Project Cost Estimating Manual

Third Edition

December 2007

Queensland Government
Department of Main Roads

December 2007

Revision Register

Rev No.	Reference Section	Description of Revision	Amended by	Date
1		Draft Release, July 2002		Jul 2002
2		First Edition, February 2004		Feb 2004
3		First Edition Version 1.1, April 2004		Apr 2004
4		Second Edition, December 2004		Dec 2004
5	Manual contents revised	Third Edition, December 2007	Eric Wellings and Keith Brownjohn	Dec 2007

FOREWORD

The December 2007 edition of the Project Cost Estimating Manual is an integral part of Main Roads' ongoing commitment to the production of accurate project cost estimates. This commitment promotes best estimating practice in the department. The manual will assist and guide Main Roads project personnel and industry providers in the correct methods of project cost estimating.

Project cost estimating is a key part of Main Roads business. As such, Main Roads must promote and maintain a cultural approach to project cost estimating that enables estimating practices throughout Main Roads to be of the highest standard. This manual will be updated periodically following the reviews of project learnings.

Use of this manual will provide estimates at all stages of the delivery process that are prepared on the basis of their being 'unlikely to be exceeded but not excessively conservative'.

Compliance with this manual is mandatory for all cost estimates prepared for Main Roads infrastructure projects. Project managers, engineers, technical officers and external service providers must follow these procedures when preparing cost estimates at any point in the project cycle.

In terms of contingency allocation, the project manager 'owns' the contingency for known project risks. The program manager 'owns' the contingency for unknown project risks.

District Directors are accountable for the accuracy of project estimates.

Les Ford

Deputy Director General

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1 INTRODUCTION

1.1 Purpose and Application

The purpose of this manual is to provide rules and standards for the preparation of cost estimates for all transport infrastructure projects developed by the Queensland Department of Main Roads (MR).

This manual covers the preparation of estimates over the total project life cycle to provide reliable cost information for:

a) initial justification of a project's business case (for example cost/benefit analysis)

b) ongoing cost control during the project's development, implementation and finalisation phases, and

c) project and program management.

Costs are accumulated during all phases of a project from concept to finalisation. Consequently, total project cost estimates must include the costs of all components, including developing the concept design and business case; conducting investigations and developing the design; detailing the design; acquiring land; relocating public utility plant; construction and handover. It is important, too, that project managers and estimators have an appreciation of the context (in terms of management of the road system) in which the project has been developed.

This manual provides information on a range of processes and techniques to suit the varying circumstances under which estimates are developed. In the early stages of project development, estimates will be based on scope as defined in investment strategies. Provision needs to be made for the uncertainties surrounding the project by way of contingencies. Just prior to construction, the estimate will be based on detailed design information and an accurate bill of quantities.

Project cost management, of which project cost estimating is a part, is to be applied in the context of OnQ, MR's project management methodology.

1.2 Glossary of Terms

Accountability

The final responsibility for completion of tasks and achievement of results within delegated authority and to established performance standards.

Activity

An element of work performed during the course of a project. An activity normally has an expected duration, cost and resource requirement. Activities can be subdivided into tasks.

Actual Cost

The final out-turn dollar expenditure on a project.

Anticipated Final Cost

The sum of expenditure to date and the forecast expenditure, in out-turn dollars, to complete the project.

Base Date

The calendar date at which the current project estimate has been calculated (i.e. before escalation).

Component

A definable part of a project, including elements of planning, design and construction, that contributes to the total project cost.

Concept Estimate

An estimate prepared towards the end of a project's concept phase after the options analysis, for the purpose of evaluating the project in the business case. The estimate, which is based on the scope of the preferred option, forms the basis of the project budget. It is expressed in out-turn dollars for the year the project is scheduled for construction.

Concept Phase

The initial phase of a project during which project scope is defined. It commences with the development of a project proposal and concludes with the approval of the business case. Community consultation commences during this phase.

Concurrence Review

A review of a project to achieve concurrence (agreement) on the project cost.

Contingency

An amount to cover the costs of unforeseen factors related to the delivery of the project objectives, which are not provided for elsewhere in the total job costs.

Construction / Contract Budget

The contractor's tendered price plus a suitable allowance for the Principal's costs.

Control

The process of comparing actual performance with planned performance, and analysing variances, evaluating possible alternatives and taking appropriate corrective action.

Corrective Action

Changes made to bring expected future performance of the project into line with the project plan.

Cost Budgeting

Allocating the cost estimate to individual project components.

Cost Control

Controlling changes to the project budget.

Cost Estimating

Estimating the cost of the resources needed to complete project activities.

Cost Performance Index

The ratio of budgeted cost to actual cost.

Cost Variance

Any difference between the estimated cost and the actual cost.

Definitive Estimate

An estimate that is reported as a single sum.

Deliverable

Any measurable, tangible, verifiable outcome, output, result or item that must be produced to complete a project or part of a project or phase.

Detailed Design Estimate

The total estimate of all components of a project prepared prior to calling of tenders for construction, and based on final designs, specifications and statements of rates. It is expressed in out-turn dollars.

Development Phase

The phase that follows the concept phase and the approval of the business case, during which the preferred option is developed into a detailed design and tenders called.

Direct Costs

Costs that can be directly attributed to the work being performed. For construction, it refers to the costs of constructing the physical project works (resource costs of plant, labour, materials and subcontract).

Earned Value (EV)

A method of measuring project performance. It compares the amount of work that was planned with what was actually accomplished to determine if cost and schedule performance is as planned.

Elemental Costing

An estimate of project costs prepared using composite rates for major components of a project.

Escalation

The anticipated increase in project costs over time as a result of various factors such as inflation, scope changes due to change in standards, design development, increased certainty in quantities.

Estimate

A calculated prediction of the amount of money required to undertake a specific amount of work, expressed in dollar values of the year in which it was prepared or, alternatively, in out-turn dollars. It is prepared in a systematic manner appropriate to the size and complexity of the project, and to a level of accuracy commensurate with the available information and the intended use of the information developed. It may include some prior expenditure.

Estimate at Completion (EAC)

The expected total cost of an activity, a group of activities or the project when the defined scope of work has been completed.

Estimate to Complete (ETC)

The expected additional cost needed to complete an activity, a group of activities or the project.

Finalisation Phase

Activities required to commission the works completed in the implementation phase, finalise project administration, evaluate performance and communicate learnings.

First Principles (Basic Cost) Estimating

A high-order (detailed and bottom up) estimating method based on a detailed study of work breakdown, work methods, production rates and resource requirements. The estimate is structured to provide details of direct costs, on-site overheads, off-site overheads, contingencies and margin.

Global Estimating

A very approximate, low-order estimating method based on "all in" or global rates such as $/km of road.

Implementation Phase

The phase during which the work identified in the project plan is constructed to produce the final product.

Indirect Costs

Costs that are not directly attributable to work items. For a construction project, these costs include on-site overheads (such as site supervision and site facilities) and off-site overheads (corporate/business costs). They are exclusive of contingency and profit.

Inflation

An allowance for the rising cost of the project due to rise and fall factors external to the project definition.

Investment Strategies

Strategies that define the activities required on the functional road categories to achieve road system outcomes.

Job

A stand-alone component of a project.

Management Reserve

A provisional amount to cover uncertainty that is outside the control of the project (sometimes called "unknown unknowns"). Management Reserve may involve cost and/or schedule (time) reserve. Management Reserve is to be administered at program level.

Margin

An allowance that includes the contractor's corporate overheads and profit.

Monitoring

The capture, analysis and reporting of project performance, usually as compared to plan.

OnQ

Main Roads' Project Management Framework that provides the direction and guidance for effective management and delivery of projects.

Optimism Bias

The demonstrated systematic tendency for people to be over optimistic about the outcome cost of planned actions.

Out-turn Dollars

Cost expressed in dollars of the period in which the work was or will be performed. Estimates prepared at a particular date can be converted to out-turn dollars by applying the appropriate escalation rate to the time series cost of the project.

P90 Estimate

An estimate prepared at any stage of a project which has a 90% confidence factor of not being exceeded by cost at completion.

Probabilistic Estimating

A method of generating estimates which takes into consideration that quantities measured (or allowed for) can change, rates assumed can vary and risks with a probable outcome can materialise.

Project

A series of inter-related activities with defined start and end dates designed to achieve a unique and common objective.

Project Budget

The approved project estimate.

Project Cost Management

A subset of project management that includes the processes required to ensure that the project is completed within the approved budget. It consists of resource planning, cost estimating, cost budgeting and cost control.

Project Estimate

The total estimated cost of a project in out-turn dollars for all components of a project from the commencement of the concept phase to the end of the finalisation phase.

Project Life Cycle

The total duration of a project normally dissected into sequential phases (that is concept, development, implementation and finalisation).

Project Management

The discipline of planning, organising, monitoring and controlling all aspects of a project in a continuous process to achieve its objectives, both internal and external.

Project Phase

A collection of logically related project activities, usually culminating in the completion of a major deliverable.

Project Plan

A formal approved document used to document project baselines. It is the plan against which project performance is measured.

Provisional Items

Items that should be included in an estimate when the designer knows that work is required but cannot quantify it.

Range Estimate

An estimate that is reported as a range of values within which the cost at completion is considered to lie.

Resource Planning

Determining what resources (plant, labour and materials) are needed in what quantities to perform project activities.

RIP

Roads Implementation Program; published annually on a rolling 5-year basis.

Risk

The chance of something happening that will have an impact upon project objectives. It is measured in terms of consequences and likelihood.

Scope

The sum of the products and services to be provided as a project.

Scope Creep

Increase in work required to meet a previously given outcome.

Smart Cost

A resource-based estimating tool that utilises “Expert Estimation” in the preparation of early project estimates and may be used by Main Roads to validate estimates.

Strategic Estimate

An estimate in out-turn dollars prepared as an output of a road network or road link strategy.

Sunk Cost

Cost that has occurred and charged to the project.

Value

The lowest dollar value to reliably accomplish a function in accordance with required levels of quality and performance.

Value Management

A structured, analytical process that seeks to achieve value for money by providing all the necessary functions at the lowest total cost consistent with required levels of quality and performance.

Variation

Extras or deductions to the work on a project.

Work Management

The management of project deliverables, e.g. options, in order to meet stakeholder's needs and expectations from a project.

Works Management System (WMS)

A system that supports the development of road preconstruction activities in the areas of scheme formation and project estimating.

1.3 Relationship to other Manuals

This manual has been structured as a concise reference on project cost estimating for project managers and estimators, within the context of MR's generic project management methodologies, and other planning and control processes.

The department’s various manuals and annexures are intended to be complementary. However, where a conflict occurs, the manual with the latest publication date takes precedence.

Note: Any such conflict should be reported to the manual owner through the feedback process so that necessary corrective action can be taken.

1.4 References

The following list of publications may assist estimators in the course of their work. Many of these can be found at www.mainroads.qld.gov.au.

Bent Flyvberg & COWI 2004, *Procedures for Dealing with Optimism Bias in Transport Planning Guidance Document*, for the British Department of Transport, included as Appendix 3 of Evans and Peck 2007, *A Review of the Reliability of Cost Estimation of MR Projects funded under Auslink,* Brisbane.

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Main Roads 2005, *Preconstruction Processes Manual: Scope, Risk and Cost Management and Approval Processes with a Project Management Approach*, draft ed., the Dept., Brisbane.

Main Roads 2004, *Project Manager's Risk Management Guidelines*, the Dept., Brisbane.

Main Roads 2000, *Road Planning and Design Manua*l, the Dept., Brisbane.

Main Roads 1999+, *Roads Policy Manual*, the Dept., Brisbane.

Main Roads 2006, *Standard Specification Roads*, Third Edition, Volume 1 and 2, the Dept., Brisbane.

Main Roads 2004+, *Program Delivery Policy for Project Management and Performance Measurement of Roads Implementation Program (RIP) Projects,* the Dept., Brisbane.

Main Roads 2004+, *Project Management Reference Guide*, the Dept., Brisbane.

Project Management Institute 2000, *A Guide to the Project Management Body of Knowledge (PMBOK guide)*, PMI, Upper Darby, PA.

Roads and Traffic Authority of New South Wales 2001, *Project Estimating*, RTA, Sydney.

Standards Australia 2004, *Risk management, AS/NZS 4360:2004*, Standards Australia, Sydney.

Standards Australia 1994, *Value management, AS/NZS 4183:1994*, Standards Australia, Sydney.

1.5 Acronyms and General Definitions

Term	Definition
BOQ	Bill of Quantities
CERI	Cost Escalation Road Input
D&C	Design & Construct
DD	District Directors
DDG	Deputy Director General
DG	Director General
DJC	Direct Job Costs
DoTaRS	Department of Transport and Regional Services
E&T	Engineering & Technology
ECI	Early Contractor Involvement
GM	General Manager
ICT	Information Communication Technology
IT	Information Technology
MPO	Major Projects Office
MR	Department of Main Roads
MWC	Minor Works Contract
MWPC	Minor Works Performance Contracts
NH	National Highways
OnQ	The project management methodology framework used by Main Roads and Queensland Transport
OSCR	Other State Controlled Roads
PAI	Principal Arranged Insurance
PCEM	Project Cost Estimating Manual
PD&D	Program Development and Delivery
PDI	Project Delivery Improvement
R&DP	Road and Delivery Performance
RCC	Road Construction Contract
RICI	Roads Input Cost Index
RIP	Roads Implementation Program
RMPC	Road Maintenance Performance Contract
RPC	Roadworks Performance Contract
WBS	Work Breakdown Structure
WMS	Works Management System
$OT	Out-turn Dollars

2 ESTIMATING POLICY

2.1 Policy Statement

MR develops investment strategies based on the state's strategic transport needs to ensure that consistent outcomes are delivered in accordance with government priorities and objectives.

Identifying and funding the highest priority works to meet these needs, and delivering them through an efficient roads program, is critical to realising the benefits of these outcomes for the community.

All these processes rely on sound estimates of project cost and cost control to ensure the integrity of decisions relating to project justification, government priorities and programming. Incorrect estimates can lead to delay in funding and approval of a project, or impact on other projects, leading to economic loss as well as cost overruns.

MR will maintain a system for estimating and cost control that will ensure a high level of confidence in project cost estimates, and reduce the incidence of cost overruns and scope creep.

MR's estimating policy is focused on the preparation of P90 estimates: "unlikely to be exceeded but not excessively conservative" estimates. This means that the estimate prepared at any stage of a project has a 90% confidence factor of not being exceeded by the cost at completion.

Estimating in the current market environment requires a conservative but realistic view of the project scope together with the associated risks and contingencies, particularly in the early project stages where less detailed project information is available. Estimators must make provision for items that are considered likely to be required, having regard to such inputs as environmental determinants and community input on the final project scope. Such items should be included as provisional items and not through an increase in contingency.

The challenge for the estimator is to arrive at a realistic (that is, not overly conservative) view of the project scope and risks, and assign appropriate contingencies in order to produce a meaningful estimate within the P90 "not to be exceeded but not to be excessive" band of acceptability.

All estimates must include a detailed consideration of MR's project costs, including project management. These costs must be estimated essentially on a first principles basis, taking into account the expected MR personnel required for the project and their costs. Estimates are applicable only to a particular project scope, or range of scopes, which must be clearly set out as part of the estimate.

Periodic reviews of the scope definition shall be conducted with a view to achieving continuous improvements in performance.

2.2 Estimating Principles

MR's estimating policy is founded on five key principles.

1. All projects are to be project managed in accordance with the OnQ project management methodology.
2. P90 estimates, prepared on an "unlikely to be exceeded but not excessively conservative" basis at various stages of the project life cycle will provide confidence in the processes of project priority, affordability and strategic fit.
3. Estimates are subject to a review and approval process based on consistent clear lines of responsibility and accountability that will ensure costing standards and control are applied to any budget information that is to be released.
4. Regular project and system reviews will be conducted to encourage and facilitate continuous improvement.
5. Project learnings will be shared to increase corporate knowledge.

2.3 Project Types

Type 1 Project	Significant road/infrastructure project that is complex, high risk or high cost and thus requires higher amounts of rigour and control.
Type 2 Project	Relatively straightforward, low-risk road/infrastructure project for which a lesser amount of rigour and control is appropriate.
Type 3 Project	Small, simple, low cost road/infrastructure project that progresses quickly through the concept phase.

2.4 Estimating Rationale

Estimating rationale recognises that cost management, including cost estimating, must be exercised in the broader context of project management. Estimating is an integral part of a system of interdependent core inputs of scope, time, cost and quality.

The project budget results from approval of the business case concept estimate at the conclusion of the concept phase. This project estimate, which is based on a sound definition of the scope of the preferred option from the options analysis, is of critical importance in the economic justification (cost/benefit) of the project.

Estimates for Type 1 and 2 Projects should be expressed at a P90 level for budget proposals. From December 2007 onwards, business case estimates are not to be accepted unless expressed or recorded in out-turn dollars with P90 confidence levels.

Once the project is justified, it is eligible for inclusion in the Roads Implementation Program (RIP). The amount published in the RIP for years 3 to 5 is treated as indicative for program purposes.

This manual recognises that projects are inherently uncertain and that, irrespective of the stage of a project, there will be incomplete scope information on which to base the project estimate. The aim is to establish as complete a set of project parameters as possible, and apply a risk assessment process to allocate contingencies to cover probable eventualities.

