Fiji Roads Authority

# Design Guide

# BRIDGE, WHARF, JETTY, CULVERT AND CROSSING STRUCTURES

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# REVISION SCHEDULE

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# A Introduction

## A1 Scope

This Design Guide outlines the design requirements for bridge, wharf, jetty and culverts and crossing structures that are managed by the Fiji Roads Authority (FRA). The document sets out the criteria for the design of new structures and evaluation of existing structures and any subsequent remedial repairs that are undertaken. The document covers structures formed using reinforced or prestressed concrete, structural steel, or timber.

This document provides the basis for the design of all FRA structures except as may be modified in the FRA project specific Design Brief, or accepted as departures - see section A.2 below.

**All references to the NZ Transport Agency (NZTA) Bridge Manual shall be taken as referring to the Third Edition unless specifically stated otherwise.**

Any approving authority noted in the NZTA Bridge Manual – Third Edition, or referred to in other documents, shall be the Fiji Roads Authority.

## A2 Departures from this Design Guide or other Standards

Any departures from the requirements of this Design Guide or any of the standards listed in this guide must be clearly detailed in the designer produced project Design Statement, under a heading labelled “Departures from Standards”.

Acceptance of any departure shall be entirely at the discretion of FRA. To assist the evaluation of the departure, designers must provide sufficient information and explanation to enable the effect, benefit to FRA, and adequacy of the departure to be evaluated by FRA. Proposed departures shall be notified by the designer early in the design process to avoid abortive work.

## A3 FRA Standard Professional Services Specifications

This Design Guide shall be read in conjunction with the following FRA Standard Professional Services Specifications;

1. Design and Project Documentation (D&PD)
2. Management, Surveillance and Quality Assurance (MSQA) of Physical Works Contracts
3. Contract Management

## A4 Disclaimer

*This Guide has been prepared by MWH New Zealand for the use of contractors and consultants to the Fiji Roads Authority (FRA) and sets minimum standards which should be adhered to by all contractors and consultants to the FRA. While MWH and the FRA have endeavoured to ensure material in this document is technically accurate and reflects legal requirements at the time of writing, it is the user’s responsibility to ensure that any works or services completed by the user comply with relevant standards and legislation. Reliance on this guide does not relieve the user from exercising their own skill and judgment. MWH and FRA do not accept liability for any loss, liability or other consequence arising from the use of this document.*

# B Bridges

## B1 Design Standard

The approach adopted for design is generally based on the New Zealand Transport Agency (NZTA) Bridge Manual – Third Edition (NZTA BM), incorporating the amendments as outlined under the appropriate headings noted below.

**All references to the NZTA Bridge Manual shall be taken as referring to the Third Edition including amendment 1, unless specifically stated otherwise**.

A copy of the NZTA Bridge Manual – Third Edition is available at www.nzta.govt.nz/resources/bridge-manual/bridge-manual.html.

## B2 Design Philosophy Statement

### B2.1 General

A Design Philosophy Statement shall be provided to FRA in accordance with the requirements outlined in the NZTA Bridge Manual, and as amended or clarified in the sections below.

### B2.2 Culverts

The term “Bridge” shall be read as covering both bridges and culverts.

### B2.3 Departures

As noted in section A2 above, the Design Philosophy Statement shall contain a section listing any departures from Standards or this Design Guide.

### B2.4 Environmental Impact Assessment (EIA)

Environmental screening and environment impact assessments (EIA) shall be fully documented in the Design Philosophy Statement under the following headings consistent with the various stages of the Environmental Management Act 2005.

Pre-Screening and Desktop Environmental Examination

Records of Meetings with the Department of Environment

EIA Screening Application preparation

EIA preparation

Environmental Management Plans (EMP) or Construction Environmental Management Plans (CEMP) as applicable

*Refer also:*

**Appendix 1** - Approach to environmental management of FRA projects; and

**Appendix 2** - Checklist for the Pre-Screening Environmental Assessment: Roads, Bridges, Jetties (New Works & Upgrades).

# B3 Design – General Requirements

## B3.1 General

The General Requirements for Design shall be completed in accordance with the NZTA Bridge Manual, and as amended or clarified below.

## B3.2 Design Philosophy

### B3.2.1 Design Working Life

Permanent structures shall have a 100 year design working life.

Temporary structures shall have a design working life of ≤5 years. Bailey bridges may also be designed as a temporary structure.

### B3.2.2 Bridge Categorisation

Appendix 3 shows Importance Level 3 routes and replaces Figures 2.1(a) to (c) of the NZTA Bridge Manual. Within the FRA routes are classified as Rural R1 and Urban Arterial as shown in Appendix 3. These shall be considered Importance Level 3 routes.

Importance Level 1 structures shall have the same categorisation as given in Table 2.1 of the NZTA Bridge Manual.

All other bridges shall be categorised as a Normal bridge with an Importance Level of 2.

New bridges and repairs to existing structures which are classified in the project specific design brief as a "Long Term Solution," shall be considered as permanent structures with appropriate annual probability of exceedance values obtained from Table 2.1, of the NZTA Bridge Manual.

## B3.3 Geometric and Side Protection Requirements

Bridge decks that exclude raised footpaths and kerbs are preferred.

Refer to Appendix 4 of this guide for information on bridge width and clearances.
Refer to Appendix 5 of this guide for information on side protection requirements.

## B3.4 Waterway Design

Designers shall include local knowledge of flood events to assist in establishing flood estimates for bridges and crossings.

## B3.5 Special Studies

All bridges shall meet the acceptable requirements of the documents and therefore special studies are generally not required unless specifically requested in the project Design Brief.

## B3.6 Producer Statement Design

All structural aspects of design shall be verified by a suitably qualified structural engineer experienced in the use of the design standards and the design of similar maritime structures. A producer statement PS1 - Design, shall be submitted to this effect by the Designer (Refer to Appendix 8 for Producer Statement Proforma). Verified structural designs shall be submitted to the FRA for review by a FRA approved Engineer.
Where required by the project specific design brief an independent design review shall be undertaken by a similarly qualified designer. If this design review is required, a producer statement PS2 – Design Review shall be submitted to FRA along with the PS1.

## B3.7 Safety in Design

The design shall adopt a recognised and documented Safety in Design (SID) approach to eliminate or minimize hazards for the construction, operation, maintenance and demolition of the structure.

# B4 Design Loading

## B4.1 General

The Design Loading requirements shall be completed in accordance with the NZTA Bridge Manual, and as amended below;

## B4.2 Traffic Loads – Gravity Effects

All new permanent bridges shall be designed for a traffic loading in accordance with HN-HO-72.

All temporary bridges not used by sugar cane vehicles, shall be designed for traffic loading in accordance with HN loading only.

All temporary bridges utilised by sugar cane vehicles, shall be designed for traffic loading in accordance with HN-HO-72.

All temporary bridges utilised by sugar trains, shall be designed for HN loading plus sugar train loads in accordance with clause B4 of this Design Guide.

Any bridge utilised by Fiji Sugar Corporation (FSC) trains shall be designed for a traffic loading in accordance with HN-HO-72, and for a separate load case involving the FSC trains using the imposed loading outlined below (Note diagram indicates axle loads, track gauge shall be taken as 610mm), and analysed as an HN load case for load combinations 1A, 1B, 2A, 2B, and 2C as a minimum.

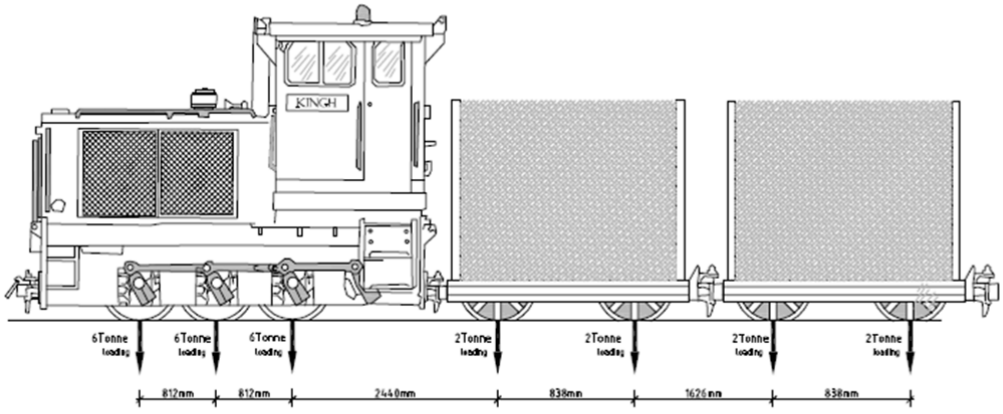



*Figure B-1FSC Train Load Diagram*

*Note – allow for multiple carriages as necessary to produce the worst effect on the member under consideration.*

## B4.3 Earthquake Actions

### B4.3.1 General

The Earthquake Resistance Design shall be completed generally in accordance with the NZTA Bridge Manual and the New Zealand Standard NZS1170.5, as amended below.

### B4.3.2 Seismic Hazard Factors and PGA

The Seismic Hazard Factor (z) shall be determined from GNS Consultancy report 2014/261 which has derived NZS1170.5 equivalent hazard factors for Fiji. Refer to Appendix 7 – Seismic Hazard Map for Fiji.
The minimum hazard factor to be used in Fiji shall be z=0.13.

Derivation of seismic peak ground acceleration for geotechnical design shall be undertaken by calculating the zero period acceleration as defined by NZS1170.5 and the Fiji specific hazard factors in Appendix 7, rather than the procedure given in section 6.2.2 of the NZTA Bridge Manual. An effective magnitude of 7.5 shall be used in conjunction with peak ground acceleration derived from this method.

### B4.3.3 Displacements

The requirements of Table 6.4 and clause 6.6.9 (b) of the NZTA BM shall be modified as below.
For bridges, the following absolute limits on displacement of the walls or earth retaining structures supporting abutment or piers shall not be exceeded:

- For importance level 3 structures (see B3.2.2) 200mm (per event) longitudinal and transverse displacement, and 100mm (per event) vertical displacement.
- For all other structures there are no limits on longitudinal, transverse, or vertical displacement.

In both cases, all other requirements of clause 6.6.9 (b) shall apply.

The displacements listed above are at the 84%ile probability under the design seismic event, and at 50%ile probability under the MCE event.

The soil approaches of importance level 3 structures shall be trafficable by emergency vehicles after temporary emergency repairs by a small excavator following a design level event.

## B4.4 Wind Actions

Wind loading shall be in accordance with AS/NZS 1170, using a regional wind speed $V_R$ = 70m/s, and a wind direction multiplier $M_d$ = 1.

## B4.5 Loads Other than Traffic

Bridges on sealed roads shall have an additional superimposed dead load of 1.5kN/$m^2$.

Bridges on unsealed roads shall have an additional superimposed dead load of 4kN/$m^2$.

The allowance for future services shall be 0.25kN/m2.

# B5 Analysis and Design Criteria

## B5.1 General

The Analysis and Design Criteria requirements shall be completed generally in accordance with the NZTA Bridge Manual – Third Edition, and as amended below.

## B5.2 Reinforced Concrete and Prestressed Concrete

Design shall be in accordance with NZS 3101: Part 1 2006, Concrete Structures Standard, NZS 3101: Part 2, 2006, Concrete Structures Standard - Commentary, incorporating the provisos stated in NZTA Bridge Manual, including draft amendment 3 October 2014, and as modified below.

