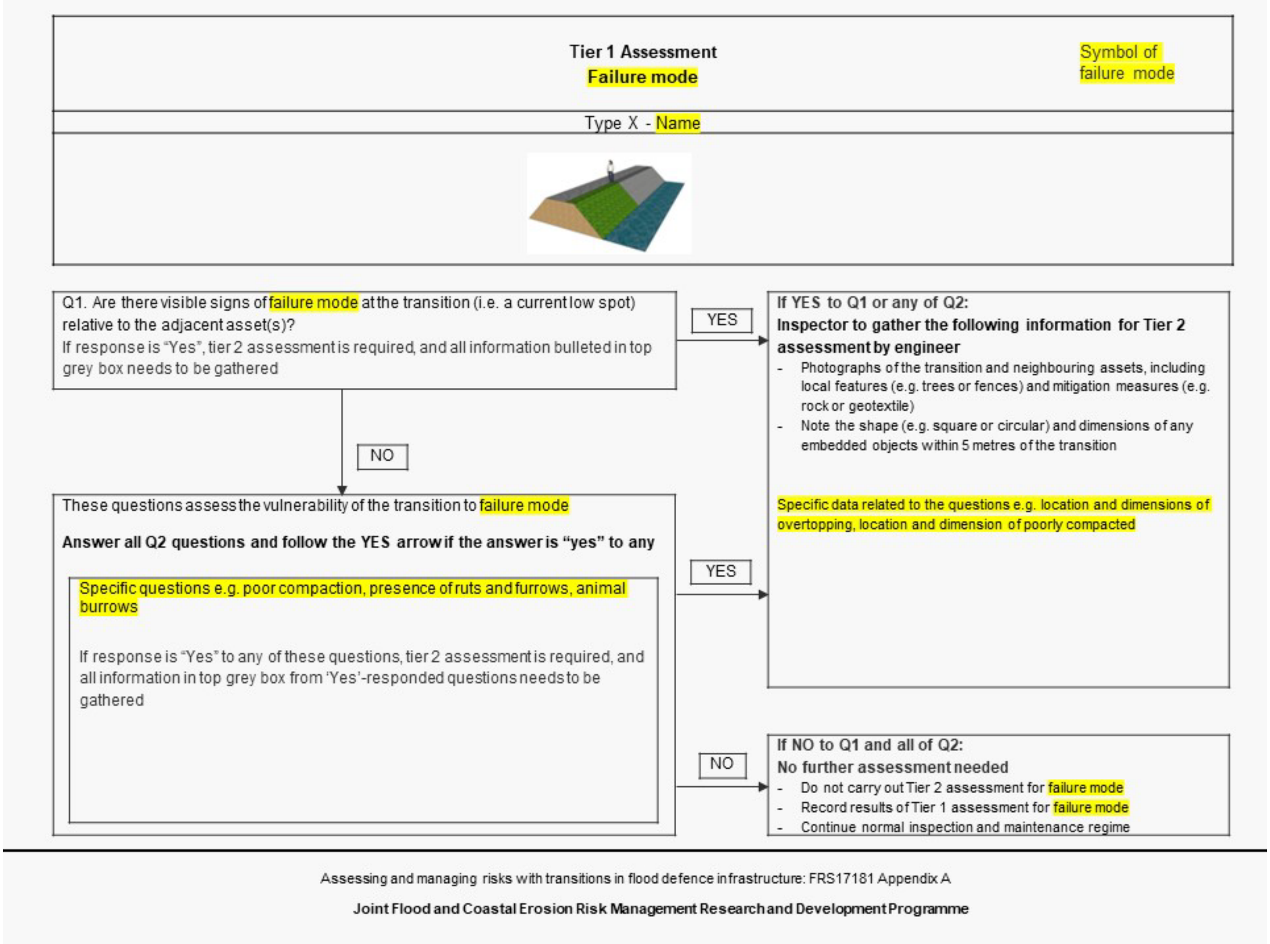


Figure 4-1: Overall set-up of tier 1 flowcharts

4.2.3.1 Overall structure

- If the Field Team finds indications that the transition's performance is worse than the neighbouring assets, then this confirms the need for a tier 2 assessment. In that case, the Field Team needs to collect all site data for the senior engineer's tier 2 assessment (see Step 4 – section 4.2.4).
- If the Field Team does not find such indications, then the transition does not need to be improved. This is the end result of the process for this failure mode.
- Note that it is not possible in tier 1 to reach an end result 'Improvement needed'; this always needs tier 2 confirmation.

