

# **REPORT**

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**Hawke's Bay Regional Council**

**Scoping Report:  
Review of Riverbed Gravel  
Management**

**Report prepared for:  
Hawke's Bay Regional Council**

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## Executive summary

The Hawke's Bay Regional Council (HBRC) is reviewing the way in which it manages riverbed and coastal gravel resources within Hawke's Bay. The review aims to:

- Improve the Council's understanding of riverbed gravel movement and the impact of gravel extraction on flood protection works and coastal processes
- Review the Council's management regime for assessing the gravel resource and allocating its use.

This report presents the outcome of a scoping study that identifies a range of issues that should be further assessed, and recommends further investigations that should be carried out to assist in meeting the above aims.

Thirteen Issues have been identified for further work. These are:

1. Review of river hydrology
2. Assessment of gravel supply and transport
3. Preparation of a gravel resource inventory
4. Determining the implications of gravel management for flood protection
5. Forecasting gravel demand
6. Monitoring of gravel and determining the available resource
7. Assessment of effects on instream ecology
8. Assessment of effects on riverbed birds and vegetation
9. Assessment of tangata whenua values and management options
10. Assessment of the effectiveness of beach-raking
11. Consideration of RMA issues that influence gravel management
12. Review of allocation and financial mechanisms that influence gravel management
13. Preparation of a Gravel Management Plan.

Indicative scopes of work have been identified, as well as an indicative schedule showing the relative timing and dependencies of each of the Issues/Work packages.

In addition, it is recommended that the following continuous activities be allowed for:

- Ongoing consultation with tangata whenua, during the life of the project
- Management of the overall Review (Steering Committee).

# 1 Introduction

The Hawke's Bay Regional Council (HBRC) commissioned Tonkin & Taylor Ltd (T&T) to assist in reviewing the way in which HBRC currently manages riverbed and coastal gravel resources within Hawke's Bay. The primary aim of the review is to improve the Council's understanding of riverbed gravel movement and the impact of gravel extraction on flood protection works and coastal processes. A secondary aim is to review the Council's management regime for assessing the gravel resource and allocating its use.

T&T was specifically commissioned to prepare a scoping report that is to set out:

- The overall objectives of the review
- The issues to be addressed
- Any ongoing consultation required, including the parties to be consulted and the matters to be addressed
- Previous work and reports to be reviewed
- New research or evaluative work required, with an explanation of the relevance of each element of the work and how it fits into the overall project
- A programme of work over the next 6 years
- A detailed brief for each element of new work research or evaluative work to enable HBRC to employ the relevant experts to undertake that work.

This report sets out the process that has been followed in this scoping exercise, the process that HBRC currently goes through in assessing the gravel resource and allocating its use, the issues identified, and areas where it is recommended that further work should be undertaken.

## 2 The Need for the Review

HBRC has the following responsibilities that have a direct bearing on the management of gravel resources in Hawke's Bay:

- It has the jurisdiction to manage and authorise activities in riverbeds
- The desire to work with iwi/hapu on river management issues
- It has the jurisdiction to manage and authorise activities in the coastal marine area
- It has responsibility for flood control and protection of assets.

There is an ongoing demand from industry for gravel and aggregate resources for a range of activities. Allocation of resources from riverbed areas and the coastal zone is undertaken by HBRC in response to this demand and balancing the need to maintain the capacity of specific flood protection schemes, while taking account of the potential environmental effects of gravel extraction.

Hawke's Bay is characterised by two main river systems that historically have provided gravel – the rivers of the Heretaunga Plains (principally the Lower Tukituki, Tutaekuri and Ngarururo Rivers) and the Ruataniwha Plains (the Waipawa/Tukituki river system). Other rivers in the north of the region (principally the Esk and the Mohaka) provide lower volumes of gravel material. The Hawke's Bay region is seismically active and significant seismic events have occurred including within historic time, affecting sea level, uplift rates, sediment supply, and river morphology.

Extensive flood protection schemes have been established throughout both the Heretaunga and Ruataniwha Plains areas, including man-made modifications to river courses, and are maintained by HBRC. Those schemes have been designed and constructed to provide protection from flood events of specific return periods. Their effectiveness is therefore dependent on those design standards being maintained particularly through maintenance of channel carrying capacity and design riverbed levels.

The main population areas and therefore gravel demand are on the Heretaunga Plains. However there are significant gravel supply sources in the riverbeds on the Ruataniwha Plains but with a lower demand from the Ruataniwha area. There is therefore a tension between gravel supply and gravel demand areas, due to the extra transport cost of getting the gravel to market from these more distant sources, which has implications for HBRC's maintenance of flood protection schemes in these areas. There are land-based sources of gravel throughout Hawke's Bay, and these (particularly those in the Heretaunga Plains) are increasingly being targeted by gravel extractors as a suitable, low cost source in good proximity to demand areas. HBRC currently has little ability to manage use of these land-based areas.

In addition, there is some uncertainty over the potential effects of riverbed gravel extraction, specifically in relation to the following aspects:

- Long-term riverbed morphology
- Long-term riverbed gravel supply
- Sediment supply to the coast, and effect on coastal stability
- Instream habitat
- Riverbed ecology (birds) and biodiversity
- Sites and issues of significance to tangata whenua.

Accordingly, this review has been tasked with addressing these aspects and determining what further work if any is needed to provide HBRC and other interested parties with the information

necessary to continue to manage the riverbed gravel resource, and importantly to confirm or otherwise whether the current management regime and processes are appropriate.

### 3 Review Methodology

The review has included the following:

- Site visit and discussions with HBRC Asset Management Group staff
- Identification of relevant background reports (see Appendix A)
- Consultation meetings with stakeholders groups:
  - Napier City Council, Hastings District Council, Central Hawke's Bay District Council
  - Department of Conservation, Fish & Game NZ
  - Gravel users (Winstone Aggregates, Higgins, Holcim, Infracon, Fulton Hogan, QRS, Russell Roads)
- Attendance at hui with hapu
- Discussions with specialists:
  - Professor Stephen Coleman, University of Auckland
  - Professor Michael Crozier, Victoria University of Wellington
  - Gary Williams, G & E Williams Consulting
  - Richard Reinen-Hamill, Coastal Engineer, Tonkin & Taylor
- Preliminary identification of issues and workshop with HBRC to confirm those issues
- Preparation of report including schedule (refer to Appendix B).