### B5.2.1 Exposure classifications for Fiji

Exposure classifications for all carbon steel reinforced, prestressed and post-tensioned concrete members shall be determined as follows:

- Assess exposure classification in accordance with Clause 3.4 of NZS3101, including draft amendment 3 (October 2014)
- The definition of B2 and C zones shall be as shown in
- Figure B-2. This figure replaces Table 3.2(b) of NZS3101.

| B2 (Coastal Frontage) | C (Tidal/Splash/Spray) |
|---|---|
| Greater than 1km and up to 2km inland of the high tide mark | Offshore and up to 1km inland of the high tide mark |

*Figure B-2 Definition of B2 and C zones*

- Inland of the B2 zone shall be classified as B1.
- The minimum allowable exposure classification for Fiji is B1 for structures designed in accordance with this Design Guide.
- Note that the B2 zone can apply inland of the 2km coastal frontage zone where surfaces are in contact with water as described in Table 3.1 of NZS 3101.

### B5.2.2 Deemed-to-comply concrete to satisfy exposure classifications

This section contains deemed-to-comply concrete specifications for use by designers or contractors on FRA projects.

There are other aspects which affect durability of concrete structures such as naturally aggressive soils or groundwater attack. These should be determined for the design in accordance with accepted methods.

Where the exposure classification is determined as being B1, then the concrete shall:

- Have a minimum 28 day compressive strength determined in accordance with Table 3.7 of Draft Amendment 3 of NZ3101 for the B1 Exposure classification.
- Include a minimum total cementitious binder content of 370kg/m$^3$.
- Have a maximum water/binder ratio (by mass) of 0.45.
- Have an absolute minimum nominal cover of 55mm (60mm specified) for 25MPa concrete, and 50mm (55mm specified) for all other concrete (allowing for a tolerance of -5mm).
- Be continuously water cured for a minimum 3 days by retention of formwork that has been sealed against moisture loss, or direct water application such as ponding, continuous sprinkling or continuous application of a mist spray. Where formwork is removed prior to completion of the curing period, curing by direct water application shall commence within half an hour of the formwork stripping. Curing beyond 3 days in accordance with Clause 7.8 of NZS3109.

Where the exposure classification is determined as being B2, then the concrete shall:

- Comply with the requirements of the B1 exposure in full except that cover shall be increased by 10mm.
- Include BASF Masterlife 2006 or other FRA approved organic corrosion inhibitor included in accordance with the supplier's recommendations.

Where the exposure classification is determined as C, then the concrete shall:

- Include 30% fly ash (AS3582.1 compliant) Class: F preferred, but class C is acceptable, Grade: Fine, manufactured by an approved supplier.
- The fly ash supplier shall demonstrate a successful track record of having supplied fly ash for marine concrete applications.
- Include a minimum total cementitious binder content of 370kg/m$^3$.
- Have a maximum water/binder ratio (by mass) of 0.45 and a minimum ratio of 0.35.
- Have a minimum 28 day compressive strength of 40MPa and a minimum 56 day compressive strength of 50MPa.

- Include BASF Masterlife 2006 or other FRA approved organic corrosion inhibitor included in accordance with the supplier's recommendations.
- Have a specified concrete cover of 65mm (-5mm/+10mm tolerance) i.e. an absolute minimum cover of 60mm. The absolute minimum stated cover requirement applies to the outer most reinforcement regardless of whether it is primary or secondary reinforcement.
- Be pre-tested for chloride ion diffusion coefficient in accordance with NT Build 443 on test cylinders that have been continually moist-cured for 56 days.
- Concrete shall be water cured. Curing compounds shall not be used.
- Be continuously water cured for a minimum of 14 days by retention of formwork that has been sealed against moisture loss, or direct water application such as ponding, continuous sprinkling or continuous application of a mist spray. Where formwork is removed prior to completion of the curing period, curing by direct water application shall commence within half an hour of the formwork stripping.

### B5.2.3 Alternative Concrete Mix Designs for Exposure Classification C

- Designers are permitted to propose alternative corrosion inhibiting technologies, reinforcing materials, concrete mix designs and/or concrete covers to those defined above.
- Alternatives shall achieve a minimum time to corrosion initiation of 100 years in the Fijian environment.
- Alternative proposals must recognise the characteristics of the Fijian environment and its effect on accelerated corrosion of ferrous reinforcing compared to more corrosion in more temperate climates.
- Designers are referred to Opus Research Report 14 – 524C97.00 Marine Concrete Durability Advice for the Fiji Roads Authority. Designers are required to take account of the particular effects of the Fijian environment in their design of all concrete mixes for use on FRA projects in Fiji. The Opus report is available on request.
- Have other concrete covers determined in accordance with Table 3.7 of Draft Amendment 3 of NZ3101. Note that cover tolerances are -5mm/+10mm tolerance so that should a 50mm cover be required by Table 3.7, a cover of 55mm shall be specified to achieve a minimum cover of 50mm. The absolute minimum stated cover requirement applies to the outer most reinforcement regardless of whether it is primary or secondary reinforcement.
- If fly ash is used, sources of fly ash must be tested for compliance with AS3582.1 but additionally shall be tested for periclase (crystalline magnesia) and autoclave expansion.
- If fly ash is used, proposed sources of fly ash shall have a documented record of use in concrete in a marine environment.
- The proposed alternative mix designs shall be submitted with the Contractor's tender for review, including the following details:
    - Type, brand and proportions of all cementitious binder components
    - Aggregate and sand proportions
    - Admixture types and dosages
    - Free water to cementitious binder ratio
    - Target workability
    - Documented proof of prior use and acceptance of proposed SCM's in a marine environment
    - Testing for chloride ion diffusion as described in the following section.
- In addition to the concrete production quality control testing specified by NZS 3104 the Contractor shall carry out verification and benchmarking tests as follows. Prior to commencing the supply of concrete to the site, the Contractor shall complete two trial mixes and submit test data based on cylinders cast from each mix. To verify that each trial mix achieves the properties required, this data shall include the following measurements, made on standard continuously wet-cured cylinder specimens:
    - 28 and 56 day concrete compressive strength
    - Have a maximum chloride ion diffusion coefficient of less than $4.0 \times 10^{-12}$ $m^2/s$. when measured in accordance with NT Build 443 on test cylinders that have been continually moist-cured for 56 days
    - Electrical resistivity measured at 3, 7, 28 & 56 days using a 4 probe Wenner array (e.g. a Proceq 'Resipod' surface resistivity meter) in accordance with AASHTO TP95-1118 or an equivalent
- If the proposed mix has not been pre-tested and approved, sufficient time must be allowed for this testing in the pre-construction stage. Note that the critical durability parameter from the mix specification (the non-steady state diffusion coefficient) is not measured until the concrete is 56 days old and the testing takes approximately two months to complete.

- Proposed alternatives shall be submitted with tender and full details shall be submitted to the FRA for approval prior to use in any construction. Tenderers/contractors shall allow one month for assessment of any proposed alternative. Such alternatives shall be supported by full technical details including durability modelling and/or test results that demonstrate equivalent durability to the requirements for the deemed-to-comply mix for exposure classification C concrete above.
- Mix designs incorporating microsilica as the sole SCM are not acceptable (based on the findings of Opus Research).
- The responsibility for provision of full supporting information rests entirely with the tenderer/contractor. FRA will not carry out acceptability testing on mix designs proposed by the contractor.
- FRA does not warrant that any alternative proposal will be accepted and tenderers/contractors are to construct the particular project with the deemed-to-comply mixes should the alternative be rejected by FRA.

### B5.2.4 Alternative Concrete Mix Designs for Exposure Classifications B1 and B2

- Designers are permitted to propose alternative corrosion inhibiting technologies, reinforcing materials, concrete mix designs and/or concrete covers to those defined above.
- Alternatives shall achieve a minimum time to corrosion initiation of 100 years in the Fijian environment and have an equivalent time to initiation of corrosion similar to the deemed-to-comply mixes.
- Alternative proposals must recognise the characteristics of the Fijian environment and its effect on accelerated corrosion of ferrous reinforcing compared to corrosion in more temperate climates.

## B5.3 Structural Steel and Composite Construction

### B5.3.1 General

Design shall be in accordance with NZS 3404: Steel Structures Standard, incorporating the provisos stated in NZTA Bridge Manual, as modified below.

### B5.3.2 Design for Durability and Corrosion Protection

Corrosion protection of steelwork shall comply with AS/NZS 2312 Guide to the Protection of Structural Steel against Atmospheric Corrosion by the Use of Protective Coatings, for the appropriate exposure classification as defined below.

| C3 (Medium) | C4 (High) | C5 M (Very High, Marine) |
|---|---|---|
| Everywhere inland of the C4 classification | Up to 0.5km inland of the high tide mark | Structural steel shall not be used in a location classified as C5 M |

*Figure B-3 Exposure categories for structural steel*

The design life of structural steel corrosion protection system shall be “Extra-long term” as defined by AS/NZS 2312 – 25+ years.

For a deemed-to-comply specification for new structures, refer to “Resene – Engineered Coating Systems” specifications provided in Appendix 6 – comprising preamble and specification.

Also included in Appendix 6 is a deemed-to-comply specification for touch up and repair of existing steel structures.

## B5.4 Timber

### B5.4.1 Design Standards

Design shall generally be in accordance with the New Zealand Bridge Manual, 3rd Edition, except as modified below.

Structural timber in Fiji is graded in accordance with the National Grading Rules for Fiji Timbers using F-grades consistent with the Australian Timber Code. It is therefore recommended that structures using timber sourced from within Fiji should be designed using the Australian Timber Structures code: AS1720 – 2010 Timber Structures Part 1: Design Methods, and Part 2 Timber Properties.

### B5.4.2 Timber Selection and Stresses

The preference for new timber material is to use treated Fiji Pine which is a sustainable source of timber in Fiji. Where treated Fiji Pine is not suitable due to strength requirements, hardwood may be used.

All existing timber bridge decks utilising hardwood material shall be considered as Grade F11 and assessed using AS 1720.

Characteristic stresses for Fijian timbers shall be as Figure B-4.

| Species | Stress Grade | Characteristic Values for Design | Comment |
|---|---|---|---|
| Fiji Pine | F5 | from Table H2.1 of AS 1720.1 ($f'_b$ = 14 MPa) | All structural timber used for FRA purposes not in a marine environment shall be treated to H5. Timber used in a marine environment shall be treated to H6. |
| Hardwoods - Vesi, | F14 | from Table H2.1 of AS 1720.1 ($f'_b$ = 36 MPa) | Timbers are required to be 100% heartwood. Vesi is naturally durable to the equivalent of H5. Cannot be used in fully submerged marine environments, eg. as jetty piles. To assist with nailing Vesi is best used in a green condition. |
| Hardwood – Yasiyasi | F11 | from Table H2.1 of AS 1720.1, ($f'_b$ = 31 MPa) | Timbers are required to be 100% heartwood. Yasiyasi is naturally durable to the equivalent of H4. (in contact with ground non-structural purposes). |
| Hardwood - Sacau | F11 | From Table H2.1 of AS 1720.1 ($f'_b$ = 31MPa) | Timbers are required to be 100 % heartwood. Sacau is naturally durable to the equivalent of H5. |

*Figure B-4 Characteristic Stresses of Fijian timbers*

### B5.4.3 Inspection of Timber

To maintain standards in Fiji and to ensure consistency of supplied timber, it is a requirement of all FRA contracts that the Ministry of Fisheries and Forests Timber Utilisation Division carry out inspections of projects utilising timber. These inspections are to be undertaken to confirm the supplied timber is of the required species and that any timber defects do not exceed allowable limits.

Designers shall specify the required frequency of such testing which shall be appropriate to the scale and importance of the works.

## B5.5 Abutment Type, Bearings and Deck Joints

Due to the high maintenance associated with bearing and deck joints, preference shall be given to the design of integral or semi-integral bridges in accordance with the NZTA Bridge Manual – Third Edition.