4.2.3.2 Two types of indications for transition performance

There are 2 types of indications that the transition's performance is worse than the neighbouring assets, addressed by questions 1 and 2 in the flowchart:

- Question 1: If the inspector sees signs that the transition is already causing the failure mode, then a tier 2 assessment is needed.

- Question 2: If the nature, geometry or state of the transition suggests there could be negative impacts that could lead to failure, then a tier 2 assessment is also needed.

This is the general set-up. In some of the flowcharts there are multiple sub-questions to confirm whether the transition could reduce strength and/or increase loading, as far as relevant to the failure mode and transition type.

Question 1 and question 2 need to be responded to in sequence. The failure modes can be addressed in any order, but it could be efficient to start with the one most likely to conclude that there are negative impacts.

The flowcharts have been translated into the Environment Agency's AIMS app, containing the exact same steps, logic and data requirements as the paper versions in Appendix A.

4.2.4 Step 4: Collect information related to the 'surface' failure modes

The third part of each proforma specifies information to be collected about the 'surface' failure modes. As introduced in section 2, this concerns crest height degradation and surface erosion, but not all of these need to be addressed for each transition type: crest height degradation is not relevant for type 2 (cross-sectional) because the transition impacts focus on the direct interaction between the hard and soft components.

The questions mainly concern whether the inspector sees any indications of damage or weakness around the transition that may be related to the failure mode, and the requested evidence concerns photos, sketches and descriptions. In principle, the proforma only needs to be used for the 'surface' failure modes flagged up for tier 2 assessment in step 3.

4.2.5 Tips and tricks

For both the 'hidden' and the 'surface' failure modes, it is imperative for the field inspector to report and record everything that is visible and would be required during the next tier 2 assessment stage. Sections 4.2.5.1 and 4.2.5.2 give some practical tips and tricks, based on experiences in the pilots used in developing this method.

4.2.5.1 Report everything you see

Inspectors should report everything they see on the inspections and should not accept particular defects which could be perceived as being normal.

For example, soil erosion where grass is killed adjacent to structures needs to be reported, because poor grass cover could lead to surface erosion. Flagging this up is useful because it can help to identify and resolve any conflicting issues (Figure 4-2).

Figure 4-2: Poor maintenance regime causing vulnerability to surface erosion

4.2.5.2 Judgement during the tier 1 site inspection

The field inspectors collate information from the site. They are not required to make a judgement whether the severity of the issue is significant enough to decide whether improvement works would be required or not. It is for the field inspector to record what they see and collate as much information as possible for the tier 2 assessor to make this decision.

For instance, an area could have a number of molehills along the river bank. It will depend on factors such as the location, size and frequency whether these molehills could be an issue or not. The field inspector records what is visible, records dimensions, size and location and takes photographs and presents this to the tier 2 assessor to make a judgement whether there is an issue.

5 Tier 2: Assessment – senior engineer

5.1 Aims

1. Confirm if there is sufficient data to decide if the transition needs improvement.
2. Determine if the transition needs improvement.
3. Determine whether further monitoring is required.
4. If assessment methods are inadequate, then refer to tier 3 for specialist assessment.

5.2 Approach

The tier 2 assessment needs to be carried out for all transitions identified in tier 0. The assessment is not needed for 'surface' failure modes filtered out by the tier 1 inspection. The assessment follows the flowcharts provided in Appendix C. At tier 2, this is the full list of transition type/failure mode combinations identified in Table 2.1. Combining the combinations with identical assessments provides the resulting list of 7 flowcharts:

- Global instability:
  - type 1
  - type 3
- Seepage and piping
  - type 1, 2 and 3
- Backfill washout
  - type 4
- Crest height degradation
  - type 1 and 4
  - type 3
- Surface erosion
  - type 1, 2, 3 and 4

Each tier 2 chart has a similar set-up (see Figure 5-1). Text in yellow is generic in this figure, but is made specific in the flowcharts for each transition type and failure mode.