## 4 Current Management of Gravel Resources in Hawke's Bay

The key points of the gravel management system currently used by HBRC can be summarised as follows:

- HBRC's Assets Management Group surveys the channels of the main river systems on a 3 yearly basis. These surveys have been undertaken at this frequency since the late 1970s
- The rivers surveyed are the Esk, Ngaruroro, Tutaekuri, Tukituki and Waipawa
- For the purposes of calculating gravel volumes and allocation, the surveys are undertaken at fixed cross-section lines with 500m being a typical spacing
- The rivers are divided into reaches, based on changes in river grade
- A 'gravel extraction line' has been determined for each river, taking into account river management requirements (based on the flood conveyance capacity of the channel section)
- The change in volume of gravel bed material in a river reach from one survey period to the next is calculated by determining differences in mean bed levels at each cross-section, and using the distances between cross-sections to calculate reach volumes
- Gravel users provide HBRC Asset Management Group with an estimate of their riverbed or coastal gravel requirements on an annual basis
- An annual 'Gravel Allocation Plan' is prepared by the Asset Management Group that presents:
  - the results of each 3-yearly survey and calculation of current gravel availability for each river (based on each river reach/cross section and the difference between the surveyed bed level and gravel extraction grade line)
  - identifies the proposed gravel extraction sites (reaches) for each river
  - allocates specific annual volumes to each gravel user for each river and reach, taking into account an estimate of volume removed based on allocation and industry returns) since the previous survey
- HBRC allocates gravel to users on an annual basis based on the Gravel Allocation Plan
- Resource consents for gravel extraction are issued by HBRC Assets Management Group to each gravel user for each annual allocation period i.e. each consent is issued for a 12 month duration
- Gravel users are required to monitor the volume extracted from each reach and to report to HBRC
- If extracted volumes are less than allocated volumes, there is no 'roll-over' of allocation from one year to the next
- Historically some reaches of the Ngaruroro and Tutaekuri Rivers have been over-allocated, whereas the gravel supply in the rivers of the Ruataniwha Plains (the Waipawa and the upper/mid Tukituki) exceeds demand and allocation.

## 5 Issues

### 5.1 Introduction

This section reports on the issues identified from this review and suggests areas for further assessment.

The format is as follows:

- Subject area
- A description of the issue, including how the issue arose or what party/parties raised it
- The objective of further assessment
- A preliminary scope of work. The scopes are presented at a high level, as it is considered more appropriate that the respective specialists develop a methodology that is appropriate to meet the stated objectives.
- Intended outputs
- The approximate duration of the work package, and its timing relative to other packages (predecessors and dependents).

### 5.2 Issue 1: Hydrological review

#### 5.2.1 Description

Hydrological cycles potentially influence gravel supply. The observation was made by HBRC staff that relatively few floods have occurred over recent years, and that therefore there may be a relationship between this and supply of gravel to and transport through the river systems. The period of the 1980s and 1990s were an Interdecadal Pacific Oscillation (IPO) passive phase and in many regions in New Zealand fewer flood events have occurred compared to the 1960s and 1970s. Although an increase in flood frequency and magnitude has occurred subsequently in other parts of NZ, this trend has not been observed in Hawke's Bay. Therefore, there is concern whether the current gravel management practices are based on an unrepresentative hydrological period. In addition, it is unclear whether changes to rainfall and flood frequency that are predicted from climate change will have an impact on gravel supply and transport.

This issue was raised by HBRC staff, gravel industry representatives and specialist advisors.

This study involves a review of the hydrological history of Hawke's Bay rivers. It is needed to inform the Gravel Supply and Transport study (Issue 2). It is treated separately from that study because it requires specialist hydrological skills. The output is also likely to be relevant to the Implications of Gravel Management for Flood Protection study (Issue 4).

#### 5.2.2 Objective of further assessment

To assess the representativeness of the recent hydrological regime in Hawke's Bay rivers (flow magnitude and frequency) in a longer-term context as a means of assisting the determination of the influence of hydrological cycles on gravel transport in the Hawke's Bay rivers.

#### 5.2.3 Preliminary scope of work

- Review of recorded and synthetic hydrological records (rainfall and river flows) for the main river systems (build on work to date by HBRC)
- Correlate to hydrological information from other parts of NZ
- Identify/assess any changes/trends

- Consider the likely effects from climate change
- Assess the representativeness of the current hydrological regime in a long-term context.

#### **5.2.4 Outputs**

- Hydrological records and trends for Hawke's Bay rivers
- Statement of assessed representativeness and reliability
- Inputs to gravel sources and supply study where correlations to sediment transport will be made.

#### **5.2.5 Likely duration and timing relative to other studies**

Expected duration: 3-4 months

This work package will provide input to the following studies:

- Gravel Supply and Transport study (Issue 2)
- Gravel Resource Inventory (Issue 3)
- Implications of Gravel Management for Flood Protection (Issue 4)
- Gravel Management Plan (Issue 13).

#### **5.2.6 Potential parties to undertake the work**

It is considered that this Issue requires specialist hydrological analysis. This package could be undertaken on a consultancy basis, or by a Council hydrologist. If this package were undertaken by a consultant, support would be required from HBRC technical staff. It is noted that a rainfall frequency analysis has recently been completed by HBRC and this work will be a useful starting position.

### **5.3 Issue 2: Gravel supply and transport**

#### **5.3.1 Description**

The fundamental issue is being able to determine, to an appropriate degree of accuracy, the sources of gravel and the long-term supply/transport of gravel (volume). This has implications for management of the river systems in terms of sustainability, and supplying the demand for aggregate resources both in terms of quantity and quality for industry purposes.

This is an issue raised by HBRC, district councils, gravel industry representatives, and specialist advisors.

While the gravel resource in the surveyed river reaches can be, and is being, quantified, there remains uncertainty relating to what the long-term supply of gravel to those river systems and how this may be changing with time. Sediment supply can be influenced by a number of interrelated variables including:

- Ground cover and landuse especially in the headwaters
- Influence of vegetation e.g. lupin in the upper sections of the river systems holding sediments in river/valley floor outside the active channel
- Role of in-channel reserves/sources of sediment
- Hydraulics for sediment transport i.e. the size of flood necessary to overcome bed armouring and move sediment
- Hydrological factors and influence of hydrological cycles (refer to 'Hydrological Review' – Issue 1)

- Seismic events and the role of catastrophic events in the supply of gravel
- Seismic events (1931 earthquake) and the role of uplift (Tutaekuri/Ngaruroro) and subsidence (Tukituki) to river hydraulics and sediment transport
- Changes to gravel extraction over time
- Variation in sediment size down the river
- Silt sources and supply and sustainable extraction rates.

The study of supply and sources of gravel is an applied science issue with a focus on geomorphology (land and fluvial).

The issue of river gravel supply and sources is also related to the coastal sediment budget. The key uncertainties for the coastal sediment budgets are:

- The role of sediment supply from rivers in the local coastal sediment budget, and particularly with regard to coastal erosion in the Haumoana/Te Awanga area
- What the current sediment supply is to the coast and whether this has changed and whether this has affected beaches and coastal areas
- How this amount is currently and historically affected by gravel extraction, hydrology, seismic events and other variables listed above.

### 5.3.2 Objective of further assessment

1. To improve understanding of the sustainability of the gravel resource and the science that influences its supply
2. To identify potential sources and rates of gravel supply
3. To assess the relationship between river gravel supply and movement and the coastal sediment budget
4. To identify ongoing monitoring needs.

### 5.3.3 Preliminary scope of work

Stage 1:

- Review previous investigation reports (including those by Gary Williams and Robin Black)
- Confirm scope of work for Stage 2.