# B6 Evaluation of Bridges and Culverts

## B6.1 General

The Evaluation of Bridges and Culverts shall be completed in accordance with the requirements outlined in the NZTA Bridge Manual, and as amended below.

## B6.2 Deck Capacity and Evaluation

Results of any posting evaluation shall be presented as a maximum allowable axle load and gross vehicle weight.

### B6.3 Sugar Cane Trains

Where bridges and culverts carry sugar cane trains an assessment shall be carried out based on the FSC load (defined in Section B4.2). The result shall be reported as a percentage of the full FSC train and axle loads using the methods defined in the NZTA Bridge Manual.

If the result is less than 100% then sugar cane trains shall not be permitted to travel over the structure.

## B7 Structural Strengthening

### B7.1 General

Structural Strengthening design shall be completed in accordance with the NZTA Bridge Manual.

## B8 Emergency and Short-term Structural Measures

### B8.1 General

The NZTA Bridge Manual covers temporary bridges ie. those with a design working life of less than or equal to five years. Emergency and short term structural works covered by this section are expected to have a maximum life of two years. They may be designed to a lesser standard than listed elsewhere in this Design Guide. Such repair or emergency works once implemented may require increased monitoring to ensure continued effectiveness.

### B8.2 Design Statement

A design statement is not required.

However the drawings or sketches produced for the works shall note:

- The design life of the works (eg. two years maximum).
- The design load (as below).
- Any increased monitoring requirements (eg. inspect after all flood flows).

### B8.3 Load Cases

Existing bridges requiring urgent remedial repairs, and not used by sugar cane vehicles, shall be designed for traffic loading in accordance with HN loading only.

Existing bridges requiring urgent remedial repairs, and utilised by sugar cane vehicles, shall be designed for traffic loading in accordance with HN-HO-72.

Existing bridges requiring urgent remedial repairs and utilized by sugar trains, shall be designed for HN loading plus sugar train loads in accordance with clause B4 of this Design Guide.

Existing bridges requiring urgent remedial repairs are not required to be designed for seismic loads, but should incorporate sensibly robust detailing such that their current seismic capacity is not diminished.

Existing bridges requiring urgent remedial repairs are not required to be designed for flood flows but waterways shall not be diminished by more than 10%.

### B8.4 Short Span Steel Bridges

The recommended approach to short span (<12m) steel bridges where the timber decking and/or the steel beams have corroded, is to.

1. Remove entire deck and steel beams.
2. Replace with new painted steel beams and new timber deck on the existing abutments.

It is recognised that such an approach may, depending on the state of the abutments, provide a life in excess of two years.

# C Wharves and Jetties

## C1 Applicable Standards and References

The approach adopted for the design of FRA jetties in Fiji shall be based on the current version of.

1. The New Zealand Transport Agency (NZTA) Bridge Manual – Third Edition, 2013.
2. The Australian Standard AS4997-2005, Guidelines for the design of maritime structures.
3. The New Zealand Standard NZS 3101, Concrete Structures, 2006.
4. The New Zealand Standard NZS 3109, Concrete Construction, 1997.
5. AS/NZS 1170, Parts 1 to 5.
6. BS 6349 (all parts, various dates) Maritime Structures, (in particular Part 8: Code of practice for the design of Ro-Ro ramps, linkspans and walkways.
7. FRA - Jetty Waiting Sheds - Wastewater Treatment and Disposal Design Guide, MWH, January 2015.
8. The amendments to the above standards as outlined under the appropriate headings noted below.

The following are references to be used in the design of Jetties in accordance with this Design Guide. This list is not exhaustive or complete and designers may adopt different references as they see fit.

1. PIANC Design of Fender Systems 2002.
2. Trelleborg Fender Design (Section 12) http://pdf.nauticexpo.com/pdf/trelleborg-marine-systems/fender-design/22887-43713.html
3. “Waves in the Koro Basin, Fiji” by Mulgor Consulting Ltd, dated July 2014.
4. Fiji Nautical Manual.
5. Pile Design and Construction Practice M Tomlinson & J Woodward (Section 8 Piling for marine structures).
6. AS 2159:2009 Piling – Design and installation.
7. “Port of Los Angeles-Code for Seismic Design, Repair and Upgrade of Container Wharves, Part 1: Seismic Design of New Wharves”.
8. “Port of Long Beach Wharf Design Criteria”, Version 2.

## C2 Design Philosophy Statement

### C2.1 General

A Design Philosophy Statement shall be provided for all wharves and jetties. The Design Philosophy Statement shall be generally in accordance with the requirements outlined in the NZTA Bridge Manual – Third Edition, and as amended below.

### C2.2 Design Philosophy Statement Content

All significant factors that affect the design shall be discussed. These shall include, but not be limited to:

**Introduction**

Reasons for the construction of the structure
General description of the site including subsurface conditions
General description of the structure
Review of Previous Reports and Existing Information
Pile type
Causeway works
Waiting shed works
Wastewater systems and other services.

**Detailed Description of Proposed Jetty Site**

Topography
Bathymetry
Geology and Geotechnical considerations
Wind and Wave Climate
Accessibility from land and water
Constraints (if any).

**Consultation**

Record of consultations undertaken.

**Environmental Screening and Environmental Impact Assessment (EIA)**

Pre-Screening and Desktop Environmental Examination
Records of Meetings with the Department of Environment
EIA Screening Application preparation
EIA preparation
Environmental Management Plans (EMP) or Construction Environmental Management Plans (CEMP) as applicable
*Refer also:*

**Appendix 1** - Approach to environmental management of FRA projects; and
**Appendix 2** - Checklist for the Pre-Screening Environmental Assessment: Roads, Bridges, Jetties (New Works and Upgrades).

**Jetty Design Considerations**

Jetty Usage
Design Vessels, Water Depth and Berth Length,
Access considerations for small boats
Design life of components Roll on - Roll off (Ro-Ro) (if any)
RoRo ramp geometrics
Design Loadings – vertical, fenders, seismic, storm
Assumptions on global warming and sea level rise
Services (if any)
Vessel displacement tonnage, and berthing velocity
Description of the structural form of the structure, vertical and lateral load (seismic and ship) resisting mechanisms
Methods of analysis
Assumptions on structural stiffness
Materials and finishes
Durability
Fender selection and force transmitted to structure via the fender
Dolphins and mooring buoys
Bollards.

**Alternative Location and Layout Options**

Options
Comparison of Alternative Layouts.

**Construction**

Impact on Existing Users
Foundation Options
Construction Methods and Materials
Concrete supply source
Proposed curing regime
Issues
Procurement
Maintenance regime.

**Developed Design of Preferred Option**

**Construction Cost Estimates**

# C3 Site Investigations and Planning

The Site Investigation and Planning shall be completed in accordance with the Australian Standard AS4997, Guidelines for the design of maritime structures, and as amended below.

# C4 Dimensional Criteria

The Dimensional Criteria shall be determined in accordance with the Australian Standard AS4997, Guidelines for the design of maritime structures, and as amended below.

# C5 Design Requirements

## C5.1 General

The Design Requirements shall be completed in accordance with the Australian Standard AS4997, Guidelines for the design of maritime structures, and as amended below.

The structure and its components shall be designed for stability, strength, serviceability and durability in accordance with the appropriate Standards and the information provided in this guide.

## C5.2 Design Working Life

All jetty structures shall be classified as Facility Category 4, Special Structures (refer to Table 6.1 of AS4997) with a design life of 100 years, unless noted otherwise in the project specific Design Brief. The designer shall determine and document an appropriate maintenance regime consistent with the adopted design and materials. Components that are inaccessible should have a 100 year design life with no maintenance.

## C5.3 Producer Statement Design

All structural aspects of design shall be verified by a suitably qualified structural engineer experienced in the use of the design standards and the design of similar maritime structures. A producer statement PS1 - Design, shall be submitted to this effect by the Designer (Refer to Appendix 8 for Producer Statement Proforma). Verified structural designs shall be submitted to the FRA for review by a FRA approved Engineer.

Where required by the project specific design brief an independent design review shall be undertaken by a similarly qualified designer. If this design review is required, a producer statement PS2 – Design Review shall be submitted to FRA along with the PS1.

## C5.4 Safety in Design

The design shall adopt a recognised and documented Safety in Design (SID) approach to eliminate or minimize hazards for construction, operation, maintenance, and demolition of the facility.

## C5.5 Concrete and Reinforcing

In AS4997 delete reference to AS3600 Concrete Structures, and replace with NZS 3101 Concrete Structures Standard as modified by C7.

Section B5 of this guide and the requirements for exposure classification C shall apply to all jetty concrete.

Due to the unpredictable structural performance of prestressing steel in marine environments the recommendation in Clause 6.3.5.2 of AS 4997 should be followed. If prestressed steel is to be used this requires non- prestressed reinforcement to provide at least 40% of the total reinforcement capacity. This non-prestressed steel should be located in the most exposed section of the element to provide an early indication of chloride-induced corrosion.

## C5.6 Timber

Refer to B5.4 which shall apply in full to FRA jetty design work.

## C5.7 Sea Level Rise

The allowance for sea level rise shall be allowed for in accordance with recommendations in AS4997, Guidelines for the design of maritime structures, or (IPCC) recommendations.

# C6 Design Actions

## C6.1 General

The Design Actions shall be determined in accordance with the Australian Standard AS4997, Guidelines for the design of maritime structures, and as amended below.

## C6.2 Imposed Actions

The jetty structures shall be designed in accordance with the loading requirements from Table 5.1 of Australian Standard AS4997, Guidelines for the design of maritime structures, for the appropriate Deck Load Classification.

Small jetty structures (ie. jetties utilised solely by vessels less than 6.0m in length) shall be classified as a Class 5 Deck load in accordance with AS 4997.

Medium jetty structures (ie. jetties used for handling general cargo and also utilised by an interisland ferry) shall be classified as a Class 25 Deck Load in accordance with AS 4997.

Large jetty structures (ie. jetties for cargo or container wharf) shall be classified as a Class 40 Deck Load in accordance with AS 4997.

## C6.3 Wind Loads

Wind loading shall be in accordance with AS/NZS 1170.2, using a regional wind speed $V_R$ = 70m/s, and a wind direction multiplier $M_d$ = 1.

Wind action on vessels may be designed using a wind pressure based on a 30 s gust rather than basic wind speeds due to 3 s gusts. The 30 s wind speed may be taken as 0.87 times the relevant basic wind speed.

## C6.4 Wave Actions

Designers are directed to “Waves in the Koro Basin, Fiji” by Mulgor Consulting Ltd, dated July 2014.
This wave data is limited to 23 years of records and has been used to determine 100-year design waves.

Designers shall use the 100-year design wave determined from the Mulgor Report for the design of FRA jetties. This shall apply even when Table 5.4 of AS4997 indicates that a more onerous annual probability of exceedance (eg. 1/1000) should be used.

Breaking wave height needs to be considered when determining design wave heights. BS 6349-1:2000 advises:

> *Various empirical attempts have been made to determine a maximum breaker height in a given depth of water but the large scatter in the data makes the resulting relationships unreliable. In those situations where the inshore structure is subject to breaking waves, the following wave parameters, which give an upper limit to the wave height, can be used, but only as a general indicator of possible wave conditions.*

a) *Where the prediction for the design significant wave height in the depth of water at the structure exceeds that water depth and J, the ratio of the offshore wave gradient to the square of the beach slope, tan αs, is less than or equal to 5, then assume a significant wave height equal to that water depth.*

b) *For more gentle slopes in front of the structure where the waves can be expected to spill, i.e. J greater than 5, and the design significant height exceeds 0.8 times the still water depth, then assume a significant wave height equal to 0.8[1] times that depth.*

## C6.5 Earthquake Actions

Earthquake actions shall be assessed in accordance with AS/NZS 1170.5 and the requirements of 0 of this Design Guide for Bridges. (Note - AS 4997 refers to 1170.4, the Australian section).