Total project cost estimates must include the costs of all component activities from the initiation of the project proposal to finalisation. These will include the cost of developing the concept design and business case; conducting investigations and developing the design; detailing the design; acquiring land; altering public utility plant; construction and handover.

It is expected, as project scope and design detail are progressively refined and uncertainty reduced, that the various stage estimates (concept/preliminary design/detailed design) will improve in accuracy.

The preliminary design estimate is used to confirm the project budget before being incorporated in the committed Years 1 and 2 of the RIP.

Each estimate shall be presented using a standard estimate work breakdown structure format, and incorporate a report that defines the scope and assumptions on which the estimate has been based.

Estimates shall be reported in out-turn dollars based on an assumed construction date and escalation rate.

Control of project costs will be achieved by the application of a systematic review and approval process based on clearly defined accountabilities.

2.5 Performance Standards

Estimates prepared for inclusion in the RIP (refer Section 12), when compared with the actual cost at completion, are expected to fall within the ranges shown in Table 2.1.

The expectation is that individual project estimates, prepared at all stages of a project from Business Case forward, have a 90% confidence factor of not being exceeded by the cost at completion.

Table 2.1 Budget Estimate Standard

Project Phase	Budget Estimate	Percentage of Completed Project Cost	
		Lower	Upper
Pre-project and Strategic	Strategic & Pre-project (this manual does not apply to these estimates)	-50% (percentages will vary according to project definition)	+200% (percentages will vary according to project definition)
Concept	Proposals and Options	-30%	+100%
Concept	Business Case (P90)	-15%	+20%
Development	Preliminary Design (P90)	-10%	+15%
Development	Detailed Design (P90)	-5%	+10%

Pre-project or Strategic Estimates will necessarily be developed on poor or negligible information. Great care needs to be exercised in publishing these estimate figures. The percentage ranges on these types of estimates are indicative only, and must be viewed against the background information upon which these estimates are developed.

Performance against these standards shall be reviewed in the finalisation phase of the project as per Figure 9.4, Project Cost Estimate (Approval).

As the above measure is a lag indicator, districts may wish to adopt other measures to indicate whether their estimating processes are under control at any particular time. Variance from previous stage estimate may be one such measure.

2.6 Performance Measures

The estimating performance of MR districts will be measured annually by an independent auditor to assess estimate consistency and accuracy. These will be reported internally to the General Manager (Program Development & Delivery) and the District Director.

Internal reports on Major Projects Office projects should go the General Manager (Major Projects Office).

These measures are detailed in Main Roads' Program Delivery Policy for Project Management and Performance Measurement of Roads Implementation Program (RIP) projects.

3 ESTIMATING PROCESSES

3.1 General

The project management environment in which cost estimating takes place is described in Section 11.4, Project Cost Management. The purpose of this section is to discuss the general sequence of activities involved in the production of a cost estimate.

The estimating process comprises four key activities:

i. Scope definition

ii. Risk identification/quantification

iii. Estimate planning

iv. Cost estimating

The procedure for concurrence review and approval of estimates at concept, preliminary design and detailed design is illustrated in Figures 3.1 to 3.4.

3.1.1 Concept Phase

The concept phase is the first and, arguably, the most important phase of the methodology and the estimate which is developed in the concept phase is critical to a project's success. The concept estimate will be the benchmark against which all future estimates will be referred.

The objectives of the concept phase are to:

- understand the nature of the problem, need or opportunity;
- articulate the functional requirements that any solution must satisfy;
- identify all possible solutions, evaluate them and select the preferred option;
- develop the preferred option sufficiently such that its associated costs and risks can be confidently and reliably included in the business case; and
- present an un-biased business case that portrays the costs and benefits applicable to the potential project from an organisational perspective.

The concept phase provides the reason for the project's existence and sets the criteria by which the project will be judged to have succeeded or not. It is important to obtain customer agreement to the articulated problem and the functional requirements that define the solution. Such agreement provides an important baseline for controlling subsequent design development resulting from approved functional or standards changes.

Design development is related to:

- growth in the designed works required to meet the agreed functionality, and
- growth in functionality itself due to changed standards. (For example, growth in functionality may require a different project.)

The key project management deliverables of the concept phase are the:

- the Proposal
- the Options Analysis
- the Business Case
- Risk Analysis
- Peer Review.

The key components of work associated with each of these project management deliverables are included in the OnQ project management methodology.

Figure 3.1 Procedure for Preparation, Concurrence and Approval: Concept Estimate

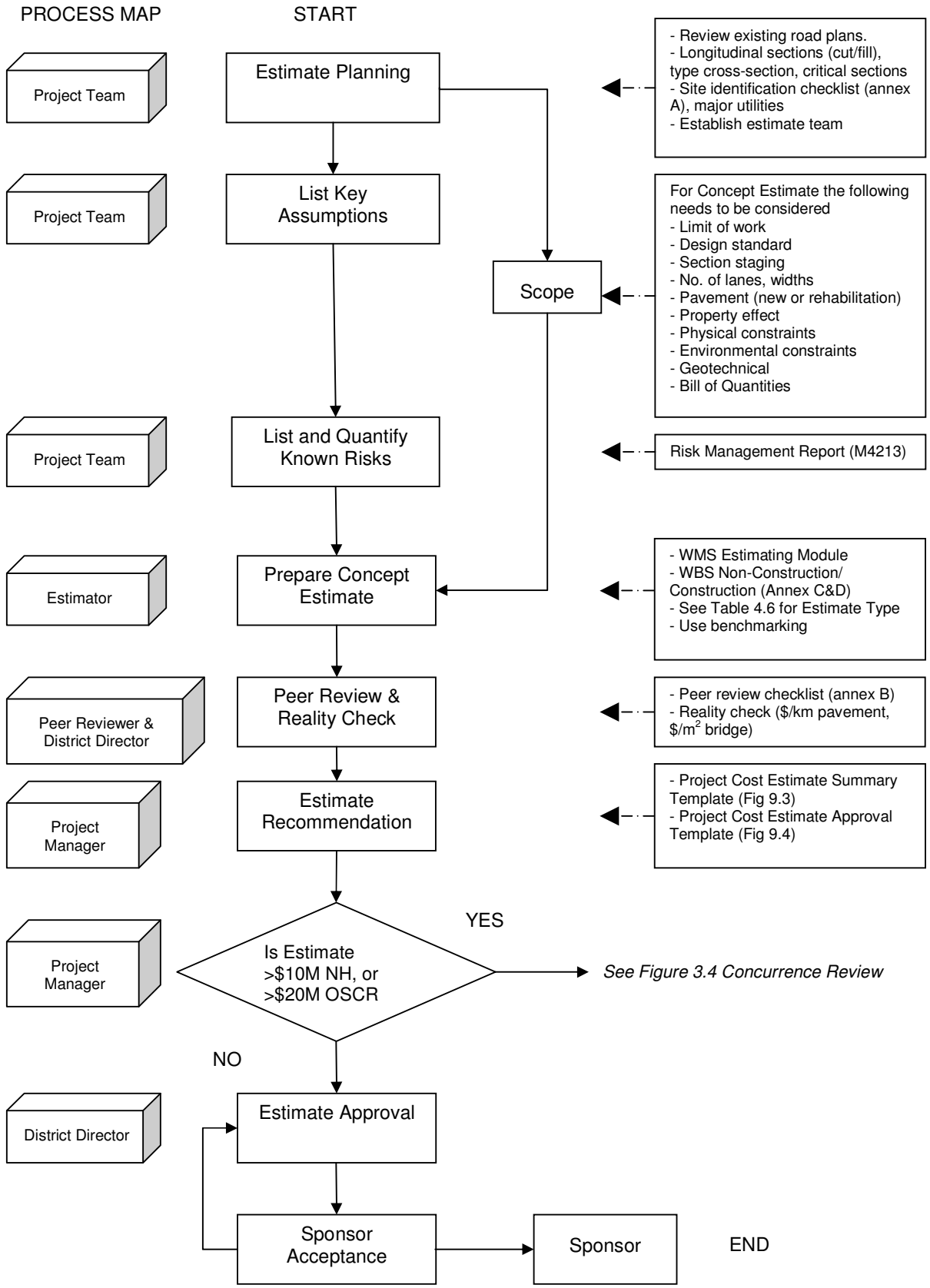


Figure 3.2 Procedure for Preparation, Concurrence and Approval – Preliminary Design Stage Estimate

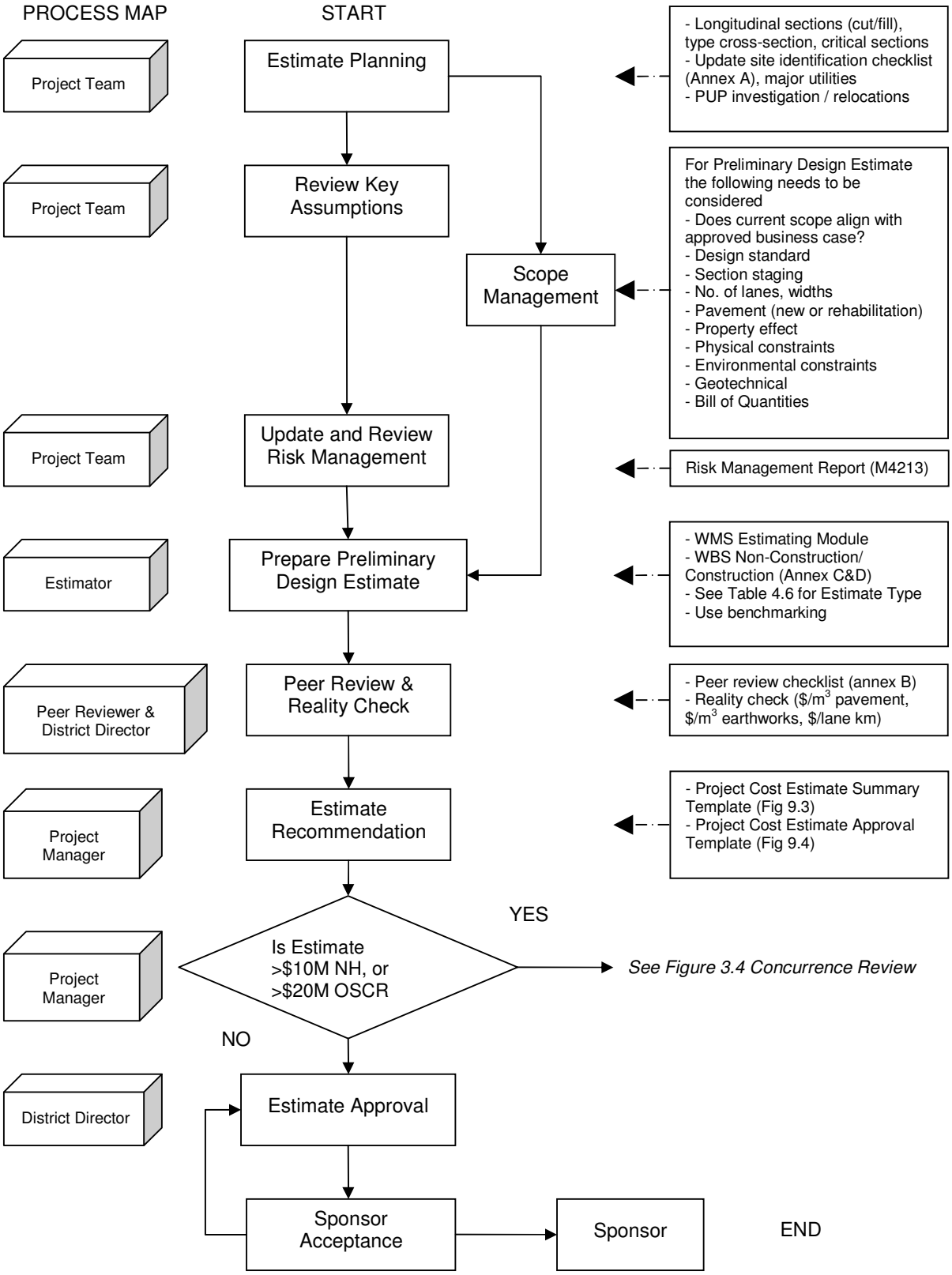


Figure 3.3 Procedure for Preparation, Concurrence and Approval – Detailed Design Stage

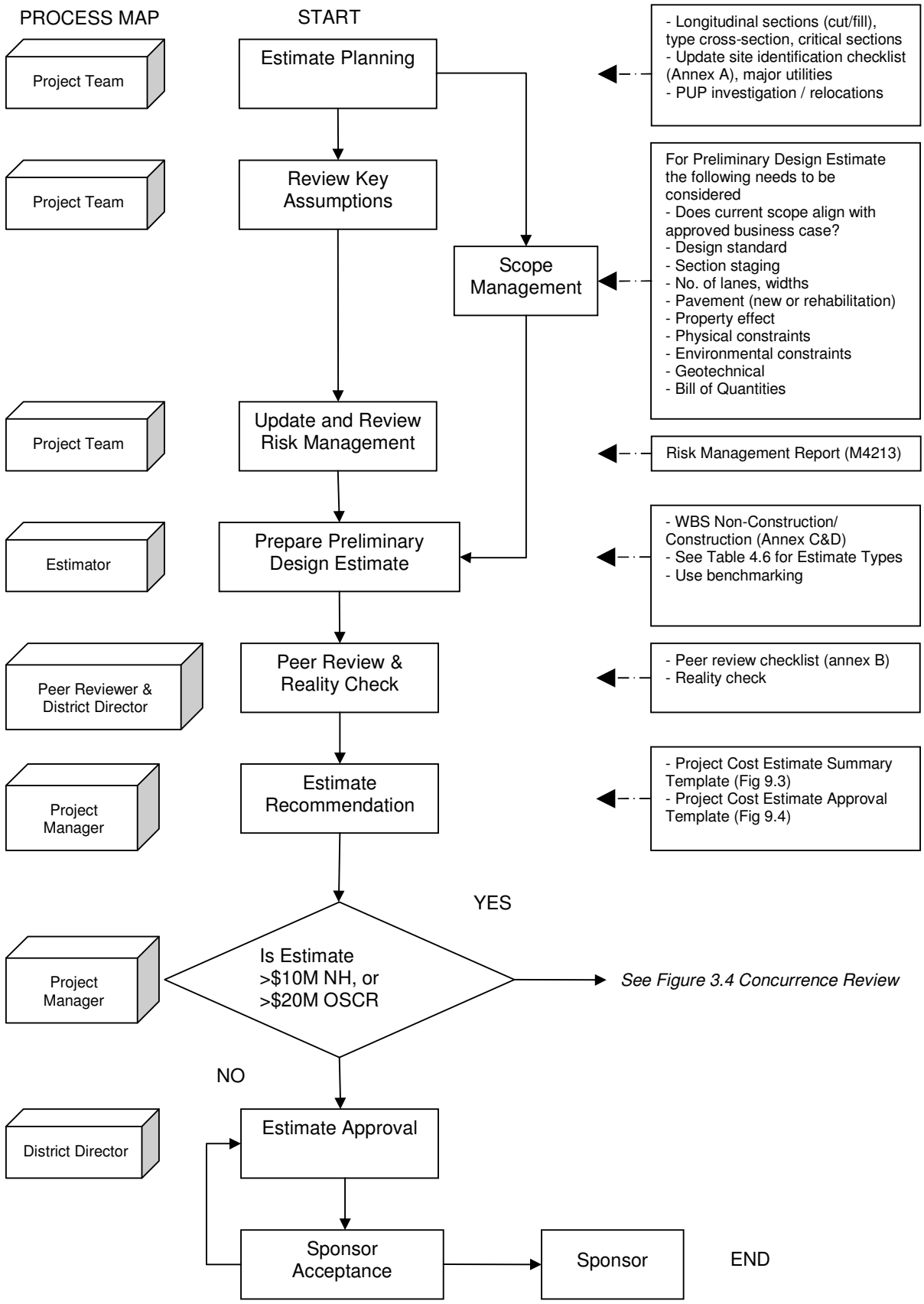
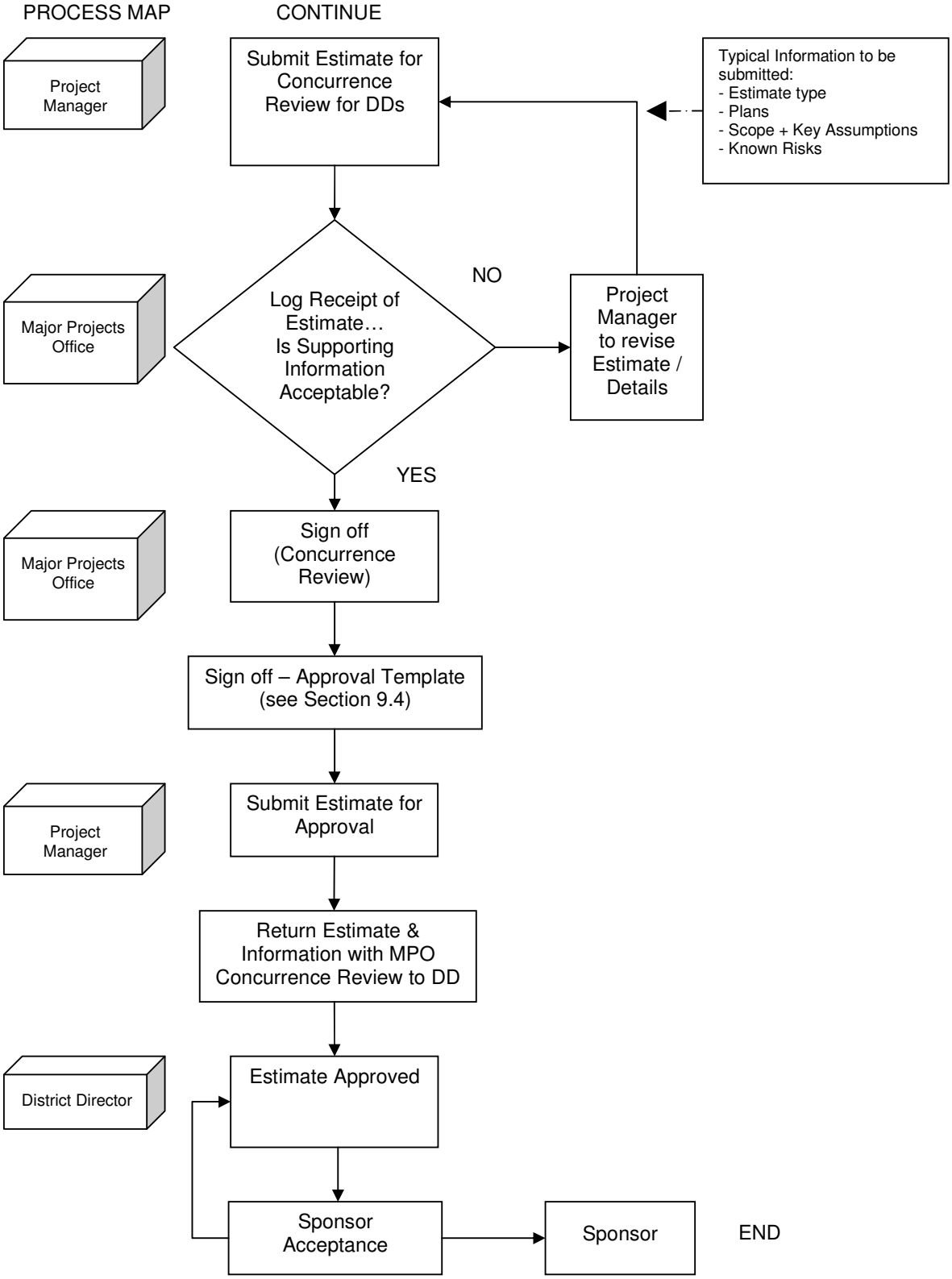