Stage 2 (likely to involve):

- Review of historical aerial photographs – for changes in ground cover (proportion of bare areas), land use, river channel widths
- Assess mineralogy of potential supply areas:
  - Assess sediment type (mineralogy) and size in rivers
  - Assess sediment type (mineralogy) and size on coast
  - Compare sediment type (mineralogy) and size in rivers and coast to determine relationship
- Incorporate results from Hydrological Review (Issue 1) and assess correlation between river flows and sediment transport
- Assess long-term sediment budget (quantity and quality) in rivers, based on HBRC surveys, potential source areas, and the assessment of the representativeness of the hydrological regime.

### 5.3.4 Outputs

- Identification of historic, current and potential gravel supply areas
- Comparison of historic and current gravel supply areas (relative volumes of contributing areas)
- Identification of the influences/constraints on gravel supply and gravel transport
- Determination of gravel supply rates and influence of coastal sediment budget
- Identification of ongoing monitoring requirements.

### 5.3.5 Likely duration and timing relative to other studies

Expected duration: 4-6 months

This work package is dependent on the prior completion of the following studies:

- Hydrological Review (Issue 1)

This work package will provide input to the following studies:

- Gravel Resource Inventory (Issue 3)
- Gravel Monitoring and Determination of Available Resource (Issue 6)
- Gravel Management Plan (Issue 13).

### 5.3.6 Potential parties to undertake the work

It is considered that this Issue is one that could be appropriately undertaken by a research organisation such as a university or Crown Research Institute. There are specific aspects within it that could form suitable student research projects, and/or be undertaken as student holiday projects. A senior researcher would be required to oversee the total package as well as take responsibility for some of the more complex aspects. Integration of a specialist consultant or HBRC staff into this project team/management would be beneficial, so that the project remains focused on the Council's objectives.

## 5.4 Issue 3: Gravel Resource Inventory

### 5.4.1 Description

Gravel extractors and district councils expressed the view that it is important that the gravel resources are managed for the appropriate end-use. A significant driver in this is the location of gravel resources and access to those sources.

Further, there is uncertainty about the sustainability (longevity and quantum) and access to the river-based gravel resource. Gravel extractors consider the short-term (annual) nature of allocations and resource consents granted by HBRC for river gravel extraction is unsatisfactory for business planning, and as a result are tending to turn to alternative land-based sources for which security of ownership and long-term consents can be obtained. Their moving from river-based extraction sites has the potential to affect HBRC's responsibilities with regard to flood protection.

There was strong support from gravel industry representatives, the district councils, and HBRC that there was a need to have better information on the gravel resources (their location, quantities and quality) to enable more informed decisions to be made by both the users and HBRC as to what resources are suitable for use.

A gravel inventory would:

- Identify source locations, available quantities, and quality of the gravel

- Identify any risks and/or expected variability in the gravel supply and/or quality
- Assist in determining the sustainability (longevity and quantum) of the river based gravel resource.

The inventory should also cover land-based gravel resources. This would be useful if the river-based sources are limited and land-based resources need to be identified and protected.

Sensitive sites, such as ecologically sensitive areas and waahi tapu, could be added to the database as these may be constraints to use of the resource.

The inventory would provide a resource document to guide allocation and long-term management of the region's gravel resource.

#### **5.4.2 Objective of further assessment**

1. To provide a resource inventory describing location, quantity and quality of the gravel resource in Hawke's Bay (both river-based and land-based)
2. To demonstrate the sustainability (longevity and quantum) of the river-based gravel resource
3. To inform preparation of the Gravel Management Plan.

#### **5.4.3 Preliminary scope of work**

- Identification and mapping of gravel source locations (maps to be produced on GIS base).
- Incorporate information from Gravel Supply and Transport study (Issue 2)
- Estimate of available volumes (from Gravel Supply and Transport study (Issue 2))
- Assessment of material type (quality and mineralogy) and size (including in context of industry requirements)
- Landuse zoning and constraints in district plans
- Assessment of capacity of current and potential land-based quarries
- River access mapping
- Input on environmentally sensitive areas from Ecological Effects studies (Issues 7 and 8)
- Input from tangata whenua values study (Issue 9)
- Seek input from industry representatives.

#### **5.4.4 Outputs**

- Maps showing the gravel resource locations including spatial coverage, supply rates, quality, access, land use constraints, ecological constraints, waahi tapu (integrated with HBRC's GIS base)
- Report of volumes, quality
- Assessment of issues.

#### **5.4.5 Likely duration and timing relative to other studies**

Expected duration: 3-4 months

This work package is dependent on the prior completion of the following studies:

- Gravel Supply and Transport study especially quality and size of gravel in rivers (material sampling) (Issue 2)
- Ecological Effects studies (Issues 7 and 8)
- Tangata Whenua Values and Management (Issue 9).

This work package will provide input to the following studies:

- Gravel Management Plan (Issue 13).

#### **5.4.6 Potential parties to undertake the work**

It is considered that this Issue is largely a data input and management task, with a GIS focus. It is expected that this could be done in-house by HBRC.

### **5.5 Issue 4: Implications of Gravel Management for Flood Protection**

#### **5.5.1 Description**

HBRC has responsibility for several flood protection schemes in the region, particularly on the Ngaruroro, Tutaekuri, Waipawa and Tukituki rivers. These have been in place since the 1960s, but with significant reviews occurring in the 1980s to 2000. The schemes have been constructed to specific design standards, and their effectiveness is therefore dependent on maintaining these design standards. The changes in riverbed levels from variations in sediment supply and extraction directly affect the ability of the schemes to operate to the design standards.

Currently one of the ways in which HBRC manages these systems is through balancing the needs of retaining channel carrying capacity with the demand for gravel by industry. This balancing is a factor in the allocation of riverbed gravel for extraction by industry.

The Ruataniwha Plains rivers are further from the gravel market (demand), so additional transport costs are incurred for gravel supply from these sources. These sources are therefore less attractive to the gravel industry, and it appears that the high transport costs may be influencing the trend for contractors/extractors to secure land based supplies from areas which are closer to market. In the absence of industry extracting gravel from the Ruataniwha Plains rivers the effectiveness of the flood protection schemes may be compromised. HBRC is faced with the issue of determining how otherwise to address flood protection i.e. does HBRC directly take over maintenance of the channel carrying capacity (with financial implications), or does the standard of protection provided to communities need to be reassessed and potentially lowered. HBRC has commenced a review of the level of service that these schemes need to provide, including seeking feedback from community to see what level of risk they are willing to accept.

There is therefore a need to:

- Identify those river reaches of concern i.e. where riverbed level increase will have significant implications on flood protection standards and security
- Understand the movement of gravel through the systems
- Determine the extent of reliance on gravel extraction for the maintenance of flood protection design standards.

#### **5.5.2 Objective of further assessment**

To assess the relationship between:

- River-based gravel volumes and locations
- The integrity of flood protection schemes
- Reliance on gravel extraction activities.