[1] Note others eg. Mulgor use 0.75

# C7 Durability

## C7.1 General

The Durability requirements shall be determined in accordance with the requirements outlined in the Australian Standard AS4997, Guidelines for the design of maritime structures, and as amended below.

Information on how the maritime structure is going to achieve the durability criteria of 100 years to first maintenance shall be provided in the Design Statement. Designers shall note that many Fijian jetties have performed poorly and significant improvement in durability performance is a key requirement of this Design Guide.

## C7.2 Concrete

Reinforced concrete and prestressed concrete elements for all maritime structures shall have the concrete and reinforcing items designed for durability in accordance with NZS3101, and as modified below.

Durability requirements shall generally follow the principles in clause B5 of this Design Guide for Exposure Classification C.

Cathodic protection of carbon steel reinforcement is considered to be an inappropriate mechanism for providing an extended design life of most FRA jetties.

## C7.3 Steel

Steel shall generally not be used as part of a suspended deck structure for jetties or wharves.

Permissible uses for steel are as sheet piles, or driven piles (pile tubes or H piles).

Durability of steel elements of the structure shall be ensured by concrete encasement, sacrificial thickness and/or corrosion protective coatings.

## C7.4 Timber

All timber used in jetties or wharves shall be treated to H6.

# C8 Fenders

## C8.1 General

Design of fenders shall adopt pragmatic solutions that balance cost with robustness and effectiveness, recognising that most fendering to date on FRA jetties has been chain suspended tyres, and most have been destroyed in operation.

Many FRA jetties are in exposed locations with limited mooring dolphins or buoys and control of berthing vessels is often difficult.

Fender selection shall be such that any replacement of damaged fenders can be undertaken by unskilled staff.

The logic for fender selection shall be clearly detailed in the Design Statement and any limitations on the fender size selected shall be described and presented for approval by the FRA.

## C8.2 Basis of Design

Fenders are to comply with the specification in Appendix E of the PIANC Guidelines for the Design of Fender Systems 2002 as modified by the following.

## C8.3 Durability

This is regarded as the main design issue for the fenders due to the remote nature of some of the jetties and the lack of local resources for maintenance.

## C8.4 Materials

### C8.4.1 Fender

Rubber used for fender bodies are to be resistant to ozone aging. Acceptable materials are saturated rubbers resistant to ozone attack such as Chloroprene or HNBR or un-saturated rubbers such as EPM or Butyl.

Certification is required to demonstrate rated performance data for the chosen fender to a recognised international Standard.

### C8.4.2 Suspension System

Suspension and restraint systems composed of mild steel bar, chain and chain accessories are to be galvanised for corrosion protection. Galvanising minimum thickness to be 85 microns for the main elements and 40 microns at threads. Any system using galvanised components is to be galvanised throughout including anchors unless isolation is used.

Fixing plates are to be designed with a minimum FoS of 2 over the weakest link in the system

### C8.4.3 Retaining device

All Fenders which use a chain suspension system or similar are to have a separate retaining device, either a chain finished to the same protection as the main chain or a stainless steel cable with anchorage remote from the fender site.

### C8.4.4 Anchors

Anchors are to be sized to provide additional reserve strength over the chain system. Galvanised suspension systems are to be used with galvanised anchors.

Directly fixed fenders are to use Gr316 or superior stainless steel.

## C8.5 Accidental damage

Anchorage, suspension systems and facing plates are to be designed to minimise damage due to accidental impact or snagging by belting or other protuberances.

Fender spacing to be chosen to suit the size of ships using the jetty but also to minimise the chance of snagging or end collision. For berths that are used exclusively for side loading vessels a practical maximum spacing of 6m is to be adopted.

Fenders with face plates and an UHMW PE facing are to be used for the RoRo berths and fenders providing low resistance to vertical mooring movements such as cylindrical fenders are to be adopted for side loading conditions subject to continuous movement.

## C8.6 Berthing Energy

### C8.6.1 Berthing/Exposure Condition – Approach Velocity

For all FRA jetties the following berthing and exposure conditions shall be adopted.

- For vessels below 1000t DWT – Use AS4997 (Values from table B1) approach velocity based on a moderate or severe exposure assessed using the guidance to Table B1 of AS4997.
- For vessels between 1000 and 2500t DWT - Use PIANC (Figure 4.2.1) approach velocity assuming Berthing Condition (c) – Easy Berthing, Exposed.
- For vessels in excess of 2500t DWT - Use PIANC (Section 4.2) Kinetic approach with an approach velocity of 0.2m/s.

### C8.6.2 Coefficients for Berthing Energy Calculation

Use the following methods or values unless there is strong evidence to the contrary.

- Added Mass Coefficient – CM. Use Vasco Costa method.
- Eccentricity Coefficient – CE. Use 1.0.
- Berth Configuration Coefficient – CC. Use 0.9.

- Softness Coefficient – CE. Use 1.0.

### C8.6.3 Abnormal Energy

Normal Energy ($E_N$) as calculated above is to be multiplied by a Factor of Safety to provide the Abnormal Energy ($E_A$) used in design as follows:

| | |
|---|---|
| Fenders designed for RoRos | 2.0 |
| Fenders not used by RoRos | 1.5 |

## C8.7 Physical Limitations

A number of the government vessels with considerably less freeboard than the private RoRo vessels also use ramps for unloading. . Fenders and fender panels must be arranged so that no part of the fender system projects above the lowest part of the jetty surface to avoid snagging the ship ramp on these vessels.

On existing jetties, all anchors are to be fixed to the concrete structure. Anchoring to sheet pile walls will only be permitted with validation of the design for this duty.

# C9 Roll on – Roll off (RoRo) Ramp Geometrics

RoRo ramp geometrics shall be based on BS 6349-8: 2007 Code of Practice for the design of RoRo Ramps, Link-spans and Walkways.

The above standard may be supplemented by the use of ISO 6812:1983, International Standard Roll on/Roll off ship-to-shore connection; however the later BS standard shall take precedence.

# C10 Jetty Waiting Sheds

## C10.1 General

The particular performance requirements for the waiting shed will be specified in the project Design Brief.
Waiting sheds at RoRo jetties shall be designed in accordance with the FRA's preferred standard drawings for waiting sheds. *Note – these drawings are currently in preparation and will be provided to designers*.
Waiting sheds shall:

- Have a design life of 50 years.
- Be designed in accordance with the requirements of the Fijian National Building Code (NBC), the project Design Brief, and the FRA standard drawings for waiting sheds.

Particular requirements are that waiting sheds shall:

- Be oriented if possible so that those seated in the shed can view the jetty.
- Incorporate services – power, lighting and water, as required by the project Design Brief and the standard drawing.
- Incorporate wastewater facilities (refer next section).
- Have an outside tap for washing, with sump collection and discharge to an area remote form the waiting shed.
- Have ground levels surrounding the waiting shed shaped to fall away from the waiting shed.
- Incorporate any specific landscaping and security requirements listed in the project Design Brief.

## C10.2 Wastewater Treatment and Disposal

Wastewater treatment and disposal, where required in the Design Brief, shall be designed in accordance with "FRA - Jetty Waiting Sheds - Wastewater Treatment and Disposal Design Guide", MWH, January 2015, attached as Appendix 9.

## C10.3 Building Consent

New waiting sheds and alterations to existing waiting sheds shall be submitted for a building consent by the designer.

# D Culverts and Irish Crossings

## D1 General

Culverts are typically defined as a waterway crossing with a solid base and shallow bearing foundations on insitu soils. Culverts may be designed for overtopping by flood flows, but generally only for ULS events.

Irish Crossings are a variation on culverts. They are permanent culvert structures specifically designed to overtop at higher frequency, thereby reducing the need for a large culvert waterway and providing less restriction on flood flows and floating debris once overtopped. Typically they may include multiple concrete arches, multiple box culverts or multiple concrete pipes.

Splash crossings are permanent concrete ford type structures, designed for al (or the majority) of average flow to pass over the top.

The Bridge Manual specifically covers culverts with a total waterway of 3.4 $m^2$ or greater, but should be assumed to apply to all FRA culverts and Irish Crossings regardless of size unless specifically noted otherwise in the project specific design brief. All design assumptions shall be documented in the Design Philosophy Statement.

## D2 Basis of Design

### D2.1 Basis of Design - general

The structural elements of all culvert, Irish crossings and culvert structures shall have a design working life of 100 years, unless noted otherwise in the project specific Design Brief.

For the sake of clarity, it is generally intended that for Irish crossings and culvert structures of lower importance:

- both structural and non-structural components remain undamaged in a 1 in 10 year event
- and the structures will over top by 0.2m or more approximately 10 times per year.

The use of SLS1 and SLS2, as defined in the Bridge Manual, are used to define these limits and are specified under the following sections.

### D2.2 Waterway Importance Level

Referring to Table 2.1 in the Bridge Manual:

- All Irish Crossings shall be new Importance Level 0 unless specifically noted otherwise.

Importance Level 0 is an additional row to Table 2.1 and is specified in more detail below.

### D2.3 Annual Probabilities of Exceedance (APE)

- For Importance Level 0 – ULS = 1/100, SLS1 = 1/10, SLS2 = 1/0.1

### D2.4 Freeboard Allowance for Level of Serviceability to Traffic

- For Importance Level 0 – allow 0.2 m overtopping.

### D2.5 Basis of Design – Vertical Loads

Road vehicle loads and Fiji Sugar Corporation train loads shall be in accordance with Section B4, of this Design Guide.

## D2.6 Calculation of Waterway

In calculating the magnitude of design flood events, it is recognised that underlying data is not readily available. In the absence of more reliable hydrologic data Section 2.3 of the NZTA Bridge Manual shall be amended as follows:

- The Rational Method is to be used to estimate peak flows for all catchment sizes.
- Rainfall will be based on Fiji Meteorological services (FMS) Intensity Duration and Frequency (IDF) tables and factored according to isohyet maps.
- Where local rainfall data from FMS rainfall gauges is available, it shall be used to check the validity of the isohyet maps using the Fiji Mean Annual Rainfall isohyets.
- Runoff coefficients shall be chosen from local recognised sources, and altered for varying frequencies using engineering judgement.
- The probability for exceedance shall assume no blockage exists.
- Once an annual event flow is calculated, engineering judgement shall be used to assess and modify the outcome as necessary, provided this is documented and agreed with the client.
- Debris loading for crossings should assume the width dimension W in clause 2.3.5 of the NZTA Bridge Manual is for the full width of the crossing.

## D2.7 Particular Design requirements

In addition, the following design principles shall be followed.

### D2.7.1 Irish and Splash Crossings

- The crossing length shall be optimised within practical constraints imposed by the road alignment and the waterway width, but in general should be made as long as possible to maximise the waterway area.
- Scour protection for overtopping, and road surfaces shall extend along the roadway for the full width of overtopping under SLS2, plus an additional 5.0 m (min) horizontally and 0.5m (min) vertically.

### D2.7.2 Environmental Screening and Environmental Impact Assessment (EIA)

Environmental screening and environment impact assessment (EIA) shall be in accordance with B2.4.