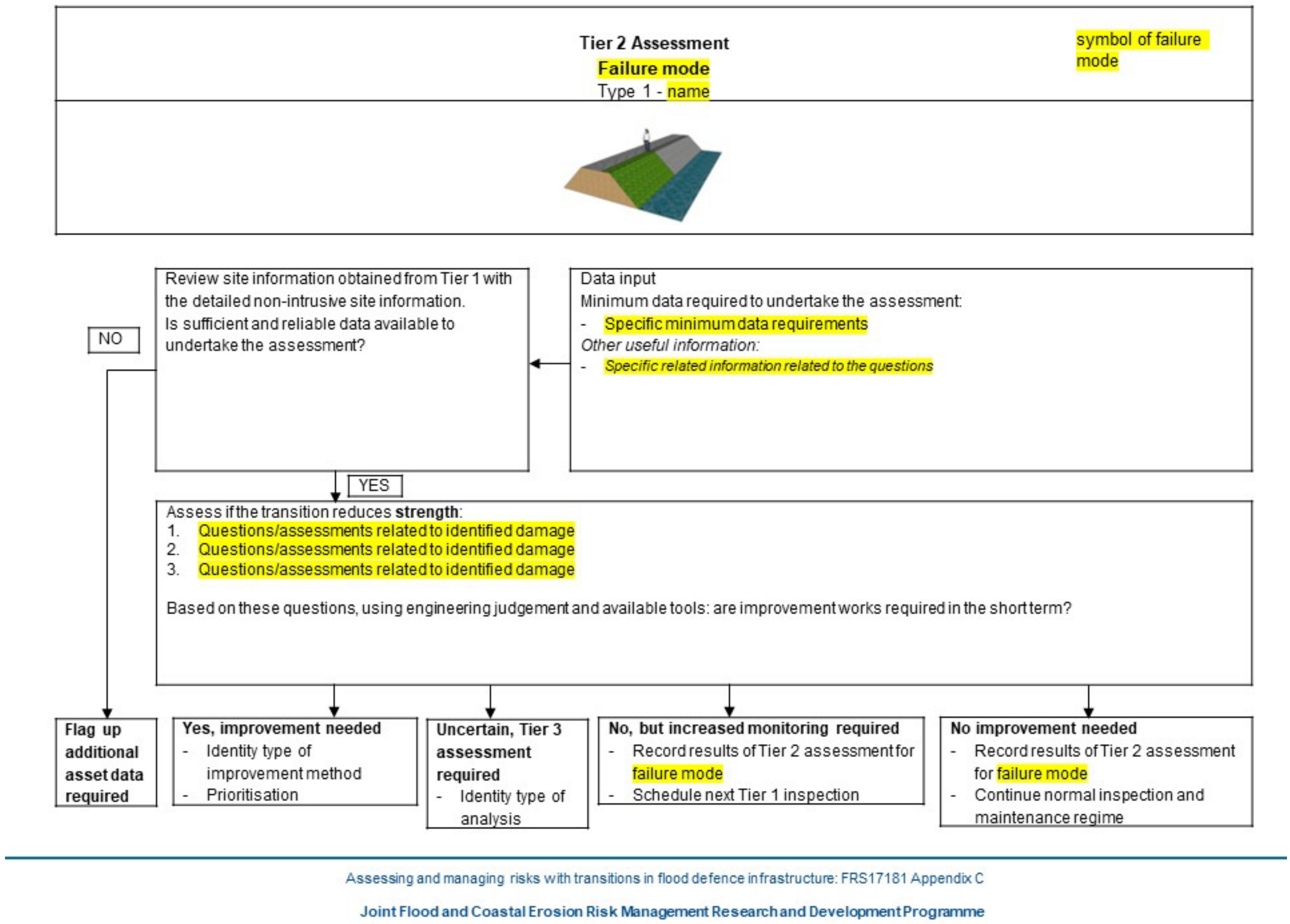


Figure 5-1: Overall set-up of tier 2 flowcharts

5.2.1 Overall structure

- Step 1 is to assess if there is sufficient, reliable information available to do the tier 2 assessment. Available information is a combination of AIMS information (including inspection history), archive (including any design data and past surveys), local knowledge (for example, from past events), and, of course, the completed tier 1 data collection proformas and flowchart information for the ‘surface’ failure modes. The data input box in the flowchart gives some guidance. If available information is insufficient, then the end result of the overall process can be to flag up that additional data is required.
  Note, in practice this conclusion can also be drawn based on an attempt to carry out the assessment in the next steps.
- The process then continues by assessing whether there are any transition impacts that make the transition a weaker link than the neighbouring flood defences. This can relate to a decrease in strength or an increase in loading as a result of the transition. The flowcharts provide a list of questions with concise guidance to support this assessment. For the ‘surface’ failure modes these questions are

directly linked to the tier 1 questions that have led to the transition being passed on to tier 2. For the 'hidden' failure modes there is a strong link with the questions from the proforma.