Figure 3.4 Procedures for Concurrence Review and Approval of an Estimate of Cost for Concept, Preliminary and Detailed Design Stages



3.2 Project Scope Definition

The starting point for any estimate is definition of the project scope. It is vital that the defined scope be checked against the desired outcome to assess whether the network needs, as defined in the project proposal, are satisfied by this definition of project scope.

The scope statement provides a documented basis for making future project decisions and for confirming or developing a common understanding of the project scope among the stakeholders. It is supplemented by the project plans and specifications.

As project planning progresses, the scope statement may need to be revised or refined to reflect the increased understanding of the project as a result of acquiring further information. The scope work breakdown structure involves subdividing the major project deliverables into smaller, more manageable components in order to improve the accuracy of cost, time and resource estimates, define a baseline for performance measurement and control, and facilitate clear responsibility assignment.

Proper scope definition in terms of the physical scope of the product and work methods is critical to achieving accurate estimates. Therefore, project scope definition is determined by:

- Project Objectives
- Project Performance Requirements
- Project Definition, and
- Physical Scope.

Together these form the Project Brief. Improving project scope definition can be better achieved by a good understanding of and better documentation of what IS and what IS NOT included. Scope should be defined using the processes in the Main Roads' Preconstruction Processes Manual, 2005.

All project estimates require the preparation of a bill of quantities (BOQ) in as much detail as is feasible for the stage of the project. Computer aided design methods such as terrain and design modelling should be utilised where possible to obtain quantities for all stages of estimate.

Note: The project manager needs to ensure the scope is defined in sufficient detail so as not to unnecessarily rely on contingencies.

3.2.1 Categories of Cost Change

The categories listed below impact on the cost of a project. Estimators must consider allowing cost contingencies for these changes. The categories can also serve as a management tool to identify the regular issues and to help find ways of managing them on future projects:

- **Policy and Standards**: This category includes changes to the design and management requirement mandated by MR through ongoing improvements in safety, and whole-of-life consideration.
- **Function and Capacity**: This category may include increased requirements such as traffic capacity, axle loadings, ramp speed, additional access points, design speed etc compared to what was originally described at project definition.
- **Third Party Influences**: This category includes requirements of authorities other than MR (for example power, water and gas utilities, rail etc) in respect of service relocations and other design adjustment that need to be considered.
- **Design Development Changes**: Increased cost from greater work scope identified during the design process required to meet the previously stated performance requirement. These increases are often incurred through lack of investigation and survey work. This category typifies "scope creep" i.e. increase in work requirement to meet a previously given outcome.
- **Client costs**: This category includes MR staff costs, consultants' fees, peer reviewers' costs and so on. These costs will vary with the type of delivery method chosen for the project.
- **Property acquisition**: This category includes the actual cost of property purchases as well as the planning and legal fees involved in the land transfers.

- **Inflation Allowance**: This may be impacted by revised value of works, revised duration additional delay in the works (including both preconstruction and delivery phases), and change in indices %pa. rates.
- **Contingency**: The change in the allowance for contingency since the previous estimate. It is anticipated that this figure should reduce as design development progresses.

3.3 Optimism bias

Optimism bias is the demonstrated systematic tendency for people to be over-optimistic about the outcome of planned actions. Optimism bias applies to professionals and lay people alike. Optimism bias arises in relation to estimates of costs and benefits and duration of tasks. It must be accounted for explicitly in appraisals, if these are to be realistic. When plans are implemented, optimism bias typically results in cost overruns, benefit shortfalls and delays.

Methods to mitigate optimism bias include:

- Emphasis on realistic budgeting as an ideal and review over-optimistic budgeting as routine;
- Introduction of fiscal incentives against cost overruns, for example through requiring local co-financing of project cost escalation where possible;
- Formalised requirements for high-quality cost and risk assessment at the business case stage;
- Introduction of independent appraisal supported by necessary procedures.

(British Department for Transport, Procedures for Dealing with Optimism Bias in Transport Planning Guidance Document, June 2004)

3.4 Estimate Planning

As part of estimating planning, all documents and plans produced to date are reviewed, the estimating team formed, and a site visit conducted.

A Site Visit Risk Check List and Record template is provided in Annex A as input to the estimate.

Information relevant to the estimate will include:

- Project history
- Project objectives
- Investigation reports (for example technical and environmental)
- Project scope statement
- Construction staging plans/methodology and temporary works
- Plans and specifications
- Bill of Quantities
- Project delivery strategy
- Preliminary program of work
- Costs expended to date
- Record of site visit – risk identification
- Historical cost information.

The estimator shall prepare a simple estimating plan to guide the estimate's production within the project's constraints.

3.5 Resource Planning

3.5.1 General

Resource planning involves determining what kind and quantity of resources (plant, labour, materials and sub-contract) are required to perform project activities.

In practice, resource planning is performed in conjunction with the next step in the estimating process, cost estimating.

Note: Resource planning requires a clear definition of project scope, a Work Breakdown Structure that subdivides the project into component work packages, an understanding of the work methods to achieve the specified requirements, the likely availability of resources to perform the work, and the expected productivity of labour and plant.

The Estimate Breakdown should be based on a WBS level 2 structure so that prices can be related to the established market benchmarks.

The estimator will be required to obtain market rates for components normally carried out by specialised sub-consultants and subcontractors. This may be done by either a formal procurement process or alternatively by maintaining contact with industry suppliers.

The process can be summarised in terms of its inputs, key activities and outputs as indicated in Table 3.1.

Table 3.1 Resource Planning Overview

Inputs	Activities	Outputs
• Plans and specifications • Work Breakdown Structure • Resource groups • Schedule of work activities • Resource pool analysis • Project cost records and reports	• Work method studies • Procurement/market testing	• Resource requirements • Resource prices • Activity durations

3.5.2 Work Method Studies (Constructability)

Studies are often required for significant items to determine the feasibility and efficiency of alternative production methods.

For example, when considering the construction component of a project, the estimator may need to examine the earthworks mass haul diagram to evaluate haul quantities and distances, borrow and spoil requirements and the most effective construction fleet for the particular site conditions.

Similarly, for major projects in high traffic areas, it may be necessary to develop traffic management and construction-staging plans in order to evaluate the cost of traffic management activities.

Estimators need to match the level of estimating effort with the expectations of estimating accuracy for the estimate stage being considered.

3.6 Cost Estimating

This is the process of developing the cost estimate.

To produce a project cost estimate, all components of the project need to be estimated, including:

- concept planning
- design development
- detailed design
- land acquisition
- risk contingencies

- alterations to public utility plant
- construction
- temporary works (including sacrificial works) and traffic management
- handover
- project management.

The first principles (basic cost) estimating method, outlined in section 4.2.3, involves calculating the cost of all the resources needed to complete the project, including an assessment of the likely risks to be encountered and allocation of contingency amounts to accommodate these risks.

For strategic, concept and preliminary design estimates, estimators are encouraged to use updated historical information as a reality check when building up their first principles estimates. This requires districts to keep accurate information on previous project costs in the form of a date/cost table for resources such as rock, gravel, sand, cement and concrete.

Because of the wide range of activities to be estimated, components of the estimate may have to be developed within their respective functional areas and combined to form the total project cost estimate. For example, designers would have input into the estimate for the planning and design components, constructors for the civil construction component, traffic technicians for the traffic signals and street lighting component and so on.

The estimator will coordinate the assembly of the various cost components to form the total estimate.

The process can be described in terms of its inputs, its key activities and its outputs, as indicated in Table 3.2.

Table 3.2 Cost Estimating Overview

Inputs	Activities	Outputs
• Plans and specifications • Work breakdown structure • Bill of Quantities • Program of work with resource requirements, resource prices, activity durations • Risk schedule • Project cost records	• Unit rate estimating • Risk assessment • Contingency assignment	• Total project cost estimate in current dollars and out-turn dollars. • Supporting details • Assumptions • Cost management plan (cost make-up) • Archived records

3.7 Cost Budgeting

The project budget is expressed in out-turn dollars ($OT) to reflect the actual completion cost of the project. These costs will include the component costs of concept development, design development, detailed design, land acquisition, alterations to public utility plant, construction, handover and project management client costs, commencing with the development of the project proposal.

Out-turn costs are calculated by adding an allowance for inflation to the cost estimate which has been developed in current year dollars. This allowance is based on a calculation of the MR established cost escalation forecast applied to the estimated project cash flow. (See Section 5.6)

Table 3.3 Example of Inflation Calculation

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Total Project Cost
Expenditure profile in current year dollars	$0.50M	$1.50M	$25.00M	$40.00M	$15.00M	$82.00M
Inflation	1.00	1.03	1.03^2	1.03^3	1.03^4	
Project budget	$0.50M	$1.55M	$26.52M	$43.71M	$16.88M	$89.16M

4 ESTIMATING APPROACH

4.1 Estimating Structure

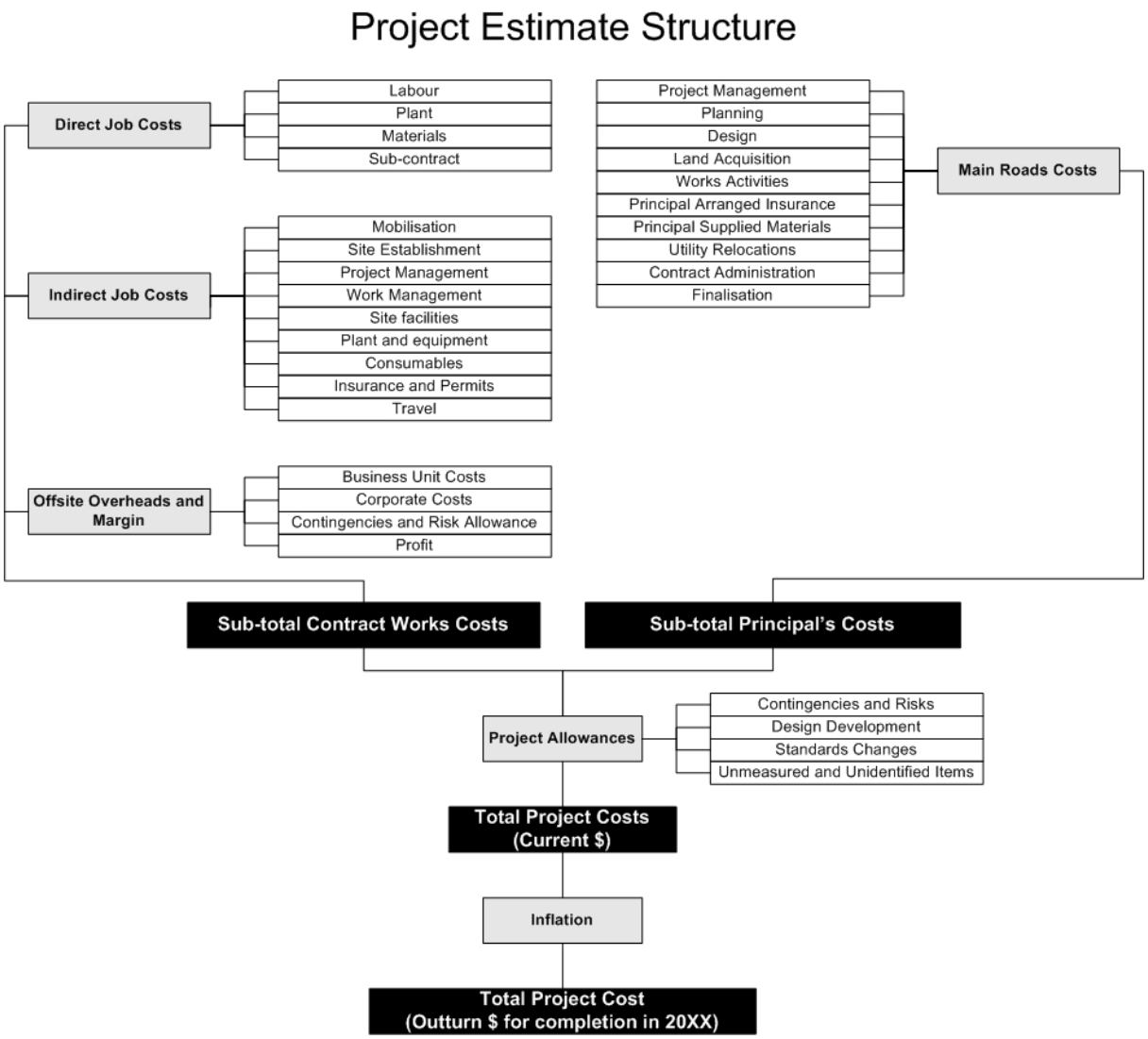
4.1.1 General

All estimates comprise:

- dividing the project into sufficiently small elements so as to allow a single rate or unit cost to be applied to each element;
- extending the quantities and rates to determine a cost for each element;
- summing the resulting elemental costs and, finally,
- applying indirect costs to give a complete estimate.

The cost structure of a typical project is illustrated in Figure 4.1.

Figure 4.1 Project Cost Structure



4.1.2 Direct Job Costs

Each activity within the standard work breakdown structure (WBS) is sub-divided into sub-activities or tasks according to the processes needed to complete the work. These work activities are usually detailed in the project specification (and as per detailed scope definition). For example, concrete in a bridge deck is typically subdivided into formwork, reinforcement steel, concrete supply and placement, finishing and curing. To determine the direct cost of the activity, resources such as plant, labour and materials are then allocated to the scheduled quantity of work according to their capacity to meet the requirements of the project, resource availability, production rates and unit costs The sum of the activity direct costs gives the Direct Job Costs (DJC) of the project.

Costs included in direct job costs are expressed in current dollar terms and are summarized in Table 4.1.

Table 4.1 Examples of Direct Job Costs (in current dollar terms)

Cost Category	Components	Sub-components
Direct job costs	Labour	Gross wages and salaries
		Award allowances (for example construction worker allowance, construction camp allowance, overtime loading, annual leave loading, site-specific allowances and severance allowance)
		Superannuation
		Training
		Work cover
		Payroll tax
		Personal protective equipment
		Labour administration support costs
	Plant	Plant hire rate for contractor's plant and plant supplied externally on a "dry" hire basis (that is exclusive of fuels, oils, expendables, ground engaging tools and operator)
		Fuels, oils, consumables and ground engaging tools of plant items
		Transport of plant items
	Materials	Permanent material incorporated in the final works (for example supply and delivery of pavement materials, supply only of RC pipe & box culverts, supply of bridge expansion joint, etc)
		Temporary materials not incorporated in the final works (for example, traffic barriers, sheet piling, formwork, silt fences, setting-out pegs, etc)
	Sub-contract	Components of the work (permanent or temporary) sub-contracted by the head contractor (for example erection of deck units, installation of sheet piling etc), and including subcontractors' indirect job costs and offsite costs
		Subcontract plant hired on a "wet" hire basis (for example plant including fuels and oils, expendables, ground engaging tools and operator)

4.1.3 Indirect Job Costs

Indirect Job Costs include the allowances that contractors require to manage the project, and cover their risk, corporate overheads and margins. Estimates prepared by MR and its service providers must show specific line items for each of the indirect cost categories.