# Appendices

1 Approach to environmental management of FRA projects

2 Checklist for the Pre-Screening Environmental Assessment

3 Importance Level 3 Routes

4 Bridge Widths and Clearances

5 Barrier Systems on Bridges

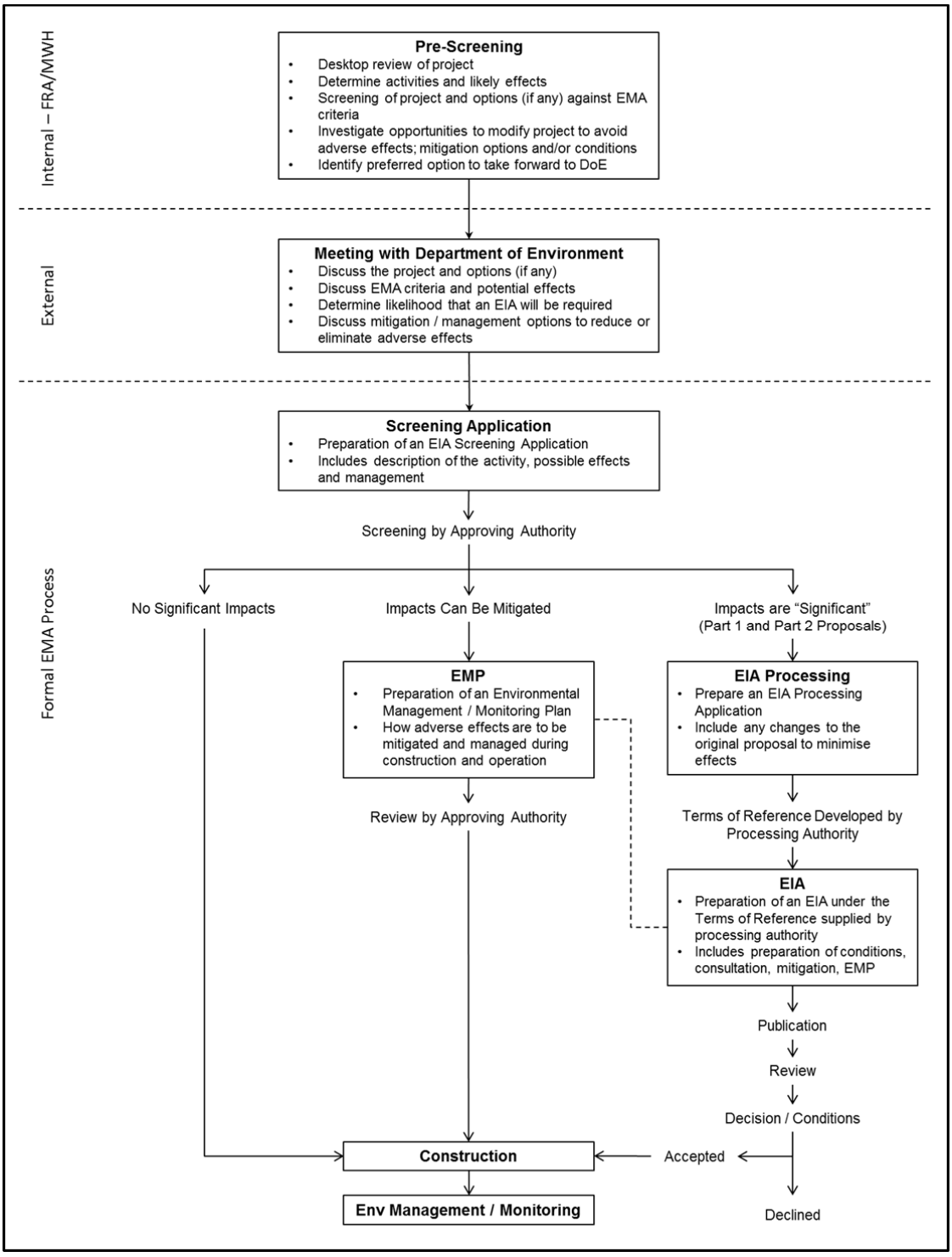
6 Resene Paint Specification

7 Seismic Hazard Map for Fiji

8 Proforma - Producer Statement PS1 – Design

9 Jetty Waiting Shed Wastewater Design and Disposal

# Appendix 1 – Approach to Environmental Management of FRA Projects



# Appendix 2 – Checklist for the Pre-Screening Environmental Assessment: Roads, Bridges, Jetties (New Works and Upgrades)

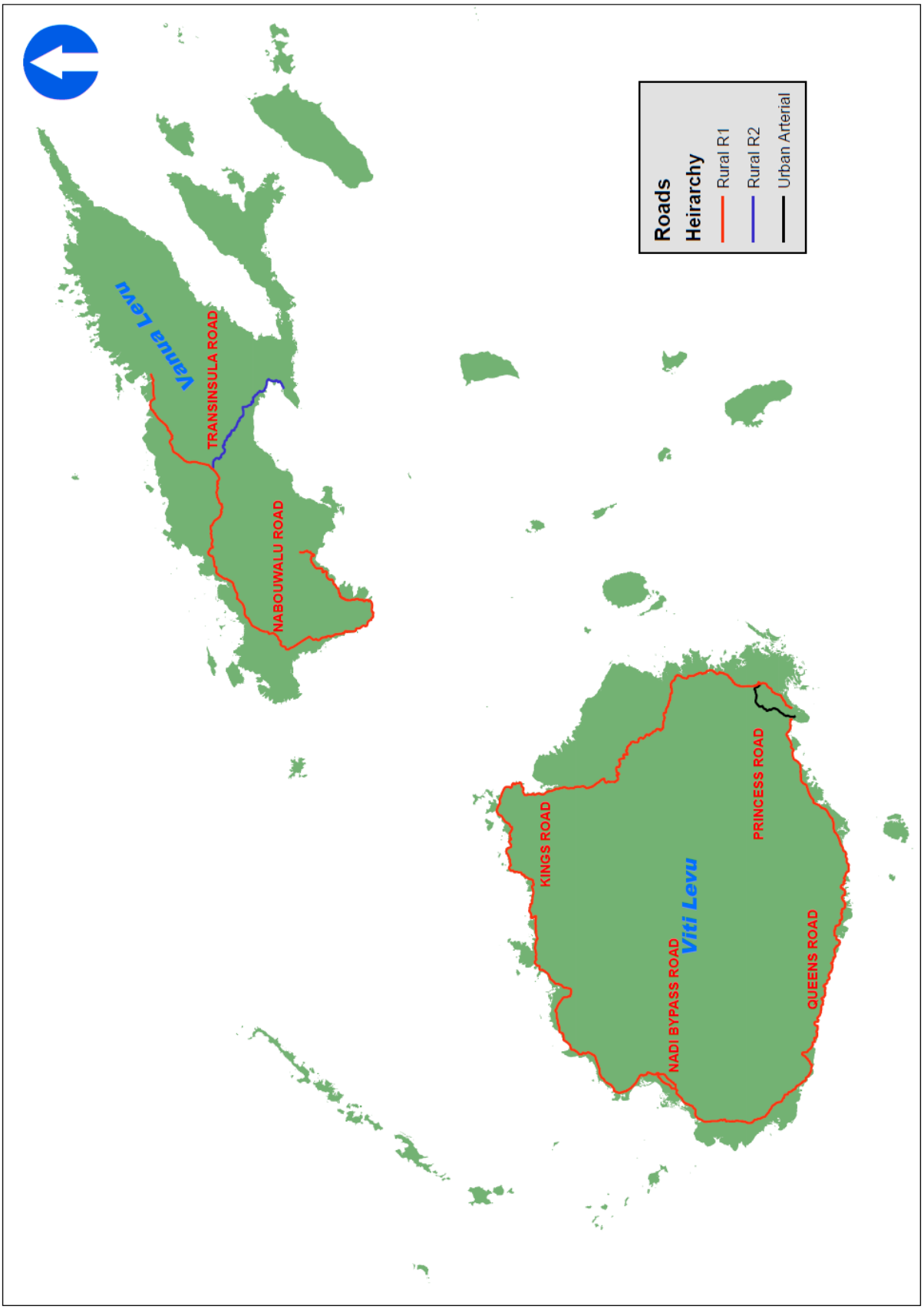
| | |
|---|---|
| PROJECT: | |
| NAME: | DATE: |
| TITLE: | JOB #: |

| |
|---|
| Brief Description of Project: |
| Site Location (attach a map or GPS coordinates if possible): |
| Timing / Commencement of Works: |
| Other Information: |

| Activity | Land | River | Coast | Activity | Land | River | Coast |
|---|---|---|---|---|---|---|---|
| Road | ☐ | ☐ | ☐ | Drilling | ☐ | ☐ | ☐ |
| Bridge / Crossing | ☐ | ☐ | ☐ | Digging / Earthworks | ☐ | ☐ | ☐ |
| Jetty | ☐ | ☐ | ☐ | Dredging | ☐ | ☐ | ☐ |
| New Structure | ☐ | ☐ | ☐ | Piling | ☐ | ☐ | ☐ |
| Upgrading Existing | ☐ | ☐ | ☐ | Wet concrete use | ☐ | ☐ | ☐ |
| Other: | ☐ | ☐ | ☐ | Piping streams | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ | Water Diversion | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ | Erosion control | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ | Sea walls / groynes | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ | Temporary structures | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ | Machinery in/nr water | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ | Air/Water Discharges | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ | Vegetation clearance | ☐ | ☐ | ☐ |

| | Location or Activity | Legislative Requirements | Notes / Comments |
|---|---|---|---|
| **Works in or within 30m of:** | | | |
| ☐ | A beach, estuary or the coast | May require a Part 1 EIA if reclamation, erosion or discharges occur | |
| ☐ | A river or stream | May require a Part 1 EIA if pollution occurs | |
| ☐ | A water supply or reservoir | May require a Part 1 EIA if pollution occurs | |
| ☐ | Agricultural land | May require a Part 1 EIA if contamination or degradation of agricultural land occurs | |
| ☐ | Archaeological sites, cemeteries, historic sites and landmarks | May require a Part 2 EIA if cultural resources are harmed or destroyed | |
| **Reclamation of:** | | | |
| ☐ | A beach, estuary or the coast | May require a Part 1 EIA | |
| ☐ | Mangrove areas | May require a Part 1 EIA | |
| ☐ | A river or stream | May require a Part 1 EIA | |
| **Construction of:** | | | |
| ☐ | A jetty, wharf, pier or bridge in the sea | May require a Part 1 EIA if it alters tidal action, wave action or currents | |
| ☐ | A marine outfall | May require a Part 1 EIA | |
| ☐ | A car park, taxi park, bus station or similar | May require a Part 2 EIA | |
| **Dredging or excavating:** | | | |
| ☐ | A riverbed | May require a Part 1 EIA | |
| **Projects that may impact:** | | | |
| ☐ | Designated or proposed protected areas (land and sea) | May require a Part 1 EIA if protected areas are harmed or destroyed | |
| ☐ | Ecosystems or national importance: beach, coral reef, rock and gravel deposit, sand deposit, island, native forest, agricultural area, lagoon, sea-grass bed, mangrove swamp, natural pass or channel, natural lake or pond, a pelagic (open ocean) ecosystem or an estuary | May require a Part 1 EIA if ecosystems are harmed or destroyed | |
| ☐ | Known habitat for protected, rare or endangered species | May require a Part 1 EIA if species or habitat is impacted | |
| ☐ | Known habitat for migratory birds | May require a Part 1 EIA if populations are depleted | |
| ☐ | Known habitat for migratory turtles, fish, marine mammals | May require a Part 1 EIA if populations are depleted | |
| **Social impacts:** | | | |
| ☐ | The projects is controversial or not supported for environmental or resource management reasons by the public | May require a Part 1 EIA | |
| ☐ | The project is financed by an institution which requires an EIA as a condition of finance | May require a Part 1 EIA | |

# Appendix 3 – Importance Level 3 Routes



# Appendix 4 – Bridge Widths and Clearances

## 1 General

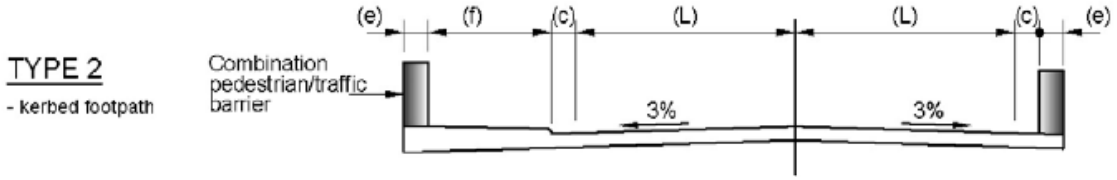
Bridge widths and clearances shall comply with Appendix A of the NZTA Bridge Manual. The modified sections below are provided as guidance to suit the Fijian road environment.