5.2.2 Outcomes of tier 2

From the assessment, 4 results are possible (in addition to 'additional data required' as mentioned above):

- If the engineer concludes that none of the issues require improvement, then this is the end result of the process and there is no need for improvement.
- If the engineer concludes that one or more of the issues require improvement, then this is the end result of the identification process, and the transition is passed on to the prioritisation process. The engineer is requested to provide their insights on the type of improvement needed, ideally with reference to the Design and Management Guide developed as part of the Transitions R&D project (Environment Agency, 2021).
- If the engineer concludes that one or more of the issues are concerning and may be deteriorating, but do not yet require improvement, then they can select this as the outcome. The end result of the process is to carry out further monitoring, and the engineer is responsible for initiating a next tier 1 inspection.
- If no results are negative, but the engineer judges that a more advanced assessment is needed, then the transition is passed on to tier 3. In practice, the engineer will make a risk-based judgement whether the costs of more advanced assessment are justified against the criticality of the transition. The engineer is requested to provide their insights on the type of advanced analysis needed.

5.2.3 Tips and tricks

Sections 5.2.3.1 and 5.2.3.2 give some practical tips and tricks, based on experiences in the pilots used in developing this method.

5.2.3.1 The need to consider a 'what if' scenario

The site visit is a 'snapshot in time'. In the decision-making process, the tier 2 assessors need to consider the situation during a high-water event (they should not only consider the conditions when the site inspection was carried out). In this case, weak points on the crest and landward slope may be flagged up as an issue.

"What would happen if a high-water event happens tomorrow?"

The tier 2 assessors do need to consider the situation 'now' but will also need to consider what could happen 'in the future'. The outcome of the tier 2 assessment needs to consider both.

5.2.3.2 Decision-making

The tier 2 assessors are required to make firm decisions, using their engineering judgement to interpret nuanced evidence. Still, it is possible that insufficient data is available to make this judgement or that more advanced analysis is needed. The method enables the tier 2 assessors to flag up if additional data or analysis is required, and justified, to come to these decisions.

6 Tier 3: Advanced assessment

6.1 Aim

Determine if there is a need to improve any transitions that were identified in tier 2 as needing advanced assessment.

6.2 Approach

The tier 3 assessment is only carried out for those transitions where the tier 2 assessor has identified that it is needed, and justified, to carry out advanced analysis to confirm the need for improvement.

The method will depend on very localised context, and will be informed by the tier 2 assessor's insights. The flowcharts in Appendix D provide a generic structure of the assessment for each relevant combination of transition type and failure mode (see Table 2.1), collated into the following list of 7 (same as for tier 2):

- Global instability:
  - type 1
  - type 3
- Seepage and piping
  - type 1, 2 and 3
- Backfill washout
  - type 4
- Crest height degradation
  - type 1 and 4
  - type 3
- Surface erosion
  - type 1, 2, 3 and 4

It is recognised that in practice, advanced assessment is very likely to require a holistic analysis of the whole transition and adjacent defences, considering all relevant transition impacts, failure modes and deterioration mechanisms.

Each tier 3 chart has a similar set-up (see Figure 6-1). Text in yellow is generic in this figure, but is made more specific in the flowcharts for each transition type and failure mode.