#### **5.5.3 Preliminary scope of work**

- Identify critical reaches of rivers that potentially affect the effectiveness/level of service of the existing flood protection schemes

- Use the outputs from the Gravel Supply and Transport study (Issue 2) to understand the long-term variability of sediment supply and transport through the river systems, and particularly at the selected reaches
- Use existing hydraulic models to understand the sensitivity of current flood management schemes to changes in riverbed levels (based on an agreed number of scenarios)
- Determine the potential changes in the performance of flood defences arising from changes to gravel supply/management
- Quantify the risk to flood defence standards
- Identify options to address the risk as appropriate.

#### **5.5.4 Outputs**

- A report addressing the risk to flood defences from changes to gravel supply/management, and recommending measures to address the risk.

#### **5.5.5 Likely duration and timing relative to other studies**

Expected duration: 3-4 months

This work package is dependent on the prior completion of the following studies:

- Hydrological Review (Issue 1)
- Gravel Supply and Transport study (Issue 2)
- Level of service review for flood protection (separate study being undertaken by HBRC).

This work package will provide input to the following studies:

- Gravel Management Plan (Issue 13).

#### **5.5.6 Potential parties to undertake the work**

It is considered that this Issue is one that should involve input by HBRC staff as well as input from a consultant. It is assumed that HBRC would undertake the identification of river reaches and the modelling.

### **5.6 Issue 5: Gravel Demand Forecast**

#### **5.6.1 Description**

HBRC allocates river gravel resources to industry on (amongst other things) the basis of demand forecasting by industry for aggregate usage. This is done on an annual basis, with the industry organisations estimating their likely requirements in terms of volume (and presumably taking quality, and preferred location related to their operational bases, into account). While most of the industry representatives involved in the current review indicated that this system generally works satisfactorily due to the constructive approach of HBRC staff, there was a strong concern that the annual basis did not provide appropriate assurance for industry business planning.

In addition, HBRC expressed concern that the estimate of demand may not adequately reflect that some major projects (and therefore aggregate demand) may be competitively tendered and more than one company may therefore seek to cover the required allocation in any one year, thus resulting in a distortion of actual demand. Further, there is the issue of how to accommodate or respond to a demand from either a new major project within the region or for demand from outside the Hawke's Bay Region.

This Issue includes determination of whether there are specific quality issues associated with gravel demand, such as the size and material properties that influence the appropriate end use for the aggregate. This would link to the Gravel Resource Inventory (locations, volumes and quality of material) (Issue 3). The demand for river-based gravels versus land-based sources is an important input to the Gravel Management Plan.

The Aggregate and Quarry Association has undertaken studies into gravel consumption. Usage figures of 10-11 tonnes/person/year are quoted. The applicability and relevance of these numbers to the Hawke's Bay Region should be reviewed. Demand could be forecast based on the expected population growth in the region. The demand for river-based gravels as a proportion of this total demand should be assessed.

In addition, there is a need to include the supply of sand and silt in this study as well as gravel.

### **5.6.2 Objective of further assessment**

To determine the most accurate method of assessing demand for total and river-based gravels, and to determine that demand for a range of timeframes.

### **5.6.3 Preliminary scope of work**

- Review Aggregate and Quarry Association's studies into gravel demand, including specific data for Hawke's Bay for both river-based and land-based gravel sources
- Review local estimates for gravel/aggregate demand and split between river-based gravels, land-based gravel quarries and hard rock quarries
- Develop projections for gravel/aggregate demand based on expected population growth or other means if more reliable
- Assess viability of supply of gravel to outside the region and estimate potential demand.

### **5.6.4 Outputs**

- Report forecasting gravel demand.

### **5.6.5 Likely duration and timing relative to other studies**

Expected duration: 3-4 months

This work package will provide input to the following study:

- Gravel Management Plan (Issue 13).

### **5.6.6 Potential parties to undertake the work**

This package may most appropriately be undertaken by a former member of the gravel industry or a resource economist on a consultancy basis.

## **5.7 Issue 6: Gravel Monitoring and Determination of Available Resource**

### **5.7.1 Description**

HBRC has developed a process for monitoring the riverbed gravel resource and calculating the quantity:

- Available to be allocated to users for extraction, and/or
- Necessary to be extracted to maintain flood conveyance capacity.

There is a need to assess:

- Whether the current approach is appropriate, and
- Whether it is taking account of relevant factors and has the required degree of accuracy.

This issue has been raised by HBRC.

Cross-sections of the managed areas of rivers are surveyed every three years. The difference between the surveyed bed level and the 'extraction grade line' is used as the basis for calculating the volumes available for extraction in any particular river reach.

This issue is a technical check of HBRC's processes for monitoring gravel and calculating the quantities of available resource (who allocates it and how it is allocated is covered by a separate brief – see Issue 12). It is dependent on knowledge from the Gravel Supply and Transport study (Issue 2).

### **5.7.2 Objective of further assessment**

To review the adequacy of current monitoring, particularly in terms of:

- Frequency and sites
- Setting the 'gravel extraction line'
- Identifying changes in sediment supply and locations.

### **5.7.3 Preliminary scope of work**

Review current processes and assess alternative processes, including the following:

- Assess the appropriateness of cross-section surveys as a method of determining changes in sediment supply and locations
- Assess whether alternatives to cross-section surveys are necessary or viable and the pros and cons of alternative methods such as the use of LiDAR – accuracy, technological changes, spatial coverage, continuity of record, cost etc
- Assess the adequacy of the frequency of surveys, as well as the spacing between cross-sections and their location/spatial extent
- Assess the appropriateness of the practice of site verification of gravel quantities
- Assess whether there are alternatives to the allocation method such as those based on sediment supply/transport rates
- Assess the appropriateness of the gravel extraction lines particularly in areas where historically over-extraction has occurred. In these areas, assess whether there are additional costs from bank stabilisation that need to be considered
- Identify any issues that arise in relation to the 'disconnect' between the data interval of 3 years and consent interval of 1 year
- Assess the appropriateness of the extent of river reaches monitored. Assess whether upstream areas which are supply areas should also be monitored
- Identify/report advantages and disadvantages of current system
- Identify/report advantages and disadvantages of alternative systems
- Undertake a benefit/cost analysis of current and likely alternative systems.

### **5.7.4 Outputs**

Report on assessment and recommended system for monitoring, setting the gravel extraction line, and determining the volumes of resource available in each river/reach.

### 5.7.5 Timing/duration

Expected duration: 3-4 months

This work package is dependent on the prior completion of the following studies:

- Hydrology review (Issue 1)
- Gravel Supply and Transport study (Issue 2)
- Implications of Gravel Management for Flood Protection (Issue 4)

This work package will provide input to the following studies:

- Gravel Management Plan (Issue 13).

### 5.7.6 Potential parties to undertake the work

This package may most appropriately be undertaken on a consultancy basis by a river engineer with experience in survey techniques. The project requires an external/independent point of view.