The guidance below is intended to apply to all new bridges and new deck replacements subject to existing bridge constraints.

## 2 Side Protection

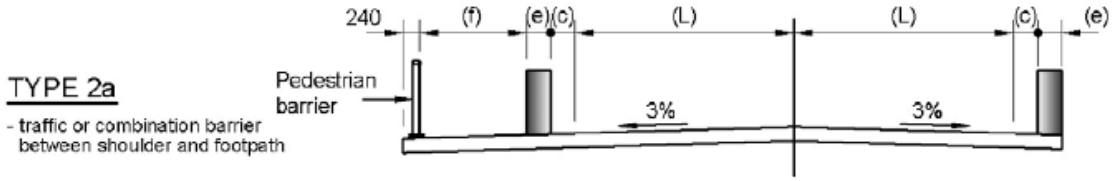
Where there is a footpath, 2 possible options are available.

Where the speed limit is 60kph or less, then either Type 2 or Type 2a (of Figure A1 of NZTA BM) may be used.




*From Figure A1 of NZTA Bridge Manual*

Where the speed limit is greater than 60kph then Type 2a (of Figure A1 of NZTA BM) shall be used.




*From Figure A1 of NZTA Bridge Manual*

Due to high volumes of pedestrian traffic in rural high speed areas a separation barrier between the road and footpath is required.

# Appendix 5 – Barrier Systems on Bridges

## 1 General

Bridge barrier type and use will generally be based on Appendix B of the NZTA Bridge Manual Third Edition, except as modified below.

## 2 Barrier Performance Selection Method

### 2.1. General

Bridge barrier type and use will generally be based on Appendix B of the NZTA Bridge Manual, except that Clause B3.1.2 through B3.1.6 shall be replaced with the following.

### 2.2. Barrier Performance Level 4

A barrier performance level 4 barrier provides for the appropriate containments of cars, heavy utilities and light to medium mass commercial vehicles.

A barrier performance level 4 barrier system shall be provided as edge protection for a structure where one or more of the following conditions exist:

a. the road is a divided multi-lane carriageway
b. commercial vehicle volumes exceed 1,000 per day with a posted speed limit of greater than 60km/h
c. commercial vehicle volumes exceed 2,000 per day with a posted speed limit of 60km/h or less
d. the AADT (annual average daily traffic) is 10,000 or more vpd
e. the structure spans rail lines
f. the structure spans high occupancy land such as houses, factories, areas for congregating, etc.
g. the height differential is more than 10 metres
h. the water depth is greater than 3 metres
i. the carriageway on the structure is on a horizontal curve with a radius of 600m or less.

The AADT referred to above is the estimated construction year AADT (refer to B3.2 for further explanation of this). Refer B3.2.3 for heavy commercial vehicle definitions.

### 2.3. Barrier Performance Level 3

A barrier performance level 3 barrier provides for the safe containment of light vehicles, with occasional use by medium-heavy commercial vehicles, such as stock trucks and/or farm equipment.

A barrier performance level 3 barrier systems shall be provided as edge protection for a structure where one or more of the following conditions exist on the road or hazard being spanned by the structure:

a. on roads with AADT of greater than 150 vpd but less than 10,000 vpd (and lower than the heavy commercial vehicle criteria identified for a performance level 4 barrier), or
b. The height differential is more than 3 metres but less than 10 metres.
c. Water depth is greater than 1.0 metre but less than 3 metres.

### 2.4. ‘No Barrier’ Option

Where a structure does not meet the criteria for a performance level 3 or 4 barrier or the structure cannot easily cater for such a barrier system eg. timber deck structure, consideration may be given to not providing a barrier.

On bridges with no barriers, a handrail shall be provided on both sides for pedestrian use where

- there is high pedestrian traffic, and
- where the drop is greater than 1.5m, and
- where the bridge is not regularly overtopped by floods likely to result in damage to the handrail.

On remote rural bridges, a handrail shall be provided on one side only where

- there is a low traffic and pedestrian count, and
- the drop is greater than 2.5m.

On remote rural bridges, it is acceptable to have no handrails provided

- there is a low traffic and pedestrian count, and
- the drop is less than 2.5m.

Handrails shall comply with the requirements of AS 1657 “Rules for fixed platforms, walkways, stairways and ladders”.

# 3. Side protection design criteria

**Combination barriers (traffic and pedestrian/cyclist/equestrian)**

Notwithstanding the requirements of the NZTA Bridge Manual, semi-rigid combination barriers shall use a standard W-section (TL-3) or Thriebeam (TL-4) barrier with an extended post to accommodate a handrail. This barrier shall be used on bridges which pedestrians are likely to frequent.

Reference may be made to the suite of CSP Pacific's drawings including FX350-1 and FX493 for detailing of TL-3 and TL-4 combined barriers respectively.

# 4. Approach barriers, geometric layout, end treatments and transitions

## 4.1. FRA Specification

Design of approach barriers, geometric layout, end terminals and transitions are detailed in FRA specification X.XX. *Note - This specification is in development and once approved by FRA it will be available to designers.*

## 4.2. Bridge End Markers

Bridge End Markers are required. Detailed requirements are to be checked against Fijian road signage standards.

# Appendix 6 – Resene Paint Specification

Resene
Engineered Coating Systems

# Corrosion Protection Systems

| | |
|---|---|
| Project: | Fiji Road / Transport Infrastructure Protection |
| Location: | Fiji Islands – South pacific |
| Environment: | Tropical - Marine |
| Engineer: | MWH New Zealand<br>Nigel Beatson - Senior Structural Engineer |
| Author: | John B. Kilby |
| Date: | 18th June 2015 |

**Introduction:**

**This specification must be read in conjunction with the information contained in the relevant product data sheets, quoted standards and all procedures shall be carried out in a professional tradesman like manner.**

**It is understood that upon acceptance of this project / contract / application that the contractor will adhere to the requirements outlined within this document and all specified or related standards and procedures.**

**Notes:**

**A/** All unions of dissimilar metals shall be insulated from contact with each other by means of a non-conductive washer or gasket.

**B/** On completion of painting and erection, all crevices shall have a suitable type silicone or mastic sealant applied into them as per manufacturer's instruction to aid in corrosion prevention.

**C/** Any areas of the structure that are at ground level (including the foundation) are to be designed to ensure that there is adequate drainage and no holding of water.

## 1.0 GENERAL

1.1 These specified paint systems, under the appropriate environmental conditions, are intended to be applied by applicators with the necessary equipment and experience to ensure that the potential of the paint system is maximised.

1.2 Before commencement of the contract, all parties, including the contractor, engineer, owner, inspector etc will attend a meeting. During this meeting all aspects of this specification and contract shall be discussed and agreed upon. At this time standards can be discussed and programs for contract completion understood.

1.3 The work shall be carried out strictly to this recommendation and shall be subject to the inspection of the Engineer or his agent to see that it conforms in every way with the requirements as described below.

1.4 Workmanship shall be of a high standard to provide coats of reasonable uniform thickness, free of runs, pinholes, bubbles, dry spray or dry overspray and other film defects.

All paint coating shall be mixed and applied as per manufacturer's Data Sheets. All applications shall be carried out during acceptable climatic conditions .If unsure about any procedure within this specification, or for any advice please do not hesitate to contact the writer for further assistance.

1.5 The Contractor shall supply all qualified supervision, labour and equipment (including abrasive blasting equipment and materials, spray painting equipment, hoses, tools, false-work, scaffolding, and lifting and handling gear etc), necessary for preparing and painting the steel.

1.6 It is a requirement that the superintendent or foreman of the painting contractor keep a diary of each day's events. This diary should include information of all work, standards, weather, progress etc. On request this information must be available to the inspector or engineer.

1.7 The Engineer or his deputy, will be free to inspect the work at any time and require the contractor to carry out any remedial action to their satisfaction if it is considered that any aspect of the work does not meet the requirements of the specification or other relevant documents.

1.8 All defective paint work and paint affected by such causes as climatic conditions, improper workmanship or trade practice, inadequate cleaning, or paint applied contrary to this specification, will be removed, cleaned off and repainted to the satisfaction of the Inspector.

Application and Coating Defects that are Unacceptable

- Missed or skipped areas and low film builds
- Runs, curtains or sags
- Roughness or loss of gloss caused by improper application
- Embedded dirt, dust, grit, sand, abrasive, bugs or other contaminants.
- Extremely heavy orange peel, dry spray, overspray or bubbles.
- Softness, tackiness, peeling, blistering, delamination, powdering.
- Mud cracking, fish eyes (cissing) or wrinkling in the dry film.
- Visible pinholes in the coating.
- Incorrect mixing, induction time, pot life etc; of two component products.

1.9 Mixing of paint shall be by mechanical means. The paint is not to be mixed by stirring with a dowel. Paint shall not be mixed or kept in suspension by means of an air stream bubbling under the paint surface. The paint shall be mixed in a manner, which will ensure breaking up of all lumps and complete dispersion of settled pigments.

The bottom of the containers shall be inspected for unmixed pigments.

All paints are to be used in accordance with the Manufacturers specifications. Where there appears to be a conflict with this specification, the Supervisor will specify what action is to be taken and this decision will be adhered to by the contractor. Containers will be received form the Manufacturer tightly sealed against air and moisture and will remain sealed until the paint is to be used.

1.10 No painting shall begin on any area until the approval of the engineer's representative is given.
Paint shall not be applied when any one of the following conditions exists:

a) The surface is less than 10°C.
b) The ambient air temperature is below 10°C.
c) The relative humidity exceeds 85% (unless precautions are taken to ensure that the surface is at least 3°C above the temperature of the surrounding air and consent is given from the paint manufacturer).
d) There is moisture or ice visible on the surface of the steel.
e) Any condition stipulated by the paint manufacturer, which is more restrictive than 'a)' to 'd)' above.

This is established by using a sling hygrometer utilizing a dry and wet bulb, a surface temperature gauge and a data converter chart. Records shall be kept for each days painting using the AS 3894.10 Inspection Report – Daily format.

The engineer or representative may order painting to cease if, despite all conditions being met, there is a likelihood of frost. The contractor may propose protective measures against frost and these measures will be subject to the approval of the engineer.

1.11 Wind blown salt deposits should be thoroughly washed off with copious amounts of water and the surfaces allowed to dry before painting commences and at the beginning of each day's painting.

1.12 Any contaminants such as airborne pollutants, greases, oils, dirt's, dust, which would effect the integrity of the applied coating must be removed prior to application of paint coatings.

1.13 Note any edges and welds shall have a stripe coat of each specified coating applied to them, to ensure correct film build is achieved, and to maximise the potential of the paint system.

1.14 On completion of painting, all crevices shall have a suitable type silicon or mastic sealant applied into the as per manufacturer's instruction to aid in corrosion prevention.