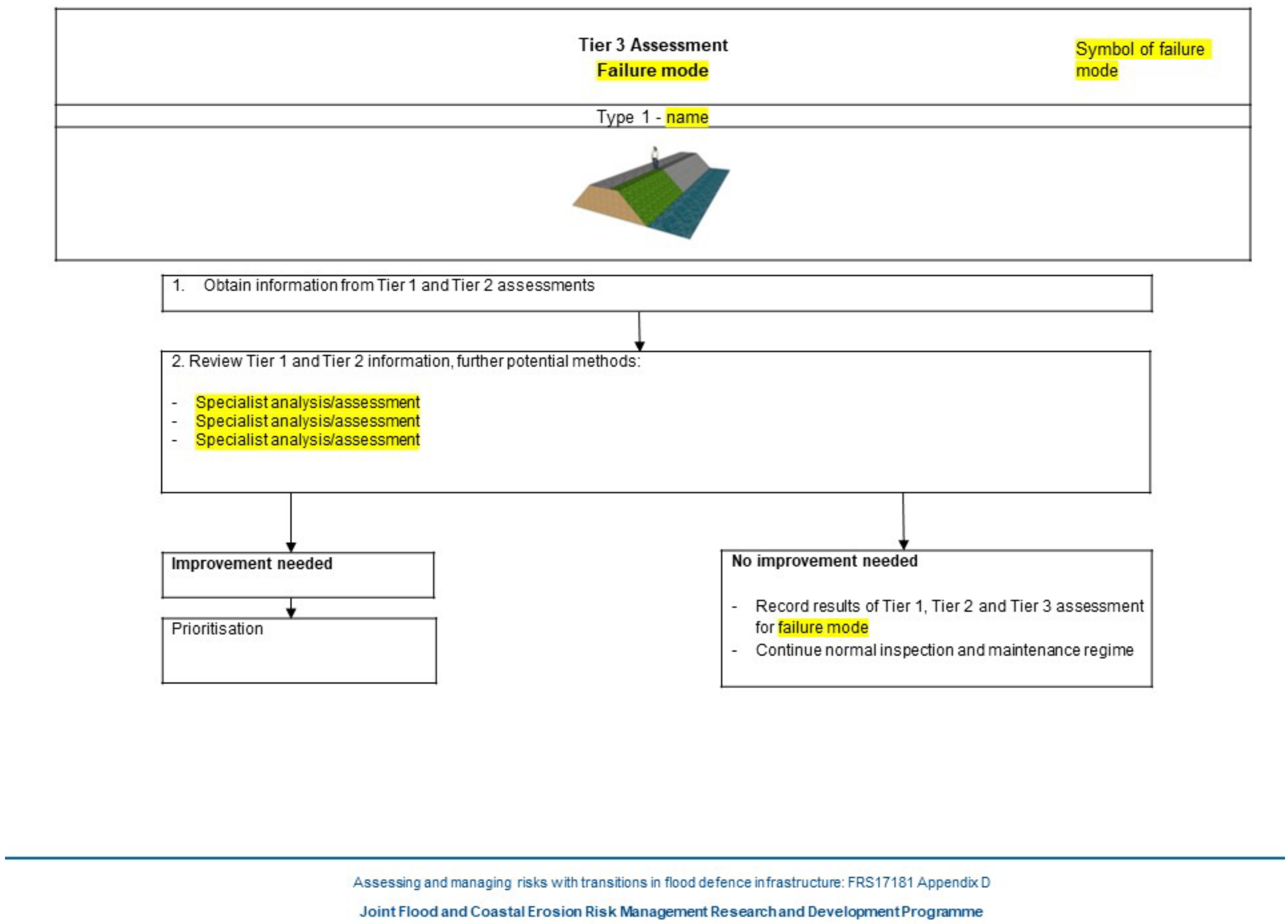


Figure 6-1: Overall set-up of tier 3 flowcharts

6.2.1 Overall structure

- Step 1 is to collate available information from the tier 1 and tier 2 process and identify if there is a need for advanced data collation (for example, intrusive surveys or specialist inspection). Note, in practice this conclusion can also be drawn based on an attempt to carry out the assessment in the next steps.
- The process then continues by further assessing the questions from tier 2 that have led to the transition being passed on to tier 3. This can relate to a decrease in strength or an increase in loading as a result of the transition. The flowcharts contain references to typical approaches, but the exact approach is case specific and to be determined by the specialist.

6.2.2 Outcomes of tier 3

- From the assessment, 2 results are possible:

- If the specialist concludes that none of the issues require improvement, then this is the end result of the process and there is no need for improvement.
- If the specialist concludes that one or more of the issues require improvement, then this is the end result of the process, and the transition is passed on to the prioritisation process. The specialist is requested to provide their insights on the type of improvement needed, ideally with reference to the Design and management guide for fixing asset transitions developed as part of the Transitions R&D project (Environment Agency, 2022d).
- In practice, it is also possible that the specialist recommends monitoring, data collection or a different analysis; these outcomes are not explicitly mentioned in the flowcharts.

References

ENVIRONMENT AGENCY, 2022a. Assessing and managing risks within transitions in flood defence infrastructure: Development of top-down methods for identifying and prioritising asset transitions based on risk. FRS17181. Bristol: Environment Agency

ENVIRONMENT AGENCY, 2022d. Assessing and managing risks within transitions in flood defence infrastructure: Design and management guide for fixing transitions. FRS17181. Bristol: Environment Agency

Would you like to find out more about us or your environment?

Then call us on

03708 506 506 (Monday to Friday, 8am to 6pm)

Email: enquiries@environment-agency.gov.uk

Or visit our website

www.gov.uk/environment-agency

incident hotline

0800 807060 **(24 hours)**

floodline

0345 988 1188 **(24 hours)**

Find out about call charges (https://www.gov.uk/call-charges)

Environment first

Are you viewing this onscreen? Please consider the environment and only print if absolutely necessary. If you are reading a paper copy, please don't forget to reuse and recycle.