## 5.8 Issue 7: Ecological Effects – Instream

### 5.8.1 Description

There appears to be a lack of information about whether gravel extraction activities have any significant effect on instream river ecology, particularly on indigenous fish species and trout (and associated angling). This issue has been raised by Department of Conservation (DoC), Fish & Game, HBRC and tangata whenua.

Gravel extraction has the potential to affect instream fauna and flora:

- Directly through disturbance of habitat within wetted area (albeit extraction within wetted area is probably discouraged)
- Indirectly through discharge of sediment from gravel extraction activities
- Alteration to channel characteristics causing aggradation or erosion of riverbed.

Beach raking has the potential to affect instream fauna and flora:

- Indirectly through discharge of sediment during or following raking activities (after freshes in system)
- Alteration to channel characteristics causing aggradation or erosion of riverbed
- Directly through disturbance of habitat (albeit raking within wetted area is not undertaken)
- Indirectly through disturbance of habitat following raking activities (after freshes in system).

### 5.8.2 Objective of further assessment

1. To identify the potential effects of riverbed gravel extraction on significant instream species (indigenous fish and trout)
2. To classify areas according to their potential sensitivity to gravel extraction
3. To inform preparation of the Gravel Resource Inventory
4. To identify monitoring programmes that will provide necessary information for ongoing management
5. To inform preparation of the Gravel Management Plan.

### 5.8.3 Preliminary scope of work

Stage 1:

- Review of previous investigations and management plans (e.g. Ngaruroro Management Plan)
- Review of existing fisheries data (trout, and indigenous species) from previous surveys
- Review existing data on significance of rivers and reaches for angling
- Determine any requirements for further surveys and scope the work.

Stage 2:

- Undertake any new surveys as considered necessary from the above review.

Stage 3

- Preliminary assessment of effect of disturbance from gravel extraction activities (including beach raking), including identifying sensitive rivers/reaches
- Mapping of environmentally sensitive areas for use in the Gravel Resource Inventory (Issue 3)
- Preparation of monitoring programme – sites, methodologies, frequencies, triggers, management feedback and review.

### 5.8.4 Outputs

A report including:

- Maps identifying key rivers and reaches for indigenous fish, trout and angling
- Seasonal requirements
- Seasonal and operational constraints
- Potential management techniques to minimise effects
- Classify rivers and reaches according to sensitivity to gravel extraction; eg avoid, manage effects/operations, no specific need to constrain
- Monitoring programme.

### 5.8.5 Timing/duration

Expected duration: 12 months (seasonal data)

This work package will provide input to the following studies:

- Gravel Resource Inventory (Issue 3)
- Gravel Management Plan (Issue 13).

### 5.8.6 Potential parties to undertake the work

This package may most appropriately be undertaken on a consultancy basis by a freshwater ecologist. It may be appropriate that HBRC seeks input from Fish & Game and DoC on an 'in kind' basis e.g. provision of data, provision of field staff to assist in field assessments.

Potentially this work could be undertaken on a river by river basis to spread the cost over a longer period. As noted later in this report, ecological management and enhancement plans are currently being prepared on a river by river basis (Ngaruroro River completed in 2010). Therefore

work common to both gravel management and ecological management and enhancement may benefit by being completed on a river by river basis.

There would be benefits from this project beyond gravel management such as for environmental baseline measurements, state of the environment reporting and environmental management plans.

## **5.9 Issue 8: Ecological Effects – Riverbed Flora & Birds**

### **5.9.1 Description**

There appears to be a lack of information about whether gravel extraction activities have any significant effect on riverbed birds and/or indigenous flora. This issue has been raised by DoC, Fish & Game, HBRC and tangata whenua.

Gravel extraction has the potential to affect riverbed birds and flora:

- Directly through disturbance of habitat and/or removal
- Alteration to channel characteristics causing aggradation or erosion of riverbed.

Beach raking has the potential to affect riverbed birds and flora:

- Adversely and directly through disturbance of habitat and/or removal
- Positively through promotion of suitable habitat for birds
- Positively through removal of competing species for indigenous flora
- Alteration to channel characteristics causing aggradation or erosion of riverbed, and altered access to riverbeds by predators.

### **5.9.2 Objective of further assessment**

1. To identify the potential effects of riverbed gravel extraction on significant species of indigenous riverbed birds and flora
2. To classify areas according to their potential sensitivity to gravel extraction
3. To inform preparation of the Gravel Resource Inventory
4. To identify monitoring programmes that will provide necessary information for ongoing management
5. To inform preparation of the Gravel Management Plan.

### **5.9.3 Preliminary scope of work**

Stage 1:

- Review of previous riverbed bird, lizard, invertebrate and indigenous flora surveys
- Determine any requirements for further surveys and scope the work.

Stage 2:

- Undertake any new surveys as considered necessary from the above review: bird survey of key rivers, including species, numbers, potential nesting sites, nesting seasons, threats analysis (for putting in context); indigenous flora survey of key rivers.

Stage 3:

- Identification of habitat requirements for bird species (e.g. open riverbed, braided channels, vegetation (presence or absence), predator access)
- Preliminary assessment of effect of disturbance from gravel extraction activities (including beach raking)

- Mapping of environmentally sensitive areas for use in the Gravel Resource Inventory (Issue 3)
- Preparation of monitoring programme – sites, methodologies, frequencies, triggers, management feedback and review.

#### **5.9.4 Outputs**

A report including:

- Maps identifying key rivers and reaches
- Seasonal requirements
- Seasonal and operational constraints
- Potential management techniques to minimise effects
- Classify rivers and reaches according to sensitivity to gravel extraction e.g. avoid, manage effects/operations, no specific need to constrain
- Monitoring programme.

#### **5.9.5 Timing/duration**

Expected duration: 12 months (seasonal data)

This work package will provide input to the following studies:

- Gravel Resource Inventory (Issue 3)
- Gravel Management Plan (Issue 13).

#### **5.9.6 Potential parties to undertake the work**

This package may most appropriately be undertaken on a consultancy basis by a terrestrial ecologist with expertise in indigenous birds and flora. It may be appropriate that HBRC seeks input from DoC on an 'in kind' basis e.g. provision of data, provision of field staff to assist in field assessments. Note that some of this work has been completed on the Ngaruroro and started on the Tutaekuri and Tukituki rivers.

Potentially this work could be undertaken on a river by river basis to spread the cost over a longer period. There would be benefits from this project beyond gravel management such as for environmental baseline measurements, state of the environment reporting and environmental management plans.

### **5.10 Issue 9: Tangata Whenua Values and Management**

#### **5.10.1 Description**

There is a lack of information relating to the potential effect of gravel extraction activities on values and sites of significance to tangata whenua, including taonga and mauri of the rivers. There is also likely to be a lack of information within hapu of the process and reasons why HBRC manages gravel extraction from riverbeds.

This issue has been raised by tangata whenua and HBRC.

Tangata whenua have also expressed the following desires:

- To continue to be involved in the review process
- To identify opportunities for tangata whenua involvement in management of gravel extraction

- To take part in those opportunities.