1.15 The dry film thicknesses quoted in this Recommendation are the minimum to be achieved. Do not exceed these thicknesses by more than 30% of that specified. The specified film thickness for each coat shall be achieved prior to the application of the subsequent coat.

1.16 If the structure is new then the steel needs to be selected, to be, in a new condition with the Mill Scale intact so that there would be no corrosion pitting or salt contamination of the base steel.

1.17 Sections that are prepared and painted off site and is to be allowed to sit on completion of painting for a minimum of four days to allow for curing of the paint coatings (to minimise damage during transportation).

All transporting and lifting shall be done in such a way as to minimise any damage to the paint coating.

**PREPARATION**

1.18 Thoroughly degrease the surface to remove all contaminants as per SSPC-SP1 Standard.

1.19 Water blast at 3000psi at a minimum flow rate of at least 20 litres per minute to remove all salts, dirt, dust and any other contaminants.

1.20 All sharp edges are to be removed by grinding to provide a 2mm minimum radiused edge.

1.21 Any welded sections will need special attention. After welding, all surfaces to be painted must be thoroughly cleaned and free from flux, weld spatter and surface defects, including cracks and deep pits. Weld spatter must be removed carefully by blasting or mechanical grinding. There should be no areas of rough welding.

***Note*: Removal of such defects may affect the weld certification**.

Weld flux must be removed by thorough washing with a detergent solution followed by copious washing with fresh water.

1.22a <u>Abrasive Blasting – SSPC-SP10 (Sa 2 ½ )</u>

Using clean Garnet, Blast clean to SSPC-SP10 minimum. All surfaces to be coated shall be blast cleaned to a “near white” metal finish according to SSPC-SP10 (Sa 2.5 of Swedish Standard SIS 05 59 00). A “near white” metal blast cleaned surface finish is defined as a surface from which all oil, grease, dirt, mill scale, rust, corrosion products, oxides, paint or other foreign matter have been completely removed from the surface except for very slight shadows, very slight streaks or slight discolourations caused by rust stain, mill scale, oxides or slight, tight residues of paint or coating that may remain. At least 95% of each square cm of surface area shall be free of all visible residues and the remainder shall be limited to the light discolouration mentioned above. Photographic or other visual standards of surface preparation may be used if required to further define the surface if specified in the contract.

***Note 1:*** A blast profile of 25-45 microns must be achieved in this process.
***Note 2:*** Immediately apply the specified primer to prevent flash rusting or other contamination (4 hours is the maximum time the surface can be left unprimed).

1.22b Abrasive Blasting – SSPC-SP5 (Sa 3)

Blast clean to SSPC-SP5. All surfaces to be coated shall be blast cleaned to a White Metal finish according to SSPC-SP5 (Sa 3 of Swedish Standard SIS 05 59 00). A White Metal blast cleaned surface finish is defined as a surface from which mill scale, all rust and all foreign materials are entirely removed. The surface when viewed without magnification shall be free of all oils, grease, dirt, visible mill scale, rust, corrosion products, oxides, paint and other foreign matter. The colour of the clean surface may be effected by the particular abrasive medium used. Photographic or other preparation may be used if required to further define the surface if paint specified in the contract.

***Note 1:*** A blast profile of 25-45 microns must be achieved in this process.
***Note 2:*** Immediately apply the specified primer to prevent flash rusting or other contamination (4 hours is the maximum time the surface can be left unprimed).

1.22c Power Tool Cleaning – SSPC-SP3

Power tool clean to SSPC-SP3 Standard. This is a method of preparing steel surfaces by use of power assisted hand tools. Power cleaning removes all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter. It is not intended that adherent mill scale, rust and paint be removed by this process. Mill scale, rust and paint are considered adherent if they cannot be removed by lifting with a dull putty knife. Power wire brushing, power abrading, power impact or other power rotary tools are acceptable means for the removal of loose mill scale, all loose or non-adherent rust and all loose paint. Do not burnish the surface. Use rotary or impact power tools to remove stratified rust (rust scale) and weld slag. Operate power tools in a manner that prevents the formation of burrs, sharp ridges and sharp cuts. Regardless of method used, feather edges of remaining old paint so that the repainted surface can have a reasonably smooth appearance. All areas of old paint should be thoroughly abraded to achieve a good key for adhesion. Immediately apply the specified primer to prevent further corrosion or contamination.

1.22d White Metal Power Tool Cleaning – SSPC-SP11

Power tool clean all steel to a white metal finish as per SSPC-SP11-87T Standard. Metallic surfaces, which are prepared according to this specification, when viewed without magnification, shall be free of all visible dirt, dust, mill scale, rust, paint, oxide, corrosion products, and other foreign matter.
Ensure a slightly roughened finish is achieved. The surface profile shall be not less than 25 microns and no more than 50 microns.
On steel that is painted, all paint edges must be feathered to a smooth finish and the sound paint coating slightly roughened to assist in adhesion of the newly applied coating system.

1.23 The contractor shall ensure that there is no deterioration in the condition of the surfaces to be painted between the actual preparation and the application of the priming paint including surface contamination with salts. Any extraneous matter deposited before painting shall be completely removed and the surface restored to near white metal finish.

## PRODUCT APPLICATION

1.24 With 2 component products you will require special attention. Applicators should be familiar with all the data sheets for products used and also the Material Safety Data Sheets.

**Special Mixing Needed:** All this mixing is done using an air driven or explosion proof power stirrer to ensure all the base on the sides and bottom of the can is intimately mixed in with the hardener. Add the hardener slowly to the base while power stirring. Failing to mix the hardener in properly will result in poor film formation and serious degradation of the performance of the applied product necessitating full removal.
The speed of the ***POWER STIRRER*** should be as low as possible. The coating should have a slight vortex at the surface. A large vortex tends to mix air into the coating which can cause pinholes and air bubbles during application. The mixed coating should have a uniform colour and consistency.

1.25 **Induction Time:** Further to the above, two component mixed products should be left for 10 - 15 minutes (check requirement on product data sheet) to allow for chemical cross-linking (hardening reactions) to be initiated.

1.26 **Pot Life:** The pot life will be indicated on the product data sheet and these will differ for each product and under different temperatures. Do not use the product after the stated time of pot life. Application equipment should be thoroughly cleaned before being used to apply newly mixed product. Higher temperatures will shorten the pot-life. A 10°C increase in temperature will half the pot-life so care is needed on hot days!

Product data sheets and material safety data sheets (MSDS) can be accessed from Resene Web Site www.resene.co.nz.

*This specification is written on the assumption that all substrates are sound.*

1.27 If spraying Uracryl and other similar urethanes then the OSH 'Approved Code of Practice for the Safe Use of Isocyanates' must be read and followed. .

1.28 Industrial coatings are designed to be sprayed. If for any reason small areas are touched up using brush or roller application then more than one application may be needed to achieve the specified film thickness.

# MAINTENANCE

It is very important to understand the durability of a coating system and also the environment to which it is to be exposed. It is also just as important to have in place a maintenance system with a plan on when to recoat to keep the entire system in good condition. The topcoat is designed to protect the underlying coats and the underlying coats are designed to protect the substrate.

Durability is expressed in terms of coating life to first major maintenance, assuming that the coating has been applied according to the requirements of this and other appropriate Standards, and to the recommendations of the coating manufacturer. It is stressed that the durability range is not a 'guarantee time'. Durability is a technical consideration that can help the owner set up a maintenance programme. A guarantee time is a consideration that is the legal subject of clauses in the administrative part of a contract. The guarantee time is usually shorter than the durability range. There are no rules that link the two periods of time.

A guarantee should be provided to protect against a fault in the coating product, or its application, which would generally manifest itself within a relatively short period of time. A guarantee of about one-quarter to one-third of the expected durability should be the maximum provided. Guarantees longer than this period will be costly and there may be problems in enforcing them. Furthermore, after a longer time period, it will be difficult to determine who is at fault and it may require a lengthy and costly court case to recover costs. An owner concerned about long-term durability of a coating system should consider taking out a maintenance contract.

Note that coating type is only one factor in determining the durability of a protective coating system. Surface preparation, application, procedures, design, local variations in environment and other factors will all influence the durability of coatings.

Resene Paints Limited recommends the following maintenance scheme.

## 6 MONTH REGULAR INTERVAL

Thoroughly wash down with a 25 % solution of Resene Roof Wash & Paint Cleaner and water to remove all dirt, dust, grease, chalk, cobwebs and any other contaminants as per Data Sheet D88

Thoroughly waterblast at 3000psi to remove all **salts** and residue from the Roofwash cleaning process. This particularly applies to areas **not naturally washed by rain** where dirt & salts can accumulate.

## 12 MONTH REGULAR INTERVAL

If any areas of moss or mould infestation are found then treat them with Resene Moss & Mould Killer, diluted at the rate of 200 grams to 1 litre of clean water. Leave for up to 48 hours to achieve full kill. For heavy infestations more applications may be needed as per Data Sheet D80.

Thoroughly wash down with a 25 % solution of Resene Roof Wash & Paint Cleaner and water to remove all dirt, dust, grease, moss and mould residue, chalk, cobwebs and any other contaminants as per as per Data Sheet D88

Thoroughly water-blast at 3000psi to remove all salts and residue from the Roof Wash cleaning process.

Inspect the paintwork for signs of premature breakdown. Typical causes of this may be areas of physical damage, low film builds on sharp edges etc. Any defects found should be rectified as soon as possible.

## INDEX

| | |
|---|---|
| µ | Micron |
| DFT | Dry Film Thickness |

## REFERENCES


| | |
|---|---|
| AS/NZS 2312.1: 2014 | Guide to the Protection of Iron & Steel |
| AS 3894.10 | Inspection Report - Daily |
| AS 3894.11 | Equipment Report |
| AS 3894.12 | Inspection Report - Coating |
| NACE | Designing for Corrosion Control – Landrum 1992 |
| NACE | Corrosion and its Control - Atkinson Van Droffelaar 1985 |
| NACE | Corrosion Prevention by Protective Coatings – Munger 1997 |
| NACE | Forms of Corrosion and Prevention 1982 |
| SSPC 91-12 | Coating Inspection |
| SSPC Vol-1 | Good Painting Practice |
| SSPC-PA2 | Film Thickness Readings |
| SSPC-SP1 | Solvent Cleaning |
| SSPC-SP10 | Near White Metal Blast Cleaning |
| SSPC-SP5 | White Metal Blast Cleaning |
| SSPC-SP11 | White Metal Power Tool Cleaning |
| SSPC-SP3 | Power Tool Cleaning |
| Resene | Product Data Sheets / Safety Data Sheets |



John B. Kilby

CBIP-Certified Coatings Inspector
ACA-Certified Corrosion Technologist
ASSDA-Stainless Steel Specialist
CORROSION CONSULTANT
**Resene Engineered Coatings**


Date: 18th June 2015

**TECHNICAL SPECIFICATION: 04**

New Steel Bridge Paint System to offer a Durability of 25+ Years to first Maintenance under a C4 Corrosive Category as per AS/NZS 2312.1:2014 Standard PUR 5 System Designation.

**Job No:**

**Surface Preparation:**
All surface Preparation, paint application and testing to be in accordance with MWH Master Specification Document and Resene Product Data Sheets.
Degrease to SSPC-SP1. Waterblast @ 3000psi / 16L minute minimum to clean steel.
Remove all sharp edges. Abrasive blast to SSPC-SP10 (Sa 2 ½) & achieve a surface profile of 50um. Seal all crevices after painting.