Options include:

- separate schedule item for indirect costs

- indirect costs distributed through the schedule activities, either as a uniform percentage mark-up on direct job costs or allocated to specific activities.

Contractors preparing detailed estimates for tenders normally adopt the basic cost method. It is the most accurate estimating method, but relies on a high level of scope definition for best results.

On-site indirect costs, often referred to as on-site overheads, are summarised in Table 4.2.

Table 4.2 Examples of Contractor's On-site Indirect Job Costs

Cost Category	Component	Sub-component
On-site indirect job cost Overheads (recurring)	Project management	Project Manager
		Project Engineer
	Works management	Supervisors
		Administration officer
		Systems officer
		Surveyor
		Laboratory technician
	Site facilities	Office rentals (for example accommodation, facsimile, photocopier, computer hardware and software)
		Service utility charges (for example telephone, power, water and sewerage)
		Cleaning charges (for example office cleaning, septic pumping, refuse disposal, etc.)
	Plant and equipment	Site staff vehicles Job truck (general purpose) Pumps and generators Floating plant and loose tools
	Consumables	Stationery
		Miscellaneous materials
	Insurance and permits	State government and local government permit fees, insurances required by the contractor, bank guarantees and financial charges
	Travel	Travel costs not included in wages and salaries
On-site Overheads indirect job costs (fixed)	Site establishment	Transport and erection of site facilities
	Mobilisation	Mobilisation, site offices and amenities for contractor, client's team and in some cases, subcontractors

Off-site indirect costs, often referred to as off-site overheads, are summarised in Table 4.3.

Table 4.3 Examples of Contractor's Off-site Indirect Job Costs

Cost Category	Component	Sub-component
Off-site indirect job costs, corporate overheads (recurring)	Business unit costs	Local area costs associated with the management of operations, finance, human resources and business systems
	Corporate costs	Costs associated with strategy and policy development, business development, finance, human resources, business systems, technical advice, and contract advice
Off-site allowances (fixed)	Contingencies and Risk allowances	An amount to cover the costs of unforeseen factors related to the delivery of the project objectives which are not provided for elsewhere in the total job costs
Margin	Profit margin	Provision for profit often applied as a percentage of the total job costs (direct job cost plus on-site overheads)

4.1.4 Principal's Costs

These are the costs of the project attributable to the Principal during the project lifecycle. The estimator must allow for these costs as separate line items in the estimate. Care needs to be taken in the proper allocation of escalation to these costs. Note also that although the Contract Costs will attract a margin percentage, the Principal's Costs will not.

Table 4.4 Examples of Principal's Costs

Cost Category	Component	Sub-component
Establishment Costs	Planning, design, land acquisition, administration	Planning, community consultation, land acquisition, MR staff costs, geotechnical surveys, cadastral & engineering surveys, Principal Arranged Insurance, Principal's Risks not included in the Contract risks, contract administration and so on
Project allowances	Contingencies and risk allowances	An amount to cover the costs of unforeseen factors related to the delivery of the project objectives which are not provided for elsewhere in the total job costs
	Design growth and standards growth	Increase in costs due to the change in design and construction specifications and community expectations over the life of the project

4.1.5 Unmeasured (Unidentified) Items

In addition to the items listed in the pricing schedule for the Strategic, Concept and Detailed estimates for items which have not been identified during the quantity take-off process, the estimator shall allow the following lump sum price amounts in the contract works contingency register:

- Detail Design Estimate => 1% to 3%, of total construction cost
- Concept Estimate =>3% to 5% of total construction cost
- Strategic Estimate => 5% to 7% of total construction cost

4.1.6 Inflation

Inflation is the increase in project costs over time due to rise and fall and applies to the whole of the estimated costs.

Table 4.5 Inflation

Cost Category	Component	Sub-component
Project allowances	Inflation	Within the context of project cost in MR, escalation is the increase in project costs over time resulting from rise and fall, and is applied to all estimated costs

4.2 Estimating Methods

The basic difference between different methods of estimating is the degree to which a project is divided into elements and the method used to apply rates and additional costs. The more rigorous the process used, the greater will be the certainty of estimate outcomes/the "accuracy" of the estimate.

4.2.1 Global Estimate (Benchmark rates)

Global estimating, or "Order of Magnitude" estimating, describes an approximate or low order method of estimating involving the use of "all in" or "global" composite rates. The project could be considered as consisting of one estimating element only and the estimate prepared on this basis (approximately a Level 2 WBS). Examples are road cost per km and bridge costs per square metre of deck area.

Note: Global estimating has been found to be unreliable in achieving the level of estimating accuracy required by MR, even for strategic estimates. **Consequently, global estimating must not be used for budgeting purposes or for media releases.**

4.2.2 Unit Rate Estimate

Unit rate estimating calculates the cost of each element of the project by multiplying the quantity of work by historical unit rates. The project cost is then determined by the sum of the elemental costs. The unit rate is normally determined from a careful analysis of unit costs of a number of recently completed projects of the same type, allowances being made for project differences. It is important that the project analysis recognises that the rates may include indirect costs such as contractor's management, risk, overheads and margins, which must be adjusted when converting a unit rate to the direct cost rate.

Adjustments to be considered include:

- inflation
- site conditions (mountainous or flat terrain)
- market conditions
- on-site and off-site overheads and profit
- scale of works (large or small quantities)
- site location (urban or remote)
- design complexity (unique or routine)
- risk profile ground type
- construction methods (specialised or conventional)
- specification of materials and finishes (for example architectural or plain finish).

Unit rate estimating is a relatively quick method of estimating but lacks precision, especially in the interpretation of what exactly is provided for in the unit rate. Accuracy of an estimate requires emphasis on scope, reflected in a comprehensive schedule of work items that is unique to the project. Unit rates can vary from project to project, but the use of the historical unit rate, **adjusted** by an experienced estimator and applied to a detailed schedule, produces a more accurate estimate than a global estimate.

With a sufficient level of information in terms of the scope of the project, the work breakdown, quantities and careful selection of appropriate historical rates, the unit rate method of estimating is capable of producing estimates suitable for all project stages through to detailed design.

Note: Historical costs can be misleading as they are not current rates and caution will need to be exercised in the absence of a controlled set of historical cost information. Historical costs should be used only as a reference indicator for an item.

4.2.3 First Principles (Basic Cost / Detailed) Estimate

The foundation of "first principles" estimating, sometimes referred to as "basic costs" estimating, is the calculation of project-specific costs based on a detailed study of the resources required to accomplish each activity of work contained in the project's work breakdown structure.

Caution should be exercised so that an adequate allowance for items not properly documented (see section 4.1.5) is made and included in the estimate schedule.

Before attempting to use first principles estimating to estimate construction costs, if estimators do not have experience or knowledge of the likely constructors' production rates, they should seek assistance from those who do, i.e. obtain the correct information.

Consideration needs to be taken of such things as the site conditions likely to be encountered, the program of work, work methods to be employed (including alternatives), resource availability, productivity of labour and plant, procurement of materials and subcontractors as well as risks likely to be encountered during the course of the project.

4.2.4 Hybrid (Unit Rate/First Principles) Estimate

The hybrid method uses some features of the unit rate method and some of first principles method, thereby increasing estimating accuracy above that of the unit rate method.

The estimate is completed in a similar manner to the first principles estimate, by the application of typical percentages for on-site and off-site overheads and profit to a direct job cost estimate compiled using a direct cost unit rate method.

A weakness of the method is that it relies on the availability of direct cost unit rates (that is rates which are equivalent to the direct job costs component of the first principles method before the distribution of indirect costs). These are not normally available from industry unless the organisation itself carries out basic cost estimating. Given the correct information, experienced estimators can make an adequate analysis of a contractor's tender schedule and bring the costs back to a direct cost level.

For example, a business case with limited project development detail uses first principles for high value, high risk items and unit rates for low risk items.

4.2.5 Monte Carlo analysis

Monte Carlo analysis must be carried out by expert qualified practitioners to define the P50 and P90 bounds of the estimate. Refer to section 6 and section 7.1.3 of this manual.

4.3 Selecting the Appropriate Method

The method chosen for the preparation of an estimate depends on both the purpose for which the estimate is to be used (and therefore the required level of confidence of the estimate) and the level of detail of the available data.

In practice, it is common for combinations of estimating methods to be used on the business case estimate. Most of the effort should be directed to ensuring the accuracy of the 20% of items that often make up 80% of the costs – the Pareto approach.

4.3.1 Recommended Method

The methods recommended for various types of estimates are shown in Table 4.6.

The project manager is responsible for using the appropriate estimating method to provide a P90 estimate for the different types of projects defined in the OnQ system. The project manager must decide the type of project (using OnQ) and agree with the estimator as to the estimating methodology to be employed. This table is a guide to the type of estimating methodology that may be used.

Table 4.6 Recommended Estimating Methods

Estimate Stage	Type I	Type 2	Type 3
Strategic or Pre-project	PCEM not applicable	PCEM not applicable	PCEM not applicable
Proposal	Unit Rate method	Unit Rate method	Global Estimate
Options Analysis	60% value at Unit Rates Estimate, 40% value at First Principles Estimate	Unit Rate method	Global Estimate
Business Case	First Principles Estimate at WBS3	60% value at Unit Rates Estimate, 40% value at First Principles Estimate	Unit Rate method
Preliminary Design	First Principles Estimate at WBS3	20% value at Unit Rates Estimate, 80% value at First Principles Estimate	20% value at Unit Rates Estimate, 80% value at First Principles Estimate
Detailed Design	First Principles Estimate at WBS3	First Principles Estimate at WBS3	First Principles Estimate at WBS3

5 CONTINGENCY

5.1 General

Contingency, in terms of managing risk on a project, can take many forms. It may be a time allowance in the program of work for delay such as wet weather, a cost allowance in the project cost estimate to account for the residual risk or a contingency process in case an event happens. The amount of the contingency is reassessed at project review points to reflect current knowledge and level of uncertainty of the project, with a view to forecasting the most likely outcome.

5.2 Exclusions

Contingency amounts are not meant to cover all eventualities. It is important, therefore, to understand the limitations imposed. These limitations include:

- **Contingency does not cover changes in scope**. That is, contingencies reflect only circumstances within the approved scope of the project. In the event that a decision is made to change the scope of a project, then the project will need to be justified again. This is required each time there is a revised scope definition, and a new estimate reflecting a level of contingency applicable to the revised scope.
- **Contingency is limited to probable events**. These are events that are foreseeable and pose a risk to the project in terms of their perceived likelihood and consequence. These are sometimes referred to as “known risks”.
- **Contingency does not include "unknown" events**. Events that are “unknown” in terms of their existence and likelihood of occurrence are excluded from the contingency allowance provided in the project cost estimate. This assumes that the project manager has an obligation to reasonably investigate the environment in which the project exists to minimise the number of unknowns.

5.3 Applying Contingencies

The risk treatments that result from the risk management process can be categorised as follows:

- Category 1 – Specific provision in the design or delivery method of the product that overcomes all or part of the risk (that is risk avoidance, risk reduction or risk transfer)
- Category 2 – The retained risk is allocated a contingency allowance that is included in the cost estimate, either as :
    - the Principal's contingency amount, and/or
    - the District Director’s contingency amount, and/or
    - a separate provisional item addressing the risk.

In Category 1, the cost of avoiding, reducing or transferring the risk is provided for in the cost of the work activities for the adopted design and does not appear as a contingency. (It will need to be provided in the contract estimate).

In Category 2, the accepted or residual risk is allocated a contingency allowance that is included in the cost estimate, either:

- as a Principal's contingency amount, or
- a separate provisional item addressing the risk (for example inclusion of a provisional item for removing and replacing unsuitable material, or inclusion of an item for setting up for re-driving of piles).

Total project contingency is the sum of the Category 2 contingencies, unless it is decided that a statistical approach should be applied.

5.4 Quantification of Contingencies

Quantification of contingency allowances for cost estimating items is achieved by applying the risk management processes detailed in AS/NZS 4360:2004.

Because of the uncertain nature of the assessment process, it is difficult to be prescriptive as to how contingency costs should be estimated. Sufficient to say that the estimator and project manager must use their experience and professional judgment to weigh the competing factors to arrive at the "most likely" value. Historical events may be used as a guide.

Where risks are significant and complex, it is recommended that a statistical evaluation method be used. Refer to Section 6 or 7.1.3 for information on the Monte Carlo method.

This area of cost estimating is relatively new to MR and it is appropriate that some guidance is given as to the level of contingencies that will be accepted. .

The guidance given by Table 5.1 assumes that the project manager and designers have exercised reasonable care in defining the scope so as not to unduly rely on contingencies. Larger contingency allowances must be justified.

Table 5.1 Expected Contingency Range

Estimate Stage	Typical Contingency Range
Strategic Estimate	30% to 50%
Concept Estimate	30% to 40%
Preliminary Design	20% to 30%
Detailed Design Estimate	10% to 20%

5.5 Reviewing Contingencies

Under the risk management strategy adopted by MR, risks are reviewed at intervals throughout the project life cycle and assessments updated to reflect the current level of uncertainty surrounding the project.

Risks for which contingencies were provided early in the project may, at some later time, be overcome by further investigation or modification of design within the original scope. For example, a contingency allowance for rock in cuttings early in the project may be replaced by specific quantities and costs following a geotechnical investigation with no residual uncertainty.

This example serves to highlight the importance of identification of contingencies separately from the base cost of work activities, and for the recording of reasons for their inclusion. The risk register provides a convenient place to record such decisions, in particular whether the risk is owned by the customer, by the deliverer, or by the Project Manager as the Manager of provisional scheduled items.

In terms of contingency allocation, the project manager 'owns' the contingency for known project risks. The program manager 'owns' the contingency for unknown project risks.

5.6 New Cost Escalation Road Input Index for Main Roads

The Cost Escalation Road Input (CERI) index has been developed by MR as a tool to assist district staff improve the accuracy of their estimates. It replaces the discontinued Road Input Cost Index (RICI). The CERI cost escalation index measures change in the average unit rate per quarter or year, as applicable. The base CERI index and its forecasts can be used as part of the process to turn current estimates into out-turn estimates at time of delivery.

The index utilises an innovative statistical model to map a broad suite of economic factors into a single weighted index. The system also constantly monitors market movements to ensure that the most influential and important factors are included in the rolled up index.

Procurement Development and Research Branch will be publishing regular CERI forecasts for up to two years ahead, using industry best practice methods. The latest CERI index can be obtained from the Branch.

6 PROBABILISTIC ESTIMATING

This chapter sets down the parameters for the preparation of an estimate using probabilistic simulation.

6.1 Overview

Probabilistic Estimating is a method of generating estimates taking into consideration that quantities measured (or allowed for) can change, rates assumed can vary and risks with a probable outcome can materialise.

Probabilistic estimating complements, and does not replace, the estimating procedures outlined in the previous chapters.

The calculation of the base estimate for strategic, concept and detailed estimates will be undertaken as per the relevant sections of this estimating manual.

Probabilistic simulation should be used to determine the appropriate contingency for the project. The contingency is equivalent to the difference between the cost determined using the probabilistic simulation and the cost adopted in the base estimate.

6.2 Requirements

Main Roads' estimating policy requires that the Actual Cost of a project has a 90% probability of not being greater than the estimate prepared or, as expressed differently, the estimates are to have a 90% confidence factor of not being exceeded.

The 90% confidence level is the mandatory requirement for Main Roads estimates.

P90 denotes the value of the estimate that exceeds 90% of the values generated by the simulation.

6.2.1 Risks

For risks which have been identified, reference should be made to the project risk analysis. Estimators shall review the risks identified and add any other possibilities which they may consider appropriate.

This shall include the costs associated with handing over the project and other items of cost represented in the Estimate Summary Sheet, such as:

Finalisation – Refurbish old route

Finalisation – Project data and post-completion review

6.3 Probability Distributions

All variables such as quantities, rates, risk costs, can vary from the figures adopted in the base estimate. The extent of the variance of the values for these variables can be presented by a probabilistic distribution.

All variables such as quantities, rates, costs, and so on, shall be subject to a probability distribution to allow for uncertainty and possible variation in their quantitative value.

The probability distribution adopted shall be based on historical records, industry performance, technical capabilities and other relevant performance information.

The probabilistic distribution shall be used to represent the variance of the estimated value in a model of the estimate.

7 RISK

7.1 Risk Management Overview

7.1.1 Concepts of Risk

Risk is defined as the chance of something happening that will have an impact upon project objectives. It is measured in terms of consequences and likelihood (AS/NZS 4360:2004 Risk Management).

Risk management is about managing a project within its inherent environment of uncertainty.