### **5.10.2 Objective of further assessment**

1. To identify sites of significance to tangata whenua
2. To inform preparation of the Gravel Resource Inventory
3. To provide a forum for ongoing consultation and opportunities for co-management
4. To identify opportunities for and involvement of tangata whenua in preparation of a Gravel Management Plan
5. To inform preparation of the Gravel Management Plan
6. To produce a Gravel Management Plan that is acceptable to tangata whenua.

### **5.10.3 Preliminary scope of work**

- Undertake a series of hui with hapu to confirm scope of work and identify opportunities for ongoing involvement in gravel management review process
- Prepare a map of hapu rohe boundaries
- Prepare an inventory of sites of cultural significance and other taonga of specific rivers and reaches
- Identify potential roles and protocols for iwi in management and monitoring of gravel extraction
- Review output of other studies
- Facilitate iwi input into the Gravel Management Plan.

### **5.10.4 Outputs**

A report including:

- Map of key rivers and reaches
- Classification of rivers and reaches according to sensitivity to gravel extraction; eg avoid, manage effects/operations, no specific need to constrain
- Monitoring programme
- Roles and protocols for iwi in management and monitoring of gravel extraction.

### **5.10.5 Timing/duration**

Expected duration:

- Information gathering: 6 months
- Ongoing consultation and involvement in the management review: for the entire duration of the research projects through to completion of the Gravel Management Plan (Issue 13).

This work package will provide input to the following studies:

- Gravel Resource Inventory (Issue 3)
- Gravel Management Plan (Issue 13).

### **5.10.6 Potential parties to undertake the work**

This package would most appropriately be undertaken with a major input from tangata whenua.

Specifically it is envisaged that the provision of information on sites of significance could be undertaken by a consultant acceptable to hapu, with input from hapu representatives.

The longer term dialogue, and consultative forum with tangata whenua would be done during a series of hui with HBRC staff, and involvement of tangata whenua in a Project Steering Group (see Section 6).

## **5.11 Issue 10: Effectiveness of Beach-raking**

### **5.11.1 Description**

Beach-raking is currently undertaken with the aim of breaking up the armouring layer and removing vegetation from the riverbed. It is undertaken in the expectation that it increases the potential for gravel to be entrained by river flows, allowing movement of gravel through the river system. It is the experience of HBRC staff that gravel raking is effective, which is supported by theory, but local data is not available.

There is uncertainty about the effectiveness of beach-raking, specifically:

- Whether it delivers the desired outcome (i.e. promotes gravel movement)
- The cause of the gravel build ups – whether it is lack of high flows, vegetation establishment, changes in channel gradients
- The cause of the gravel armouring – whether it is gravel size, gravel gradation, flood peak, flood hydrograph, river hydraulics (gradient, width, geomorphology, velocity)
- The controlling factor in sediment movement - whether it is size of flow event, gravel size (importance of armour), vegetation
- The effect on river ecology (fish, riverbed birds) (Issues 7 and 8).

### **5.11.2 Objective of further assessment**

1. To determine (to the extent possible) the effectiveness of beach-raking on sediment supply and transport
2. To identify a monitoring programme to allow determination of the effectiveness of beach-raking
3. To identify (to the extent possible) the areas where beach-raking may be effective from a sediment transport point of view
4. To inform preparation of the Gravel Management Plan and Ecological and Enhancement Plans.

### **5.11.3 Preliminary scope of work**

- Review of records of sites where beach-raking taken place
- Air photo and LiDAR (if available) analysis
- Review of cross-section data before and after beach-raking, and in relation to flood events
- Sediment size sampling before and after
- Monitoring of flow and sediment transport during a flood event
- Analysis of river gradient changes.

### **5.11.4 Outputs**

A report identifying the advantages and disadvantages of beach-raking in terms of:

- Maintenance of flood carrying capacity
- Sediment transport (the difference between the 'do nothing' scenario and beach-raking in terms of the magnitude and frequency of events likely to move material).
- Cross-reference to Ecological Studies (Issues 7 & 8).

### **5.11.5 Timing/duration**

Expected duration: 3-4 months

This work package is dependent on the prior completion of the following studies:

- Hydrological review (Issue 1).

This work package will provide input to the following studies:

- Gravel Resource Inventory (Issue 3)
- Gravel Management Plan (Issue 13).

### **5.11.6 Potential parties to undertake the work**

It is considered that this Issue is one that could be appropriately undertaken by a research organisation such as a university. There are specific aspects within it that could form suitable student research projects, and/or be undertaken as student holiday projects. A senior researcher would be required to oversee the total package as well as take responsibility for some of the more complex aspects.

## **5.12 Issue 11: Resource Management Act (RMA) Issues**

### **5.12.1 Description**

Gravel extractors want surety for the continuity of supply of resource (time and quantity) and access to that resource in terms of resource consents in order for them to invest in their plant and equipment. They consider the short-term (annual) nature of consents granted by HBRC for gravel extraction is unsatisfactory for business planning, and as a result are tending to turn to alternative land-based sources for which long-term consents can be obtained. Their moving from river-based extraction sites has the potential to affect HBRC's responsibilities with regard to flood protection.

Currently HBRC's Asset Management Group staff process the consent applications for river-based gravel extraction. While extractors prefer longer-term consents, HBRC's Regulatory Section has indicated that the ability to issue longer duration consents would require a more comprehensive assessment of environmental effects and a more formal processing of those applications by the consents section. This has the potential for time delays, cost increases, and potentially uncertainty of outcome.

This issue has been raised by gravel extractors, district councils and HBRC.

### **5.12.2 Objective of further assessment**

1. To determine the optimum approach, process and duration of resource consents granted by HBRC for river-based gravel extraction
2. To inform preparation of the Gravel Management Plan.

### **5.12.3 Preliminary scope of work**

- Review pros and cons with regard to duration – short-term versus long-term consents
- Review issues with regard to certainty versus lack of formality (in context of duration)
- Review issues surrounding consent holder – HBRC global consent versus individual consents (issues of liability, responsibility, environmental care etc, and prior experience with HBRC holding consent in the early 1990s)
- Review adequacy/appropriateness of conditions, including in the context of the outcome of the ecological investigations and tangata whenua values assessments (Issues 7, 8 and 9)

- Review adequacy of monitoring (of extracted volumes, and environmental effects)
- Discussion with HBRC Regulatory Section re processing approach – Operations staff versus regulatory
- Assess risks of decline of consents or unworkable conditions on HBRC’s flood protection responsibilities
- Consultation with stakeholders (e.g. tangata whenua, Fish & Game and DoC).

#### **5.12.4 Outputs**

- Report on optimum approach, process and duration of resource consents granted by HBRC for river-based gravel extraction.

#### **5.12.5 Timing/duration**

Expected duration: 3-4 months

This work package is dependent on the prior completion of the following studies:

- Ecological Effects - Aquatic Ecology (Issue 7)
- Ecological Effects - Riverbed Flora and Birds (Issue 8)
- Tangata Whenua Values and Management (Issue 9).