It is helpful at the outset to distinguish between the concepts of *uncertainty* and *risk*:

- *Risk* is experienced on being exposed to the chance or probability of suffering a loss or profit. Risk is then a measure of the probability of that loss or profit occurring.
- *Uncertainty*, therefore, represents unknown or ill-defined variables, whereas risk lies essentially in the perception of the decision-maker as to the possibility of a loss occurring.

There is no one common standard of risk. A set of circumstances declared "risky" by one individual may not necessarily be so when assessed by another using a different perspective.

The prevailing view should be aligned with MR's organisational goals as expressed in the department's strategic plan.

Within the context of a project, the project manager must consider all the uncertainties during the course of the project, and make a judgment as to the likelihood and consequences of a risk emerging that will threaten the objectives of the project. It should be remembered that these objectives are not necessarily internal to the project, but can include organisational and community considerations.

7.1.2 Management of Risk

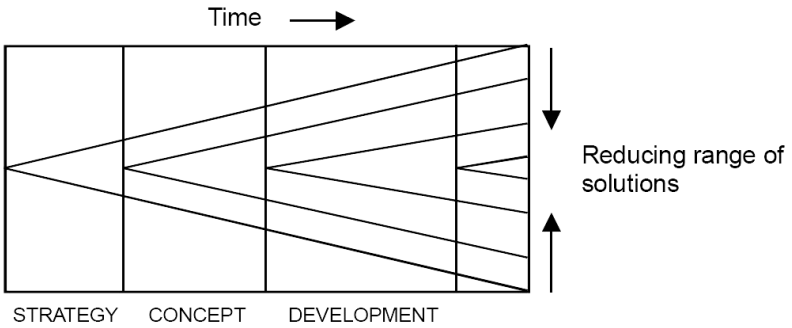
Management of risk is an integral part of the project management process. Risk management is a multi-faceted process, certain aspects of which are often best carried out by a multi-disciplinary team. It is an iterative process designed to progressively diminish risk as uncertainty about the project outcomes is reduced.

Risk Assessment must be properly applied and concentrate on:

- lower and upper ranges used for risk on measured items;
- type of distribution used (as probabilistic estimating favours the most likely figure, unless range is wide);
- correlation between estimate items, otherwise risk can be under-assessed;
- application of extensive and substantial contingent risk at the concept stage of a project.

The concept of an uncertainty cone in Figure 7.1 may help explain how uncertainty changes with time.

Figure 7.1 Uncertainty Cone



As the project moves through the phases, the range of solution options diminishes as uncertainty is reduced.

Risk identification processes are applied and documented to ensure that identified risks are tracked and progressively responded to throughout the project life cycle to ensure project objectives are achieved.

At project review and approval points, a project's risk status should be determined so as to provide the program manager with an opportunity to make a business decision on how to proceed. The project cost estimate for the review point will include, in the form of a contingency allowance, provision for all expected risks that have been identified at that time.

Project Risk Management includes the processes associated with conducting risk management planning, identification, analysis, responses and control on a project. The objectives of risk management are to increase the probability and impacts of positive events, and reduce the probability and impacts of events adverse to project objectives.

Risk management is an iterative, ongoing activity that will increase the likelihood of project success. The adoption of a structured approach to risk management encourages:

- better informed decision-making and project justification
- reliable project delivery
- effective and efficient allocation and use of resources
- high standard of accountability
- creativity and innovation in management practice
- improved capacity to manage in the face of competing obligations
- increased understanding of project
- realistic schedule and cost estimates
- build-up of statistical data for future projects
- proactive management and more effective use of time.

7.1.3 Statistical Techniques

With any estimate, there will be activities that exhibit uncertainty and variability.

Traditionally, estimating techniques tried to capture this uncertainty in one of three ways: *point* estimates, *range* estimates and *what-if scenarios*.

- **Point estimates** are produced when the estimator uses what is thought to be the most likely values (technically referred to as "the mode") for the uncertain variables. These estimates are the easiest to produce, but can return very misleading results.
- **Range estimates** typically calculate three scenarios: the best case, the worst case and the most likely case. These types of estimates can demonstrate a range of outcomes, but not the probability of any of these outcomes.
- **What-if scenarios** are usually based on the range estimates, and calculate as many scenarios as the estimator thinks fit for the project. This form of analysis is extremely time-consuming, and generates lots of data, but still does not provide the probability of achieving different outcomes.

One method of taking into account the uncertain variables involves the use of a model designed to simulate or imitate a real life system.

For each uncertain variable (one that has a range of possible values), the estimator defines the possible values with a probability distribution. The type of distribution selected is based on the conditions surrounding that variable.

A simulation calculates multiple scenarios of a model by repeatedly sampling values from the probability distributions for the uncertain variables.

Software commonly used in the analysis and quantification of risk (in the Monte Carlo analysis) includes:

- Crystal Ball
- @ Risk.

7.1.4 Risk Management Terminology

The following lists key risk management terms.

Assumption

A particular group of risks where the probability of occurrence is neither so high (nearly 100%) or so low (nearly 0%). In such cases the project assumes the probability to be either zero (ignore) or one hundred percent (constraint).

Constraint

A barrier to how the project achieves its objectives. A constraint is not a risk because it has no uncertainty; it is a given.

Contingencies

Can also be defined as the cost of retained risk or opportunity which has been allotted to the project manager (and/or program manager) to control.

Issue

An issue occurs when a risk (including opportunities) eventuates.

Opportunity

A particular type of risk where the potential impact is beneficial rather than negative.

Risk

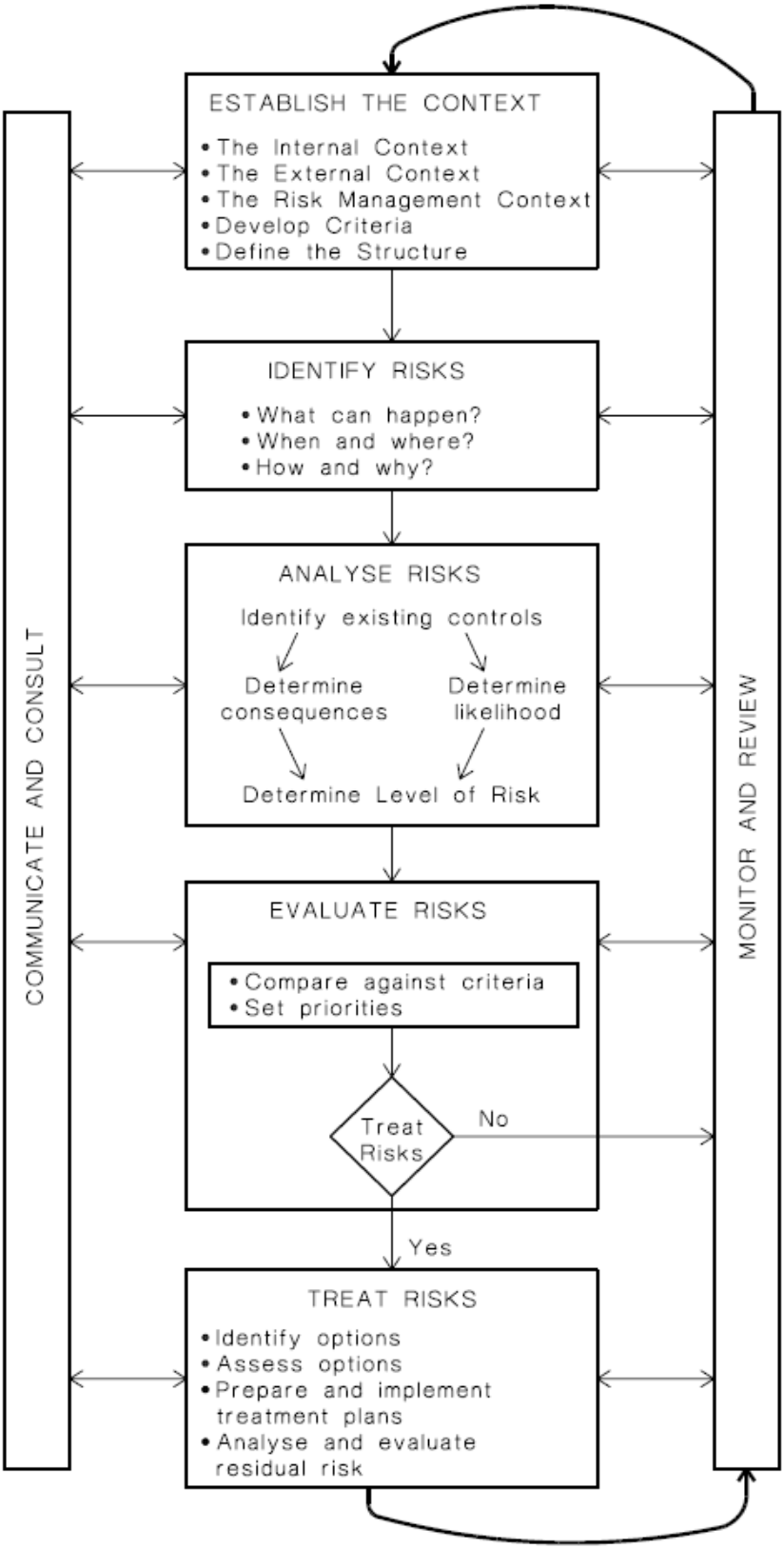
The chance of something happening that will have an impact upon project objectives. It is measured in terms of consequences and likelihood.

7.1.5 Risk Management References

The main elements of the risk management process are shown in Figure 7.2, taken from AS/NZS 4360:2004.

Estimators and project managers should check MR's Project Manager's Risk Management Guidelines and use the risk management database included in 'Tools' in the OnQ site.

Figure 7.2 Risk Management Processes



7.2 Risk Management Processes and Their Application

The risk management processes detailed in AS/NZS 4360:2004 Risk Management provide a means of achieving some consistency in how risks are managed.

These processes can be applied at all levels in the organisation, including projects. It provides a logical and systematic approach to guide the Project Manager through an iterative process, as depicted in Table 7.2.

Managers need to identify their role in contributing to the organisation's wider goals, objectives, values, policies and strategies when making decisions about risk. These help to define the criteria by which it is decided whether a risk is acceptable or not, and form the basis of controls and management options.

Risk evaluation and treatment is project-specific. Advice is provided in the Main Roads Project Managers Risk Management Guidelines.

7.2.1 Establish the Risk Management Context

The goals, objectives, strategies, scope and parameters of the activity, or part of the organisation to which the risk management process is being applied, should be established. Key questions which need to be asked include:

- What is the policy, program, process or activity?
- What are the major outcomes expected?
- What are the dollar values?
- What are the significant factors in the organisation's internal and external environment?

A component of this step is establishing risk criteria and constraints. Consideration should be given to the level of risks the organisation is prepared to accept. The criteria are used to rank risks to decide whether they are acceptable or not in the evaluation step. Key questions which need to be asked include:

- What are the major threats and opportunities the program presents?
- What are its strengths and weaknesses?
- Who are the stakeholders?
- What problems were identified in previous reviews?
- What risk criteria should be established?
- What is the best way of structuring the risk identification tasks?

7.2.2 Identify the Risks

This refers to the identification of the risks to be managed and involves listing all risks the project may face during its lifecycle that are known at the time. Comprehensive identification using a systematic process is critical, because a potential risk not identified at this stage is excluded from further analysis.

A top-down approach is often taken as the project is looked at as a whole. It provides for an overview of the project from an early planning perspective.

A bottom up-approach ensures coverage of lower level aspects - specific issues affecting individual tasks; implementation and progress of the project.

Useful techniques include risk workshops, reviewing past project documentation and talking to the "wise old man". Some risk categories to consider in this stage include:

- political
- related projects
- scope definition
- communications

- resources
- traffic
- technical
- contractual environment
- workplace health and safety
- organisational
- financial
- business interruption
- suppliers
- natural events
- cultural
- subgrade
- stakeholders
- embankments
- timing / schedule
- drainage structures

7.2.3 Analyse the Risks

Risk analysis involves determining the likelihood of events occurring, the magnitude of their consequences should they occur, and combining these values to produce an overall risk rating.

A preliminary analysis can be carried out so that similar or low-impact risks are excluded from detailed study. Excluded risks shall, where possible, be listed to demonstrate the completeness of the risk analysis. As the project progresses, a more detailed approach may be required.

The risk management process can not only address negative impacts, but also be used to consider opportunities to achieve benefits. The results of progressive risk review include:

- identification of risks
- application of positive treatments
- cost/benefit analysis
- realisation of benefits
- project progresses to target milestones and objectives, and
- “no surprises” management.

7.2.4 Evaluate the Risks

The risks are assessed in terms of their likelihood and consequence, according to the assessment tool in Table 7.1, which provides a qualitative approach to risk analysis. The risks can then be categorised according to their severity.

Table 7.1 Qualitative Risk Analysis Matrix

Likelihood	Consequences				
	Insignificant	**Minor**	**Moderate**	**Major**	**Severe**
Almost certain	High	High	Extreme	Extreme	Extreme
Likely	Medium	High	High	Extreme	Extreme
Moderate	Low	Medium	High	Extreme	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Rare	Low	Low	Medium	High	High

7.2.5 Treat the Risks

The output of risk management processes are decisions as to how the risks will be treated. This is recorded in the project risk register, along with the assessment of contingency amounts to be provided for in the project cost estimate.

The project risk register will become an important source for organisational learning and should be reviewed in the project finalisation activities.

The project risk register can be developed using the generic risks listed in Annexure A – Site Visit Risk Checklist and Record.

Options for risk treatment are detailed in Table 7.2.

Table 7.2 Options for Risk Treatment

Risk Treatment Options	Description
Avoid the risk	Deciding not to proceed with the activity likely to generate risk. *Example:* *The project manager may decide to avoid exposure to acid sulphate soils by eliminating excavation in the affected area. The cost implications arising from avoiding the risk would be provided for in the cost of the revised design items.* *Inappropriate risk avoidance may increase the significance of other risks.*
Reduce the likelihood and/or consequences of the occurrence	This is a common occurrence in the delivery of projects. *Example:* *It may be appropriate to design a bound pavement as an alternative to a granular pavement to minimize the damaging effect of wet weather. The cost implications would be reflected in the cost of the substitute items.* *It may be decided to carry out detailed geotechnical investigations into soft ground conditions in order to make provision in the design for the risk of embankment failure during construction and in service. The cost of this risk reduction treatment will be reflected in the investigation costs of the project.* See “Retain the Risk” below, for how to handle residual risk. Examples of how to reduce likelihood and consequences of an occurrence are shown in Section 3.6 of AS/NZS 4360:2004.
Transfer the risk	This involves another party bearing or sharing some part of the risk. Mechanisms include the use of contracts, insurance arrangements and organisational structures such as partnerships and joint ventures. Main Roads construction and minor works projects allow for either contractor-controlled ("all risks") insurance or principal-arranged insurance. Main Roads has adopted, as policy, Principal Arranged Insurance (PAI) on open-bid contracts for construction work forming part of the Roads Implementation Program (RIP). The PAI policy is designed to comprehensively cover

Risk Treatment Options	Description
	construction risks of all project works at all levels including the principal, contractor and subcontractors. In estimating for projects covered under the PAI program, provision needs to be made for insurance premiums. Further information on PAI can be found through MR Junction. *Example I:* *It may be decided in the face of expected delays, to subcontract earthworks on a unit rate basis rather than do the work using an organisation's own resources In this way, all or part of the delay costs may be included in the subcontract unit rate thereby limiting the risk of to delay/costs.* In such circumstances, the selection of the subcontractor would include consideration of the subcontractor's capacity to handle the delay risk without creating another risk such as non-performance of the work. *Example II:* *The transfer of identified unique project risks may require customised construction insurance. In such circumstances, early consultation with insurers will be required for the settling of insurance specifications, the adaptation of the existing Principal Arranged Insurance Program or the negotiation of a project-specific policy. Insurers may include risk mitigation requirements with a direct impact on project costs.*
Retain the risk.	After risks are reduced or transferred, there may be residual risks that are retained. The cost of dealing with any residual risk event, if it eventuates, should be included as a contingency against the activities concerned or, alternatively, included in a separate item.

8 REVIEW AND APPROVAL OF ESTIMATES

This section establishes clear lines of accountability for the production, review and approval of project cost estimates, with a view to achieving a high level of estimating quality and consistency across the organisation.

Table 8.1 Responsibility Assignment Matrix – Preconstruction Activities

Ref.	Activity	Estimator	Planner Designer	Peer Review	PM	FM	DD	GM	MPO	Stakeholder Community
1.0	**Strategic Planning (pre-project)**									
1.1	Prepare link strategy		R			A	C	C		C
1.2	Scope statement				R	C	A			C
1.3	Prepare strategic cost estimate	R	I	C		A	C			
1.4	Approve link strategy					I/C	C	A[1]		C
2.0	**Concept Phase**									
2.1	Prepare project proposal (including planning estimate)		R		A	C	C			C
2.2	Detailed Scope statement				R	C	C	A		
2.3	Approve project proposal				R		A			
2.4	Develop options		R		C	A	C			C
2.5	Conduct options analysis (inc. options estimates)	R	R	C	A	C	C			
2.6	Approve options report				I/C	C	C	A		
2.7	Develop scope of preferred option		R		C	A	C			C
2.8	Prepare business case (inc. concept estimate)	R	R	C	A	C	C			C
2.9	Review project				I/C	C	A	C	R	C
2.10	Approve business case (inc. concept estimate)				I/C	C	A	E[2]		C
3.0	**Development Phase (Preliminary Design)**									

[1] General Manager (State-Wide Planning)

[2] For District delivered projects this means General Manager (Program Development & Delivery). For MPO delivered projects this means General Manager (Major Projects Office)

Ref.	Activity	Estimator	Planner Designer	Peer Review	PM	FM	DD	GM	MPO	Stakeholder Community
3.1	Develop solution design		R		C	A	C			C
3.2	Scope statement	R	I	C	A	C	C			
3.3	Prepare preliminary design cost estimate	R	R	C	A	C	C			C
3.4	Review project				I/C	C	A	C	R	C
3.5	Approve preliminary design estimate				I/C	C	A	E[3]		
4.0	**Development Phase (Detailed Design)**									
4.1	Prepare detailed design		R		C	A	C			C
4.2	Prepare detailed design cost estimate	R	I	C	A	C	C			
4.3	Peer review			C	R	R	R	R		
4.4	Approval to proceed to tender				I/C	C	A	E[3]		

Key 1: A = Accountability; R = Responsibility; C = Consult and Engage with; I = Provides Information; E = Endorse

(Convention: Accountability at one level implies accountability at higher levels in the organisation.)

Key 2: PM = Project Manager; FM = Functional Manager (for example design manager); DD = District Director; GM = General Manager, MPO = Major Projects Office

[3] For District delivered projects this means General Manager (Program Development & Delivery). For MPO delivered projects this means General Manager (Major Projects Office)

8.1 Estimate Review Process

The review process can apply at any estimate stage and can be one of three types:

Type 1 Peer Review

Unless specified otherwise, the peer review is sponsored by the District Director as the officer accountable for program delivery in the district. The review is conducted by the peer review officer (an experienced project manager or officer authorised by the District Director but independent to the project) who will report back to the District Director and project manager. The peer review officer is responsible for:

- checking that all necessary documentation has been completed and submitted by the project manager
- reviewing item quantities and rates using the Pareto approach (80:20 rule)
- reviewing optimism bias
- identifying potential errors in the estimate
- reporting cost trends for the project
- reviewing benchmarks for similar work
- reviewing project constructability
- reviewing risk registers and contingency allowances
- assessing construction methodologies and checking the preferred options
- verifying that key assumptions have been listed and appropriate allowances have been made in the estimate ensuring that the scope is fully understood and addressed
- verifying that previous quantities, rates, lump sums and contingencies have been reviewed as additional information has become available, and
- preparing an estimate peer review report (refer Annex B).

Any concerns or irregularities regarding the estimate shall be the subject of corrective action by the Project Manager before it is submitted to the District Director for approval.

Type 2 Concurrence Review

A concurrence review is prepared by a suitably qualified independent internal resource (for example, MPO or PDI) or an external party to assess:

- estimate conformance against the estimating standards, and
- estimate reasonableness.

Concurrence reviews are to be undertaken for projects that are:

- state-funded projects with an estimated cost greater than $20 million
- federally funded projects with an estimated cost greater than $10 million, or
- all high-risk or complex projects.

The responsibilities of the reviewing officer are the same as for the peer review.

Any concerns or irregularities regarding the estimate shall be the subject of corrective action by the Project Manager before being resubmitted for signing off concurrence.

Type 3 Program Review and Approval

In approving the project budget, the General Manager (PD&D) must be satisfied that the estimate is reasonable and that the project can be funded through the RIP or federal government programs. Actions taken are communicated back to the District Director.

8.2 Estimate Approval Process

The approval process applies at every estimate stage. The decisions in the review and approval process are to be recorded on the Project Cost Estimate template (see Figure 9.3) and communicated to the Project Manager through the District Director.

The approval of the estimate does not confirm approval to expend funds on the project.

Table 8.2 Approval Levels for all Estimates

Estimate Value	Approval Requirement
Estimate approval	District Directors approve
Estimate acceptance	Project sponsor accept

Note: The sponsor is required to sign off the project budget estimate for each stage of the project before it advances to the next stage

9 PRESENTATION OF ESTIMATES

9.1 General

MR has established methods for the presentation of estimates that have provided a high level of consistency over the years. These are supported by new templates which, to ensure consistency, are to be used for presentation at all mandatory estimate stages. The cost estimate templates are available from the OnQ website.

9.2 Work Breakdown Structure (WBS)

9.2.1 General

It is important that the estimator understands how estimating interfaces with the broader spectrum of project management. It is also essential to understand that the WBS is a component of the Works Management System (WMS).

9.2.2 Construction Activities

Construction activities are assigned a unique number according to the standard work items detailed in volumes one and two of Main Roads' Standard Specification Roads Third Edition, in particular MRS11.

The standard item numbering system detailed in MR's standard specifications has been retained as the basic building block for construction activities. The specifications describe the work activities and quality standards required to complete each item of work.

The work items, by their nature, are very detailed and ideally suited for detailed estimates where design and quantities are well developed. However, they have limitations when the estimate to be produced relies on only a broad scope definition.

It is expected that project managers will develop an estimate based on a work breakdown structure that reflects the level of information available for the estimate stage under consideration. The work breakdown structure described in Annexure C shall be used as a guide to match the level of work breakdown with the level of information available. For example, a strategic estimate might adopt mainly Level 1 or 2 activities, based on broad work packages, whereas a detailed design estimate will require most activities to be dissected to Levels 3 and 4 for example: WBS table showing Level 1, 2 and 3. Project managers and estimators will use their experience to breakdown the WBS as needed to the appropriate Levels 4, 5, 6 and so on.

The cost of construction work items is assumed to include distributed indirect costs.

Figure 9.1 Road Infrastructure project overview (Project Management vs Works Management)

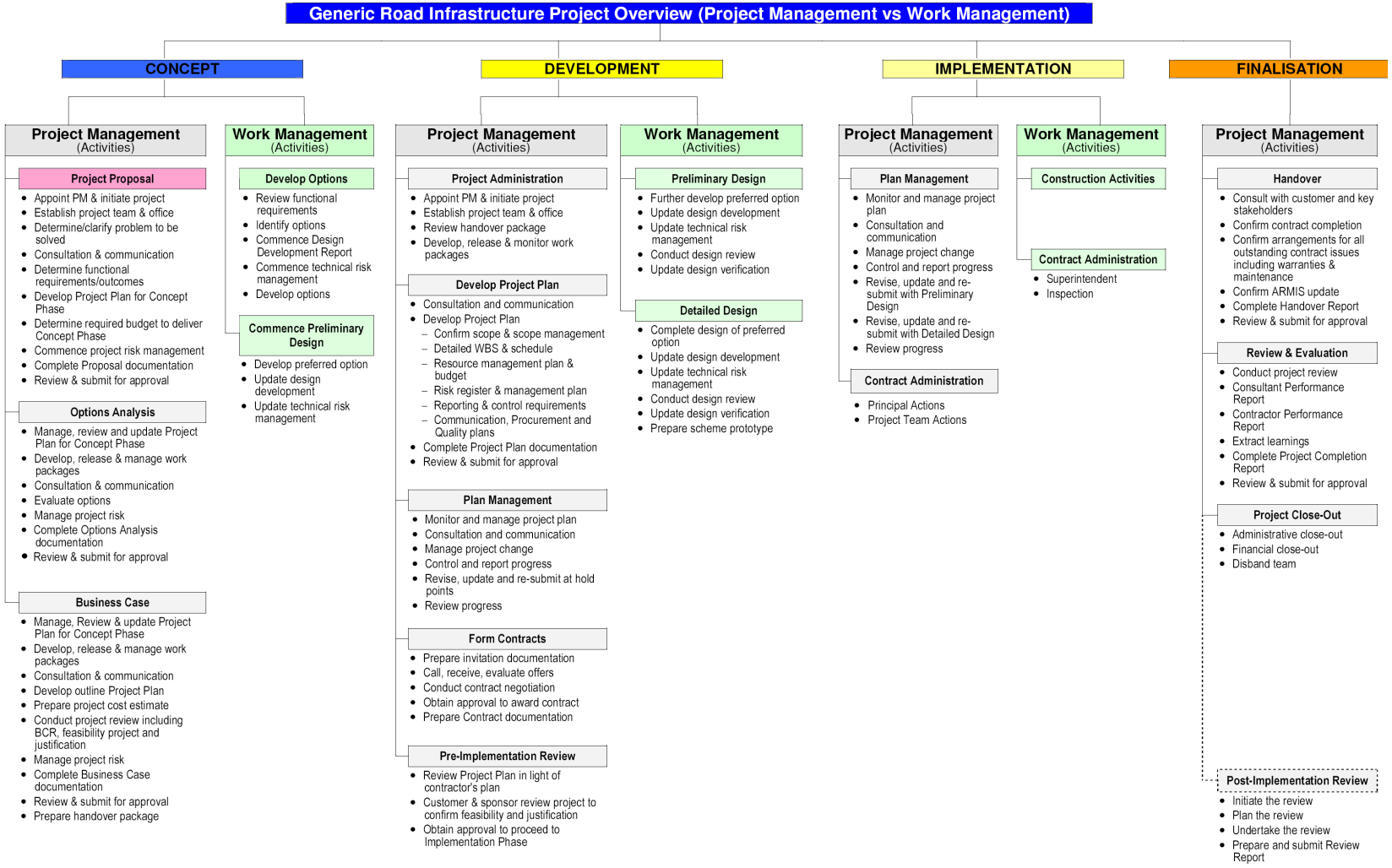
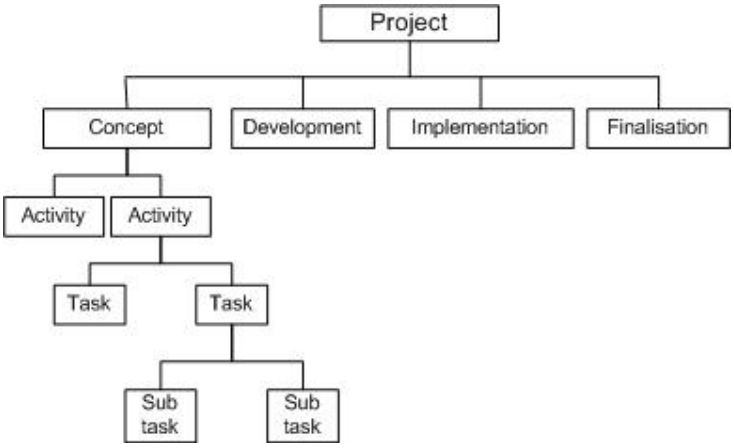


Figure 9.2 is a structured way of breaking down a project into its various components.

Figure 9.2 Example of a project's components



The MRS11 series of standard specifications gives the Level 3 WBS required for First Principles estimates as the Standard Item Number for each work activity. All estimates must follow the MRS11 WBS structure and sequence. Table 9.1 table shows the WBS at Level 1.

Table 9.1 Example of the Work Breakdown Structure (WBS)

WORK BREAKDOWN STRUCTURE (WBS)		
Standard Item Number Group		**Description**
From	**To**	
1000	1999	Site Establishment, Provision for Traffic & Environmental Management
2000	2999	Drainage, Protective Treatments & Retaining Structures
3000	3999	Earthworks & Landscape Works
4000	4999	Unbound Pavements, Stabilised Pavements
5000	5999	Sprayed Bituminous Surfacing, Asphalt Pavements
6000	6999	Road Furniture, Pavement Marking, Electrical Conduit & Pits, Traffic Signal and Road Lighting Footings, Traffic Signals, Road Lighting
7000	8999	Bridge

9.2.3 Non-Construction Activities

Non-construction activities are also assigned a unique number according to the project phase, management type, activity group and activity. The non-construction work breakdown structure is included in Annexure D.

9.2.4 Options Development and Design Activities

The work breakdown structure for project management and work management activities reflects a phased approach to project management and the essentially sequential series of processes that describe the development of options and design processes from concept through to construction.

The work breakdown structure provides a cascading menu of activities, commencing with the broadest work packages at Level 1 to the most detailed at Level 3, with unit rates made up of Level 4 (or more) detail.

It is intended that the work breakdown structure be flexible to accommodate the varying size and complexity of projects encountered in the roads program. Activities may be deleted or inserted within the series to reflect the scope of the particular project.

The work breakdown level adopted will also reflect the likely delivery method. For example, if the detailed design is being contracted out, it may be represented by a single activity based on the consultancy cost. However, if the detailed design was to be undertaken in house, the cost must be built up using design components such as geometric design, drainage design etc.

9.3 Project Cost Estimates

The release of the Project Cost Estimating Manual has introduced new templates and process requirements to assist with consistent and reliable estimates. The standard format for cost estimates has not changed, i.e. it must comprise an Item No., Description of Work, Unit of Measurement, Estimated Quantity, Unit Rate ($c), and the Extension (quantity by cost unit rate) Amount.

The presentation templates and the Works Management System (WMS) will also allow estimators to monitor the cost of individual work items in percentage terms relative to total cost, and identify the major construction activity rolled-up group costs (for example Pavements 4000-4999) for any project. Using these tools, an estimator can focus on the 20% of items that, when combined, often make up 70-80% of the costs.

The main change brought about by the introduction of this format relates to the way costs are presented.

Costs are broken up into project management or work management activities (where applicable) for each of the generic road project phases where they would generally be expected to occur. Construction activities and principal's works and/or materials and/or costs and contingencies are added to these costs to estimate the total project cost. The amount included for contingencies is to be transferred from the risk report and shown as a lump sum. The breakdown of contingencies, if required, may be determined by referral to the risk report.

Historically, project managers have tended to underestimate project costs because of insufficient rigor with scope definition and lack of solid peer review particularly where the project is complex and high cost. The introduction of a controlled process for risk assessment and contingency setting is designed to place emphasis on this aspect of project management.

The estimated cost is expressed in out-turn dollars ($OT) to reflect the actual completion cost of the project for the stated timing of that project.

9.4 Works Management System – Estimating Module (WMS: Estimating)

The Works Management System is an IT system to support the effective management and delivery of all project works within the roads program through an integrated suite of modern systems. The WMS: Estimating module is one of its modules. It allows estimators to record details of Proposal, Concept, Preliminary Design and Detailed Design Estimates in accordance with Main Roads project management methodology and the processes outlined in this manual.

The system is maintained by Business Solutions and Information. Reports developed in the module automatically produce the standard presentation templates as illustrated in Figure 9.3 and Figure 9.4 which are shown on the next two pages.

Figure 9.3 Standard Project Cost Estimate Template (page 1 of 2)

Project Cost Estimate (Summary)

Queensland Government
Department of Main Roads

Project Details

Project Number					
Road					
Project Description					
Project Location				Length	km
Region		District		Local Authority	
Estimate Stage				Date	

Total Project Cost

Phase	Activity Group	Activity	Amount ($)	Total Amount ($)
Concept				
	Project management			
	Work management			
	Key elements[1]			
		Sub Total		
Development				
	Project management			
	Work management			
		Preliminary design		
		Detail design		
	Key elements[1]			
		Resumptions		
		Public Utility Plant		
		Sub Total		
Implementation				
	Project management			
	Work management			
		Early works		
		Construction		
		Contract Administration		
	Key elements[1]			
		Sub Total		
Finalisation				
	Project Management			
		Sub Total		
			TOTAL PROJECT COST ESTIMATE (at 2/11/2007)	

1. List the activities which may have a major impact on this project

Total Out-turn Project Cost (OT$)

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Total Project Cost
Expenditure profile in current year dollars	$ M	$ M	$ M	$ M	$ M	$ M
Total Cost Escalation						
Project budget	$ M	$ M	$ M	$ M	$ M	$ M

Page 1 of 2 *(Printed2/11/2007)*

Figure 9.4 Standard Project Cost Estimate Template (page 2 of 2)

Project Cost Estimate continued ... page 2

Queensland Government
Department of Main Roads

Project Cost Estimate (Approval)

Project Details

Project Number					
Road					
Project Description					
Project Location			Length	km	
Region		District		Local Authority	
Estimate Stage			Date		

Project Cost Estimate Certification

Preparation of Project Cost Estimate

I certify that I have prepared this estimate in accordance with the Project Cost Estimating Manual based on the project information contained in the project scope statement, plans, documents and program of work included in this submission. I further certify that this is a P__ risk adjusted estimate

Estimator:
Signature
Name: Date
/ /

Peer Review

I certify that I have conducted a peer review for this estimate in accordance with section 8.1 of the Project Cost estimating Manual. Points of difference have been resolved and adjustments incorporated in the cost estimate as appropriate.

Peer Reviewer:
Signature
Name Date
/ /

Estimate Recommendation

I am satisfied that this P__ estimate has been prepared in accordance with the Project Cost Estimating Manual and meets the requirements of approved project proposal, business case or project plan, as relevant. I recommend that this estimate be approved.

Project Manager:
Signature:
Name: Date
/ /

Independent Project Review

I have reviewed the project in accordance with section 8.1 of the Project Cost estimating Manual and I am satisfied that the scope has been sufficiently defined and the estimate is reasonable for this stage of the project.