This work package will provide input to the following studies:

- Gravel Management Plan (Issue 13).

#### **5.12.6 Potential parties to undertake the work**

This package requires a RMA consultant to undertake a strategic analysis issues, including a consultative approach with HBRC Regulatory Section and stakeholders.

### **5.13 Issue 12: Allocation and Financial Mechanisms**

#### **5.13.1 Description**

There is an issue regarding the allocation and financial mechanisms used to manage the gravel resource. The central concerns are around the certainty, proximity to demand and maintaining flood protection requirements. The key points vary between gravel extractors and HBRC and are summarised as follows.

Issues for gravel extractors:

- Certainty of supply (allocation continuity, time, quality and quantity)
- Certainty re consents – likelihood of their being granted, and duration (refer to Issue 11)
- Cost certainty – location and volume of resources allocated to each company, haul distances, and gravel charges
- Best use of resource – that materials are used appropriately and are not wasted
- Fairness and transparency
- Desire for Memorandum of Understanding between extractors and HBRC to create greater certainty for the extraction industry.

Issues for HBRC:

- Certainty of demand - i.e. will extractors reduce their demand for river-based gravel if the cost differential (compared with land-based sources) is too great

- The extent to which extractors are dependent on supply of river-based gravel (e.g. quality, size) compared with land-based gravel
- How to get commitment from extractors to take gravel from Central Hawke's Bay rivers and/or from river reaches where extraction is needed for flood management purposes
- Potentially constrained by how much legally the extractors can be charged for gravel i.e. HBRC currently only charge to recover actual and reasonable costs associated with the gravel management programme so there is little ability to set different charges for different rivers
- HBRC's charges are insignificant in comparison with road haulage costs; therefore HBRC potentially has little control over the extractors in terms of directing locations for extraction.

### **5.13.2 Objective of further assessment**

1. To identify methods to influence and optimise take-up of allocations of river-based gravel in response to gravel supply and flood protection requirements
2. To inform preparation of the Gravel Management Plan.

### **5.13.3 Preliminary scope of work**

- Identify and assess the advantages and disadvantages to HBRC of the present system
- Identify and assess the advantages and disadvantages to extractors of the present system
- Identify and assess mechanisms that can influence allocation (e.g. resource consents, costs, ability to influence District Plans for land-based extraction, ability for HBRC to control land-based extraction through Regional Policy Statement, or Regional Plan rules)
- Assess HBRC's ability to change cost structure – i.e. what factors can be considered
- Undertake a cost/benefit analysis of subsidising transport costs compared to HBRC needing to remove gravel for flood protection reasons
- Assess the role and benefits to HBRC of establishing a Memorandum of Understanding between HBRC and extractors
- Scope the content and operational basis for a Memorandum of Understanding between HBRC and extractors – agreement on issues, processes, investigations process/studies, roles and reviews.

### **5.13.4 Outputs**

- Report identifying and recommending methods to influence and optimise take-up of allocations of river-based gravel
- Report to provide the basis for a Memorandum of Understanding between HBRC and extractors.

### **5.13.5 Timing/duration**

Expected duration: 3-4 months

This work package is dependent on the prior completion of the following studies:

- Gravel Resource Inventory - especially location, quality and size of material (Issue 3)
- Implications of Gravel Management for Flood Protection (Issue 4)
- Resource Management Act Issues (Issue 11), although this package could be undertaken in parallel, with information sharing between the two work packages.

This work package will provide input to the following studies:

- Gravel Management Plan (Issue 13).

### **5.13.6 Potential parties to undertake the work**

This package requires a consultant to undertake a strategic analysis of issues, with input on RMA and LGA issues, as well as economic evaluation.

## **5.14 Issue 13: Riverbed Gravel Management Plan**

### **5.14.1 Description**

Several of the parties involved in the review (particularly gravel extractors, and Fish & Game) commented that there was a need to have a comprehensive, overview strategy in place to guide gravel management in Hawke's Bay.

It needs to address:

- Overall principles/strategy (best use of resources)
- Gravel sources (rivers, reaches)
- Gravel demand (quantity, quality, locations)
- Constraints (e.g. environmental, cultural)
- Sustainability of supply from various sources (river by river)
- Management issues
- Approach to consents
- Allocation mechanisms
- Monitoring requirements and feedback loops (including responses to flood events)
- Interested parties, consultation processes
- Review requirements (frequencies, matters to consider etc).

Currently, under a separate project, the management of each major river scheme in the Hawke's Bay region is being reviewed for ecological and amenity values with the objective of providing a current understanding of the values and means of protecting and enhancing them. To date the Ngaruroro River Ecological Management and Enhancement Plan has been completed. Aspects of the ecological management plan (e.g. gravel extraction and beach raking) will have direct relevance to the review of gravel management and need to be taken into consideration.

### **5.14.2 Objective of further assessment**

To provide a resource management tool to ensure the sustainable management of the river-based gravel resource in Hawke's Bay taking into account flood management requirements.

### **5.14.3 Preliminary scope of work**

- Project is essentially an assessment and collation of all previous information into a management plan
- It should involve iterative meetings with stakeholders (gravel extractors, district councils, Fish & Game, DOC, tangata whenua) to ensure buy-in
- Would most likely incorporate a staged process:
  - Stage 1 Scoping – what it should cover, process to be followed in preparation and review; involvement of parties
  - Stage 2 – Preparation of the formal Management Plan.

#### **5.14.4 Outputs**

- Management Plan
- 'Buy-in' of all key stakeholders.

#### **5.14.5 Timing/duration**

Expected duration: 3-4 months

This work package is dependent on the prior completion of the following studies:

- Hydrological review (Issue 1)
- Gravel Supply and Transport (Issue 2)
- Gravel Resource Inventory (Issue 3)
- Implications of Gravel Management for Flood Protection (Issue 4)
- Gravel Demand Forecast (Issue 5)
- Gravel Monitoring and Available Resource (Issue 6)
- Ecological Effects - Aquatic Ecology (Issue 7)
- Ecological Effects - Riverbed Flora and Birds (Issue 8)
- Tangata whenua Values and Management (Issue 9)
- Effectiveness of Beach-raking (Issue 10)
- RMA Issues (Issue 11)
- Allocation and Financial Mechanisms (Issue 12).

#### **5.14.6 Potential parties to undertake the work**

This package requires a multi-disciplinary consultant to bring together the outputs of all the previous work packages. It will require consultation with a range of stakeholders.

## 6 Management of Ongoing Investigation Programme

The list of Issues and the outline Scopes of Work indicate a substantial amount of work is required to be undertaken in order to achieve HBRC's objectives of improved understanding of riverbed gravel movement and the impact of gravel extraction. The studies will extend over a significant period of time (see Section 7) due to specific requirements of the studies and in order to balance with HBRC's financial planning. In addition there will be a need to coordinate several of the studies, in terms of information sharing, and to guide the detailed briefs as information comes to hand.