Independent Reviewer:
Signature
Name: Date
/ /

Estimate Approval

I am personally satisfied with the accuracy of the project cost estimate, that this estimate does meet the requirements of the project proposal, business case or project plan, as relevant and that it has a __ % probability of non exceedance.
I approve the estimate based on the following assumptions:

- *A construction period from …… to ……*
- *An inflation rate of ____%pa*

District Director

Signature Date
Name:
/ /

Page 2 of 2 *(Printed2/11/2007)*

Figures 9.5 and 9.6 illustrate parts of the WMS system.

Figure 9.5 Welcome screen for WMS Estimating

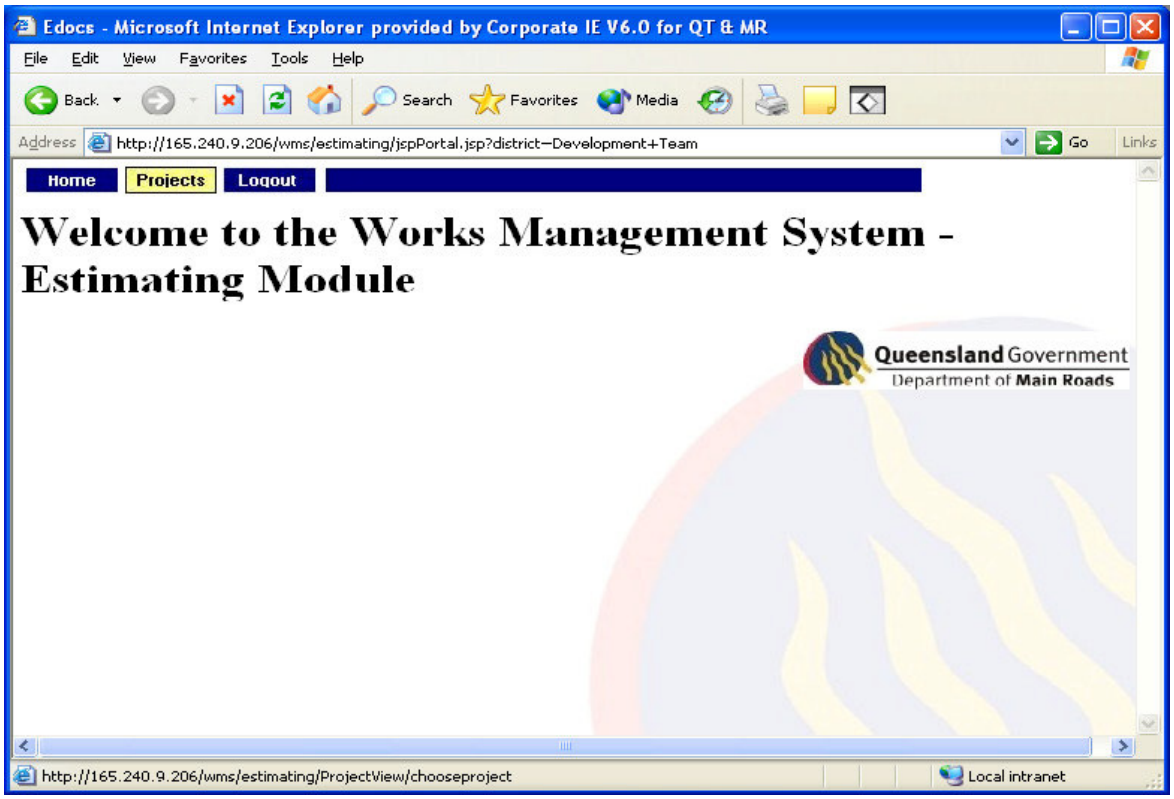
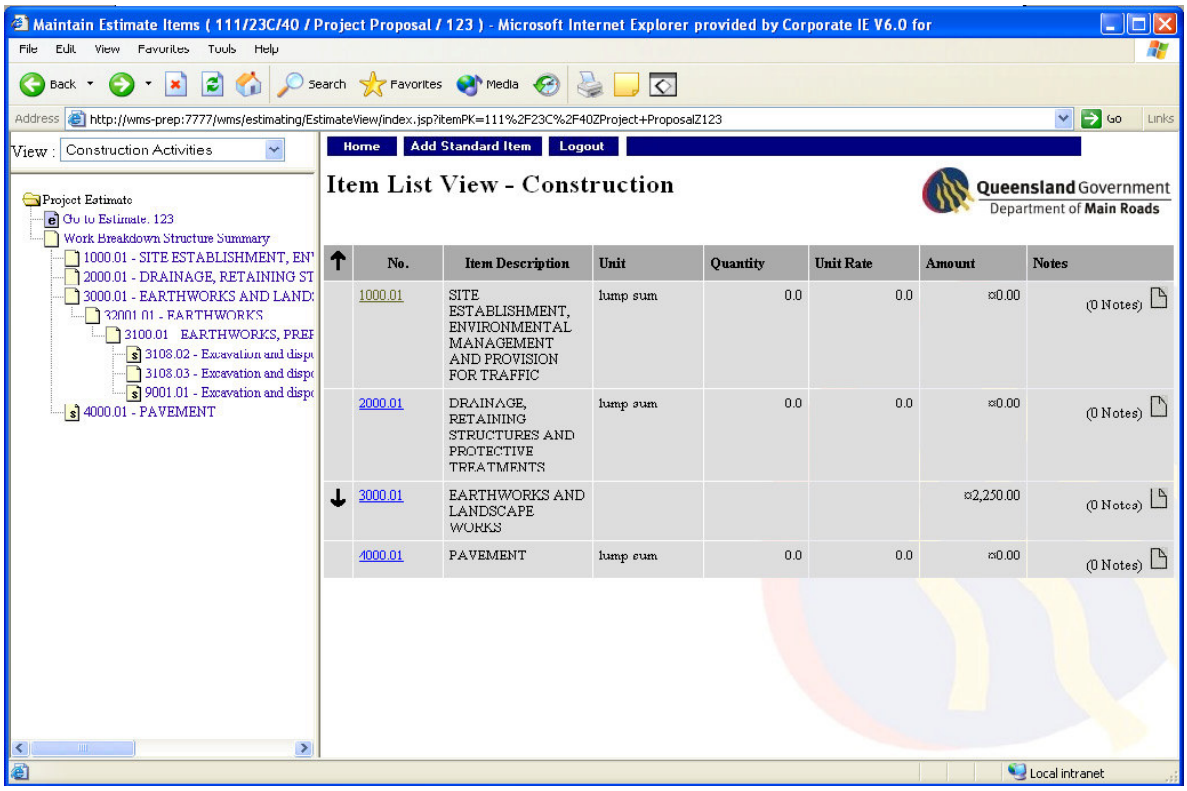


Figure 9.6 Typical layout of estimate development in WMS: Estimating



9.5 Reality Check

The inclusion of a reality check (benchmark) on the estimate as a means of assessing the reasonableness of an estimate is not new to MR. In the past, bitumen estimates have included a summary price per square metre, and bridge estimates a price per square metre of deck area.

The process is only likely to pick up gross errors but, over time, should help to develop a better sense of costs within the department.

9.6 Supporting Information

It is important that cost estimates are supported by information that is transferable throughout the project lifecycle. The introduction of stage estimates means that periodic reviews of the project cost will become routine. These review points will need access to past decisions and, in the case of estimates, documentation that describes the project scope and risk status at any particular time.

Supporting information should include but not be limited to:

- a detailed scope statement accompanied by current plans
- a current risk schedule
- a current program showing staging and significant activities
- assumptions
- options analysis
- constraints
- significant issues, and
- current approval status.

9.7 Communication of Project Cost Estimate

There is an obligation to ensure that stakeholders, both within MR and external to the organisation, are provided with appropriate information on projects, including cost. Communication plays an important part in any project and needs to be planned to ensure that the correct information reaches the target audience in a form that is easily understood. The fact that not all information will be communicated to everyone raises the issue of classification of information.

Cost estimates that have not been approved are considered to form part of the deliberative process of project development and, consequently, have no status as a project cost estimate. Estimates in this category are restricted to internal communications only as part of the project management processes.

Public information on project costs is published each year in the RIP. These budget figures are based on estimates that have been approved as part of a business case or subsequent updates and are expressed in out-turn dollars ($OT).

Note: Supporting information should be provided whenever project cost information is communicated to ensure the basis of the estimate is clearly understood.

10 ROLES AND ACCOUNTABILITIES

10.1 Overview

MR's General Managers – Major Projects Office General Manager, State-wide Planning General Manager, Program Development & Delivery General Manager and Corridor Management & Operations General Manager and 14 districts are the main drivers of the development, implementation and delivery of an estimating practice, process and culture that will deliver accurate estimates to the wider MR community.

Decentralised service delivery allows responsiveness and delivery of roads infrastructure for local needs within a broader strategic framework.

The accountabilities for project delivery reflect this approach. Districts are accountable for project development, construction and maintenance of all declared roads within their geographical area, and the Program Development & Delivery group are accountable for project approval on behalf of the program manager.

Because project cost management is a subset of project management, the responsibilities and accountabilities outlined in this section refer equally to both. Their purpose is to ensure that those involved in the delivery of projects understand their respective roles and the performance standards they have to achieve.

10.2 Accountability

The District Director is accountable for the accuracy of the estimate at any stage in the project lifecycle.

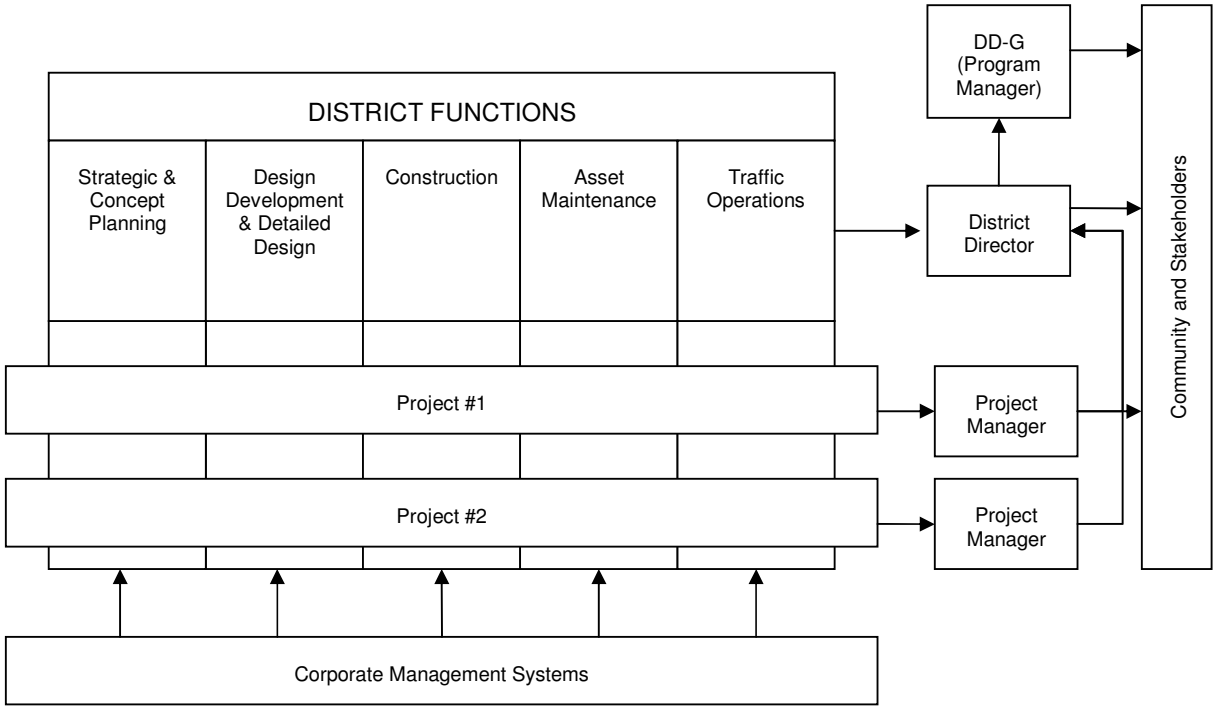
MR districts are organised along strong functional lines closely aligned to the project delivery process. They are made up of units that specialise in the sequential functions of strategic and concept planning, project development and design, construction, asset maintenance and traffic operations.

Integration of functions is provided by the district management team, which ensures that the objectives of the roads program are met across the wide spectrum of programs and projects.

In the case of individual projects, the project manager's role accepts accountability for project performance. This is not to say that the one individual has to be available for a project from start to finish, but rather that the project manager role is always filled. Management continuity and consistency is the key. An organisation operating under a single project management system that incorporates an effective record system that traces project history should be able to achieve this.

The organisational model depicted in Figure 10.1 illustrates how the functional and project management roles interrelate.

Figure 10.1 Organisational Model



11 PROJECT MANAGEMENT

11.1 General

This section has been included to provide a link between project cost estimating and the OnQ generic project management methodology adopted by MR. It is important to remember that estimating is not an activity carried out in isolation, but rather is an integral part of the project cost management process within project management.

OnQ uses the following proforma templates:

- R1001 – A stand-alone Project Proposal template. Used for all projects.
- R1002 – A stand-alone Options Analysis template. Used for Type 1 Projects – significant projects that are complex, high risk or expensive and thus require higher amounts of rigour and control.
- R1003 – A stand-alone Business Case template. Used for Planning Projects, High Risk or Complex Projects.
- R1004 – Use for Type 2 projects – relatively straightforward, low-risk projects for which a lesser amount of rigour and control is appropriate.
- R1005 – Use for Type 3 Projects – small simple projects of low cost that progress quickly through the concept phase.

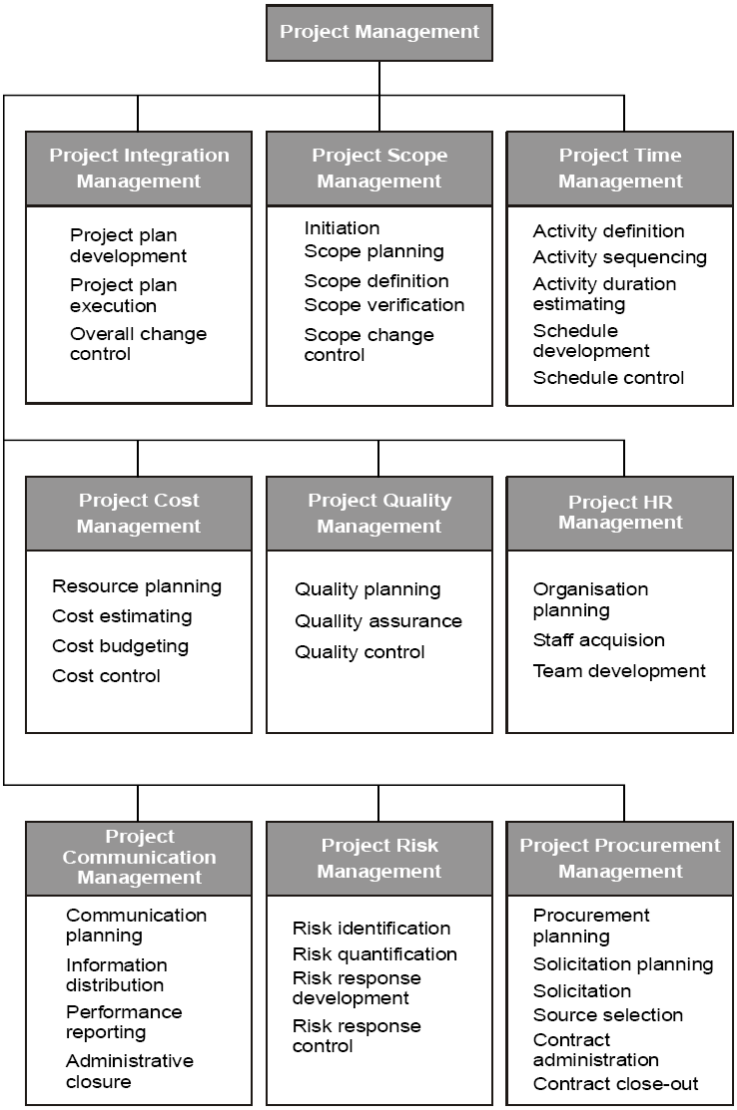
Use the intent of the Finalisation Phase to progressively close out activities if/when they are completed, for example, Performance Reports for Consultant Services.

- R4001 – Handover Report
- R4002 – Completion Report
- R4003 – Simplified Handover and Completion Report

Figure 11.1 shows how project cost estimating fits within project cost management and how it is integrated into wider project management processes.

Please refer to the Main Roads OnQ Framework for Project Management in regards to policy, principles, methodology, roles and responsibilities, approval processes, tools and techniques.

Figure 11.1 Overview of Project Management Elements (Knowledge Areas)



11.2 Project Phases

The OnQ methodology consists of four phases

- Concept
- Development
- Implementation
- Finalisation

Each phase is marked by the completion of one or more deliverables that require approval before proceeding to the next phase. The deliverables, and hence the phases, are part of a generally sequential logic designed to progressively refine the project definition from the broad concept to the final design before commencing construction.

11.3 Work Breakdown Structure

11.3.1 Overview

A work breakdown structure (WBS) is a product-oriented family tree of phases, activities and tasks which organises, defines and graphically displays the total work to be accomplished in order to achieve the final objectives of a project. Each descending level represents an increasingly detailed definition of the project. The number of levels in the WBS depends on:

- Level of detail
- Level of risk
- Level of control
- Estimate accuracy
- Work package value
- Work package man-hours

The WBS is subdivides a project into manageable work packages, components or elements to provide a common framework for scope, schedule, costs, allocation of responsibility, communications, risk assessment monitoring and control (see figure 9.1). The WBS can assist project managers in a number of ways:

- **A thought process tool.** The WBS assists the project manager and the project team visualise exactly how the work of the project can be defined and managed effectively.
- **An architectural design tool**. The WBS is actually a picture of the work which is to be completed in the project and how each of the items is related to each other. It must make sense.
- **A planning tool**. In the concept and development phases where planning is done, the WBS gives the project team a detailed representation of the project as a collection of activities that must be completed in order for the project to be completed. It is at the lowest activity level of the WBS that we will estimate effort, time, resource requirements.
- **A project status reporting tool.** The WBS is used as a structure for reporting project status. The project activities are consolidated (or rolled up) from the bottom as the lower-level work is completed.

11.3.2 The purpose of the WBS

The purpose of the WBS includes:

- Turning projects into manageable size pieces
- Starting the development of the schedule
- Starting the costing and budgeting process
- Starting the risk identification process (bottom-up approach)
- Providing the basis of control
- Identifying and coordinating objectives
- Providing a framework for identifying project skill sets
- Defining responsibility within the project, thereby determining human resources and consequently defining the project's organisation structure

11.3.3 WBS Application guidelines

Guidelines for the application of WBS include:

- De-constructing the project to a pre-agreed level of detail - "Big bits to little bits"
- No precedence
- No activity should have a single lower level activity

- Every activity must describe work (not a function)
- Every activity must have a deliverable
- Every activity must be capable of being assigned to someone (responsibility)
- The scope is the starting point
- Have you reached task level?
- Have you reached control and reporting level?
- Noun (Product Breakdown Structure), Verb (WBS), Organisational or Combination approach?

11.4 Project Cost Management

11.4.1 General

Project cost management is concerned with the planning and control of project costs from concept to finalisation. The processes include:

- **Resource Planning** – determining what resources (people, equipment and materials) and what quantities of each should be used to perform project activities.
- **Cost Estimating** – developing an estimate of the cost of resources needed to complete project activities.
- **Cost Budgeting** – allocating the overall cost estimate to individual work activities and timeframe.
- **Cost Control** – monitoring costs and controlling changes to the project budget.

These cost management processes are illustrated in Figure 11.3.

Figure 11.3 Project Cost Management Processes

11.4.2 Cost Planning

Cost planning is concerned with the development of the project budget through the processes of resource planning, cost estimating and cost budgeting. The cost estimate forms part of the stage deliverables "business case" (concept phase) and "project plan" (development stage).

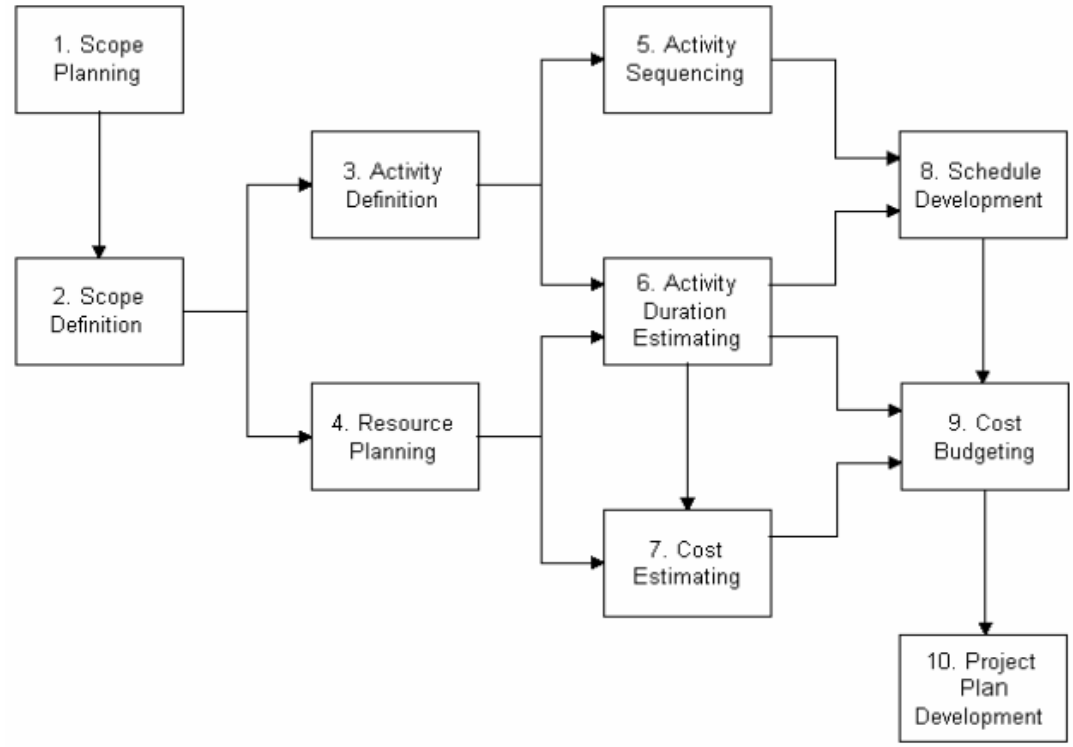
In practice, project cost management is an iterative process. Normally the process will occur at least once in each of the concept and development phases of the project, and should include high level peer review to ensure that the scope definition is as complete as possible and includes all stakeholder requirements.

Some of these processes have clear dependencies that will require them to be performed in essentially the same order on the majority of projects. The interdependencies among the core elements of project planning, namely scope, cost and time, are illustrated in Figure 11.4.

It is common to perform several iterations of these processes before completion of the project plan. For example, the project cost may exceed funds available, requiring consideration to be given to varying the scope of the project without loss of functionality or, alternatively, adopting a staged implementation over a longer timeframe.

While cost planning primarily focuses on the cost of the project, project decisions should also take into consideration whole-of-life costs and user cost.

Figure 11.4 Core Planning Processes Showing Interdependencies



11.4.3 Cost Control

Project performance, generally, must be measured regularly to identify variances from the project plan. These variances are fed into a change control process for management purposes, with work elements and impacts assessed for the project as a whole. Variances that threaten the objectives of the project will trigger an adjustment to the plan by repeating the appropriate planning process (Refer Figure 11.4). This may result in an adjustment to the plan in areas other than the area where the major variance occurred.

Cost control is concerned with influencing the factors which create changes to the cost baseline, identifying when changes have occurred, taking corrective action to correct cost overruns or prevent their recurrence, and informing appropriate stakeholders of authorised changes. For example, cost overruns may be occurring through scope creep. This may prompt action to review the process of scope control, as well as reviewing the design strategy for achieving the project objectives. If the variances are large enough, they might prompt a review of the business case and re-justification of the project.

12 PROJECTS AND THE RIP

12.1 Overview

It is important for the project team and the estimator to have a clear understanding of the framework within which the project will be developed. The RIP is the Main Roads Implementation Program published annually on a rolling five-year basis.

12.2 RIP

Each year, MR prepares the RIP in consultation with local government, industry and other stakeholders. It is a public statement of the planning, construction and maintenance activities which the state government intends to progress over the next five years. It contains firm (committed) funding for the first two years and planned (indicative) funding for potential projects in the subsequent three years. The program is published annually to reflect variations over the previous 12 months and any changes in priorities or circumstances.

To provide confidence for the program management process, projects must meet certain criteria before they become eligible for inclusion on the RIP. These are:

a) Planning Projects. The project budget must be based on an approved project proposal and include the cost of completing the Concept Phase (that is conducting the options analysis and preparing the business case). Planning projects will be created for more complex projects where significant funds need to be committed to develop the business case.

b) Construction Projects. The project budget must be based on an approved business case and include the total cost of the project (that is, planning, construction, alteration to public utilities and land acquisition). The budget is presented in out-turn dollars based on the expected period for construction.

Fig 12.1 RIP Project Plan

Phase	PRE-PROJECT	CONCEPT			DEVELOPMENT		IMPLEMENTATION	FINALISATION
Process	Strategic Planning	Proposal	Options Analysis	Business Case	Preliminary Design	Detailed Design	Construction	Project handover
Preferred Timing	Prior to Year 5	Prior to entry on the RIP			Prior to Year 2	Year 1 to 2	Year 1	Post Construction
Federal DoTaRS	Auslink Project Proposal Report Scoping Phase			Auslink Project Proposal Report Development Phase		Auslink Project Proposal Report Delivery Phase		
Estimate Stage	Strategic	Planning Estimate Concept Phase work only	Comparative Cost of Options	Concept Estimate	Preliminary Detailed Estimate	Detailed Design Estimate	Accepted Tender Price	Cost at Completion
MR Estimate Phase & Required WBS Definition	Concept –WBS Level 1/2 Concept –WBS Level 2/3 Concept –WBS Level 2/3 Development –WBS Level 3 Implementation & Finalisation-WBS Level 3							

To get reliable cost estimates it is important for Main Roads to follow these processes at all times and apply the processes using experienced practitioners, particularly experienced estimating personal. This is especially important at the concept estimate stage (at the time of preparing the Business Case) when there is less reliable information than at a later stage of a project. Experience and benchmarking data brought to the project, at this stage can pay handsome dividends later in ensuring the production of a reliable cost estimate that is unlikely to be exceeded throughout the project's development and implementation, measured in constant dollars.

Budget estimates must be based on the rigorous process of cost planning outlined in Section 11.4.2.

An overview of the project lifecycle is illustrated in Table 12.1.

The project stages and timing at which estimates are required are detailed in Table 12.2.

This framework provides for estimates to be prepared at intervals during the concept and development phases of the project to assist planning and maintain control over the cost of the project.

Table 12.1 Overview of RIP Framework

PROJECT PHASES	PRE-PROJECT	CONCEPT			DEVELOPMENT		IMPLEMENTATION	FINALISATION
Process	Strategic Planning	Proposal	Options Analysis	Business Case	Preliminary Design	Detailed Design	Construction	Project Handover
Preferred Timing (Relative to RIP)	Prior to Year 5	Prior to Entry on the RIP#			Prior to Year 2	Years 1 to 2	Year 1	Post-construction
Input	Road Network Strategy; Road Network Investment Strategy	Statement of Needs	Approved Proposal	Preferred Option	Approved Business Case	Preliminary Design	Contract Letter of Acceptance	Practical Completion
Activities	Link Strategy	Project Initiation, Proposal Development	Options Analysis	Preliminary Project Plan, Final Scope Definition, Project Justification	Project Plan, Development of Design	Documentation of Scheme Prototype, Call Tenders, Award Contract	Construction of works, Commissioning	General Acceptance, Project Close-out, Review and Evaluation
Output	Statement of Needs	Approved Proposal	Preferred Option	Approved Business Case	Preliminary Design, Stage 1 Release	Scheme Documents, Stage 2 Release, Contract Letter of Acceptance	Practical Completion	Completed Product Consultant Report Contractors Performance Report Post-construction Report
Federal DoTaRS	Auslink Project Proposal Report Scoping Phase			Auslink Project Proposal Report Development Phase		Auslink Project Proposal Report Delivery Phase		

PROJECT PHASES	PRE-PROJECT	CONCEPT			DEVELOPMENT		IMPLEMENTATION	FINALISATION
Estimate Stage	Strategic	Proposal (concept phase work only)	Options	Concept*	Preliminary Design*	Detailed Design*		Cost at Completion

Federal DoTaRS approvals: Department of Transport and Road Systems

Auslink Project Proposal Report Scoping Phase:	Funding for strategic planning studies for road corridors and certain major works proposals.
Auslink Project Proposal Report Development Phase:	Funding for preconstruction activities necessary to develop the project to the stage of calling tenders for construction.
Auslink Project Proposal Report Delivery Phase:	Funding for the construction of the project. All major works must have Stage 3a approval before tenders are called.

* These are mandatory estimates that are to be approved by District Directors.

Prior to Year 2

12.3 Stages of Estimates

Table 12.2 Stages of Cost Estimates

Project stage	Estimate stage	When prepared	Estimate Description
Pre-project	Strategic	Prepared as part of a link study to assist in long-range strategic planning. Auslink Project Proposal Report Scoping Phase (if applicable e.g. large-scale strategic studies) secures funding for Concept Phase.	• Very low level of project definition • High probability of exceedence • Accuracy -50% to +200%
Concept phase	Proposal	Estimate if the cost of undertaking the planning functions required to produce the options analysis and business case Usually applies to large or complex projects where a significant cost will be incurred before the proposal is officially recognised as a project. Entered into the RIP as planning project (series 900)	• Project definition up to 10% • Accuracy -30% to +100%
	Options	Provides comparative costs only of options prepared as part of the options analysis. (N.B. No project cost is produced at this stage. The project cost can only be prepared as part of the Business Case for the preferred option. See Concept estimate.) Approval gives authorities for the development of the preferred of the preferred option.	• Project definition up to 15% • Accuracy -30% to +100%
	Business Case (Mandatory)	A total project cost estimate based on the preferred option included in the business case. Very important as it forms the basis of the economic justification of the project and the project budget Approval requirement before inclusion in the RIP Auslink Project Proposal Report Development Phase (old Stage 2a) – secures funding for Development Phase.	• Project definition up to 40% • Accuracy -15% to +20% • P90 estimate indicates 10% chance of being exceeded • Both P50 and P90 estimate figures to be reported at this stage to indicate the extent of the estimate range to program managers.
Development phase	Preliminary Design (mandatory)	A total project cost estimate based on the final design solution, but usually before commencement of design detailing and documentation. Approval requirement prior to inclusion in Year 2 of the RIP.	• Project definition 30% to 70% • Accuracy -10% to +15%
	Detailed Design	Prepared on completion of the detailed design when final plans,	• Project definition 50% to 100%

Project stage	Estimate stage	When prepared	Estimate Description
	(mandatory)	specifications and bill of quantities are available. Forms part of the scheme prototype documents needed for approval to call tender. Auslink Project Proposal Report Delivery Phase (old Stage 3a) – secures funding for Implementation and Finalization Phases.	• Accuracy -5% to +10%

Refer to Section 4 for information on estimating methods.

It is acknowledged that projects can vary substantially in terms of scale and, therefore may have varying requirements as to the number and staging of estimates.

The full range of estimates listed in Table 12.2 would be typical of a major project where significant development activities take place between stages. There may even be a need to review estimates at intervals within these stages, particularly if the development of the project is protracted.

Fewer estimates may be required for routine projects where options are limited. In these cases, the three estimates marked "mandatory" should be provided.

Table 12.3 Accountabilities for Preparation, Review, and Approval

Estimating Process	Responsibility	Accountability	Consultation	Information
Estimate preparation	Project estimator: - Estimate plan - Estimate preparation - Contingency assignment	Project manager: • Project scope statement • Project cost estimate • Program of work • Risk assessment • Management review • Recommending approval	Functional manager: • Planning and design • District Director: • Political issues • Program management • Maintaining systems • Maintaining historical information	Functional manager: • Design documentation • Design records
Independent peer review (refer to section 8)	Independent peer review officer: - Project objectives - Scope of work - Work breakdown structure - Program of work - Work methods - Reasonableness of rates - Contingency allocation - Reality check - Preparing peer review report	Peer reviewer: • Peer review process • Outcome of peer review • Local corrective action relating to project management systems	Functional manager: • Planning and design • Project manager • Project management General Manager: • Program management	Functional manager: • Design documentation • Design records Project manager: • Project management records
Independent concurrence review (refer to Section 8)	Independent project review officer: - Scope of work - Achievement of project objectives - Design documentation - Project management documentation - Project cost estimate - Program of work	Concurrence reviewer: • Project review process • Outcome of project review • Corrective action relating to state-wide project management	District Director: • Project management systems • Recommendations of project review	Functional manager: • Design documentation • Design records Project manager: • Project management records

Estimating Process	Responsibility	Accountability	Consultation	Information
	- Risk assessment and contingency assignment - Constructability - Quality standards - Reality check - Preparation of a balanced project review report	systems		
Approvals	District Director: - Project submissions in the appropriate format - Recommendations for approval	GM (PD&D): • Budget approval	Advisors: • District program Deputy Director-General: • RIP changes	DDG and GM's: • Recommendation and support information

13 QUALITY ASSURANCE

Estimating is an activity where errors are easy to make but difficult to detect. This is because of the detailed nature of the process and the multitude of assumptions and calculations that have to be made to arrive at the project cost.

This manual has been designed to achieve a reliable and consistent approach to project cost estimating at a process level.

Standardisation of estimating computer software throughout the organisation will mean that the management of the direct estimating tasks and the archiving of estimating information will also become more consistent and reliable.

Districts may need to modify their quality procedures to reflect the processes outlined in the manual.

14 MAIN ROADS CONTRACT TYPES

The following is a list of commonly used MR contract types:

- Road Construction Contract (RCC)
- Road Works Performance Contract (RPC)
- Design & Construct (D&C)
- Design, Construct & Maintain (DCM)
- Minor Works Contract (MWC)
- Road Maintenance Performance Contact (RMPC)
- Minor Works Performance Contracts (MWPS)
- Early Contractor Involvement (ECI)
- Alliance Contracts