Accordingly, it is recommended that a Project Steering Group or equivalent be set up to guide the overall research project. This could also serve as a consultative forum for the key stakeholders. It is envisaged that such a Group may comprise:

- HBRC or consultant Project Manager
- Representatives from HBRC Assets Management Group
- Representatives from the gravel extraction industry
- Representatives from tangata whenua
- Fish & Game
- DoC
- Independent advisor.

It is assumed that the Steering Group may meet on average twice per year, and that the costs of parties' involvement would be covered by their respective organisations, with the exception of the independent advisor (assumed to be a consultant).

## **7 Indicative Scheduling**

The attached programme (refer to Appendix B) shows the relative scheduling of each of the Work Packages (Issues). This figure has been used for planning purposes and the programme time to complete the work can be shortened or lengthened based on available budget.

## 8 Applicability

This report has been prepared for the benefit of Hawke's Bay Regional Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

This opinion is not intended to be advice that is covered by the Financial Advisers Act 2010.

Tonkin & Taylor Ltd  
Environmental and Engineering Consultants

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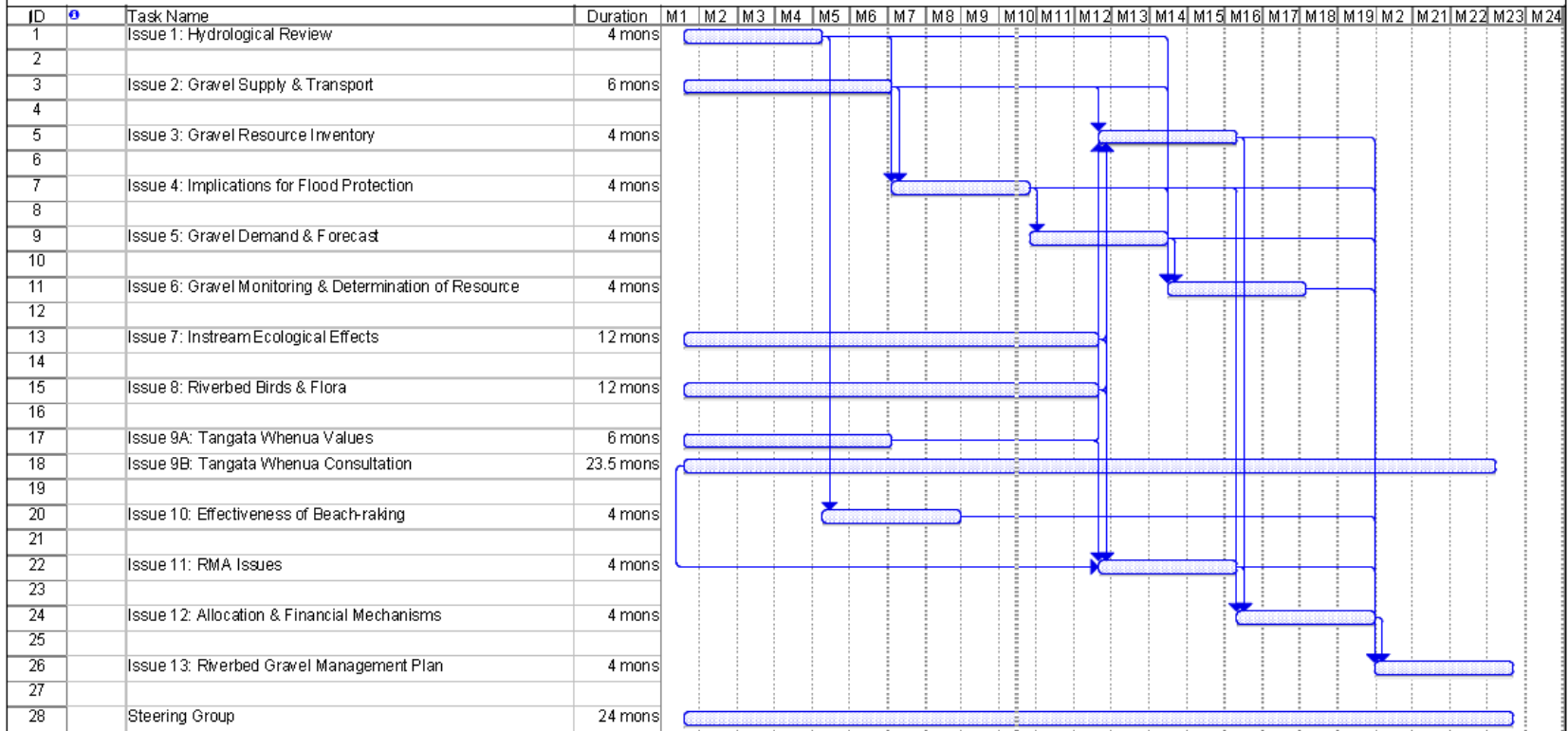
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## **Appendix A: Background reports**

- Hawke's Bay Catchment Board 1989: Heretaunga Plains Gravel Resources Management Plan.
- Hawke's Bay Regional Council 1992: The Heretaunga and Ruataniwha Plains Gravel Supply. Technical Service Department Investigations, prepared by Robin Black.
- Hawke's Bay Regional Council 1989: Heretaunga Plains Gravel Resource Management Plan.
- Hawke's Bay Regional Council 1994: Regional River Bed Gravel Extraction Plan. Operative 8 August 1994.
- Hawke's Bay Regional Council 2000: Esk River – Gravel Extraction Review. G Edmondson, Asset Management Group, September 2000.
- Hawke's Bay Regional Council 2001: Tutaekuri River – Gravel Resources. Assessment of Gravel Supply and Sustainable Annual Extraction Volume. Asset Management Group, March 2001.
- Hawke's Bay Regional Council 2001: Lower Tukituki River. Assessment of Gravel Supply and Sustainable Annual Extraction Volume. Asset Management Group, 2001.
- Hawke's Bay Regional Council 2003: Environmental Code of Practice for River Control and Drainage Works. Asset Management Group Report AM 03/12 HBRC Plan Number 3256.
- Hawke's Bay Regional Council 2008: Gravel Allocation 2008-2009. Asset Management Group Report AM 08/08 HBRC Plan Number 4054.
- Toleman, Ingrid 1999: Channel Changes in the Upper Waipawa River, Ruahine Range, 1977-1997. Unpublished Research Essay submitted to the Department of Geography Victoria University of Wellington, in partial fulfilment for the degree of BSc Hons in Physical Geography.
- NIWA 2007: Sedimentation effects of a proposed hydro-dam on the Mohaka River near Kakariki. NIWA Client Report CHCH2006-119 March 2007. NIWA project MEL06506
- Williams, G 1997: Ngaruroro River Gravel Resources. Assessment of Gravel Supply and Extraction Volume. G&E Williams Consulting Ltd

**Appendix B: Indicative schedule of work packages**

HBRC Review of Riverbed Gravel Management  
Scoping Report  
Indicative Scheduling of Work Packages



Project: Tonkin & Taylor Ref 85047  
Date: November 2010