**Item:** New corrugated welded steel road bridge sections for tropical marine environment.

**Temperature:** Ambient / Tropical <90 ºC Dry

**Coating System:**

| Product | Data Sheet | Application Method | Theoretical Spreading Rate $M^2/L$ | Dry Film Thickness Microns | Wet Film Thickness Microns | No. of Packs | Mixing Ratio | Pot Life | Thinner | Clean Up Solvent | Recoat Time Min | Recoat Time Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zincilate 10 | RA20 | AGS | 8 | 75 | n/a | 2 | 4 pbw base 2.14 pbw powder | 8 hrs @ 18ºC | No.9 | No.9 | 16 hrs @ 18 ºC | n/a |
| Armourcote 510 Note 1 | RA40 | CS/AS | 4.3 | 200 | 232 | 2 | 1:1 (by volume) | 1-2 hrs @ 21ºC | No.6 | No.12 | 16 hrs @ 21ºC | 48hrs |
| Uracryl 403 | RA56 | CS/AS | 10 | 50 | 100 | 2 | 3:1 (by volume) | 3 hrs @ 18ºC | No.7A | No.7A | 24 hrs @ 21ºC | n/a |

**TOTAL DRY FILM THICKNESS: 325 microns** (um)

**REMARKS:**
**NOTE 1 -** mist coat / full coat application to avoid pin holes

**NOTES:** Allow to cure for 7 days @ 21ºC before service.

**APPLICATION METHOD**
AS = Airless Spray CS = Conventional Spray AGS = Agitated Spray
R = Roller B = Brush

**COLOUR = _____.**

**Comment** Due to critical mix ratios, part mixing is not recommended.

**COMPILED BY:** J. B. Kilby
**APPROVED BY:** J. Jurlina

**DATE:** 18 June 2015 **Revision:** 001

**TECHNICAL SPECIFICATION: 03**
Old Existing or New Bridge
Paint System Touch Up

**Job No:**

**Scope:**

| | |
|---|---|
| **Surface Preparation:**<br>All surface Preparation, paint application and testing to be in accordance with MWH Master Specification Document and Resene Product Data Sheets.<br>Degrease to SSPC-SP1. Waterblast @ 3000psi / 16L minute minimum to clean steel.<br>Remove all sharp edges. Power tool clean to SSPC-SP11 (SP-3 as a minimum) & achieve a surface profile of no more than 50um. Seal all crevices after painting. | **Item:** Old existing or new paint site touch up of welded steel road bridge sections for tropical marine environment.<br><br>**Temperature:** Ambient / Tropical <90 ºC Dry |

**Coating System:**

| Product | Data Sheet | Application Method | Theoretical Spreading Rate $M^2/L$ | Dry Film Thickness Microns | Wet Film Thickness Microns | No. of Packs | Mixing Ratio | Pot Life | Thinner | Clean Up Solvent | Recoat Time Min | Recoat Time Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ArmourZinc 120<br>Note 1 | RA22 | AGS/CS/B/R | 6.75 | 75 | 147 | 2 | 4:1<br>(by volume) | 12 hrs<br>@<br>21ºC | No.12 | No.12 | 3 hrs<br>@<br>21 ºC | 48 hrs |
| Armourcote 510 | RA40 | CS/AS/B/R | 4.9 | 150 | 174 | 2 | 1:1<br>(by volume) | 1-2 hrs<br>@<br>21ºC | No.6 | No.12 | 24 hrs<br>@<br>21ºC | 28 hrs |
| Uracryl 403 | RA56 | CS/AS/B/R | 10 | 50 | 100 | 2 | 3:1<br>(by volume) | 3 hrs<br>@<br>18ºC | No.7A | No.7A | 24 hrs<br>@<br>21ºC | 24 hrs |
| Uracryl 403 | RA56 | CS/AS/B/R | 10 | 50 | 100 | 2 | 3:1<br>(by volume) | 3 hrs<br>@<br>18C | No.7A | No.7A | n/a | n/a |

**TOTAL DRY FILM THICKNESS: 325 microns** (um)

**REMARKS:**
**NOTE 1 -** Check existing paint compatibility with solvent test.

**NOTES:** Allow to cure for 7 days @ 21ºC before service.

**APPLICATION METHOD**

AS = Airless Spray CS = Conventional Spray AGS = Agitated Spray
R = Roller B = Brush

**COLOUR = _____.**

**Comment** Due to critical mix ratios, part mixing is not recommended.

**COMPILED BY:** J. B. Kilby
**APPROVED BY:** J. Jurlina

**DATE:** 13 June 2013 **Revision:** 001

# Appendix 7 – Seismic Hazard Map for Fiji

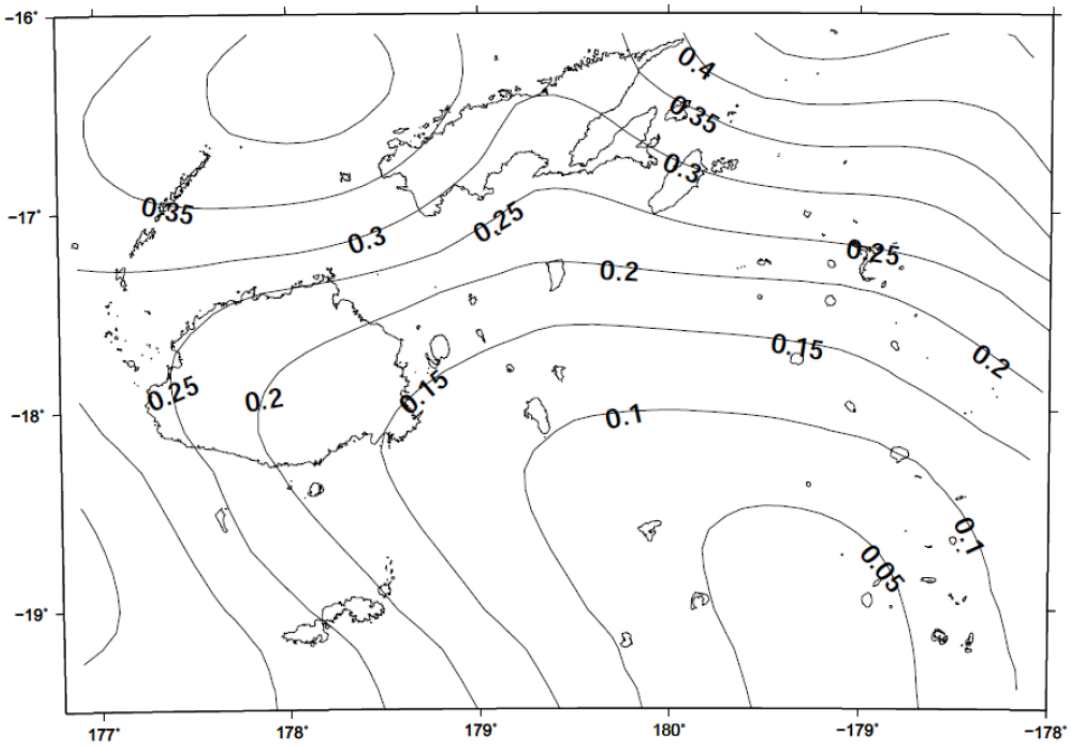



**Figure 3.3** Z-factor map for Fiji. Z is in units of g. See the text for further explanation.

Reference: Seismic Hazard Z-Factor Map for Fiji, GNS Science Consultancy Report 2014/261

# Appendix 8 – Proforma - Producer Statement PS1 – Design

## PRODUCER STATEMENT – PS1 – DESIGN

**ISSUED BY:**.....
(Design Firm)

**TO:**.....
(Owner/Developer)

**TO BE SUPPLIED TO:**.....
(Building Consent Authority)

**IN RESPECT OF:**.....
(Description of Building Work)

**AT:**.....
(Address)
..... **LOT**..... **DP** ..... **SO** .....

We have been engaged by the owner/developer referred to above to provide .....
..... services in respect of the requirements of
(Extent of Engagement)
Clause(s) .....of the Building Code for
All ☐ or Part only ☐ (as specified in the attachment to this statement), of the proposed building work.

The design carried out by us has been prepared in accordance with:

☐ Compliance Documents issued by the Ministry of Business, Innovation & Employment.....or
(verification method / acceptable solution)

☐ Alternative solution as per the attached schedule.....

The proposed building work covered by this producer statement is described on the drawings titled .....

.....and numbered .....;
together with the specification, and other documents set out in the schedule attached to this statement.
**On behalf of the Design Firm,** and subject to:
(i) Site verification of the following design assumptions .....
(ii) All proprietary products meeting their performance specification requirements;

I **believe on reasonable grounds** that a) the building, if constructed in accordance with the drawings, specifications, and other documents provided or listed in the attached schedule, will comply with the relevant provisions of the Building Code and that b), the persons who have undertaken the design have the necessary competency to do so. I also recommend the following level of construction monitoring/observation:
☐CM1 ☐CM2 ☐CM3 ☐CM4 ☐CM5 (Engineering Categories) or ☐ as per agreement with owner/developer (Architectural)

I, ..... am: ☐CPEng .....#
(Name of Design Professional)
☐Reg Arch ..... .#

I am a Member of : ☐ IPENZ ☐NZIA and hold the following qualifications:.....
The Design Firm issuing this statement holds a current policy of Professional Indemnity Insurance no less than $200,000*.
The Design Firm is a member of ACENZ: ☐

SIGNED BY ..... ON BEHALF OF .....
(Design Firm)

Date..... (signature).....

*Note: This statement shall only be relied upon by the Building Consent Authority named above. Liability under this statement accrues to the Design Firm only. The total maximum amount of damages payable arising from this statement and all other statements provided to the Building Consent Authority in relation to this building work, whether in contract, tort or otherwise (including negligence), is limited to the sum of $200,000*.*

# Appendix 9 – Jetty Waiting Shed Wastewater Design and Disposal

Prepared for

FIJI Roads Authority

# Jetty Waiting Sheds
# Wastewater Treatment and Disposal Design Guide

**January 2015**

MWH®

BUILDING A BETTER WORLD

# QUALITY STATEMENT

| PROJECT MANAGER | PROJECT TECHNICAL LEAD |
|---|---|
| Mark Ridge | John Cocks |

| | | |
|---|---|---|
| **PREPARED BY** | | |
| John Cocks | ..... ..... | 28/11/2014 |
| **CHECKED BY** | | |
| Paul Jacobson | ..... .. | 28/11/2014 |
| **REVIEWED BY** | | |
| Mark Ridge | .. ..... | 28/11/2014 |
| **APPROVED FOR ISSUE BY** | | |
| Don Clifford | .. . | 15/12/2014 |

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P:_2012 Onwards\Fiji Onsite\80502689 Protocol\SOP\DFC\R_Fiji_wastewater_DFC_2.docx

# REVISION SCHEDULE

| Issue No | Date | Description | Signature or Typed Name (documentation on file). | | | |
|---|---|---|---|---|---|---|
| | | | Prepared by | Checked by | Reviewed by | Approved by |
| 1 | Nov 2014 | Draft for Client Comment | John Cocks | Paul Jacobson | Mark Ridge | Don Clifford |
| | | | | | | |
| | | | | | | |

# Fiji Roads Authority

## Jetty Waiting Sheds

## Wastewater Treatment and Disposal Design Guide

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Attachment B: Flow Chart of EIA Process
Attachment C: Savusavu Town Council - Application Form for Permission for a Development
Attachment D: Investigation Forms
D.1 Generator Information Form
D.2 Desk Top Study Form
D.3 Site Investigation Form
D4 Bore Log Form

# 1 Introduction

## 1.1 Purpose:

The Fiji Roads Authority (FRA) develops and operates waiting sheds at jetty locations. The FRA wishes to provide suitable toilets at those waiting sheds for convenience of the users.

Wastewater from toilets needs to be appropriately managed. This document provides guidance on the selection and design of a treatment and disposal system to manage the wastewater.

## 1.2 Scope

This document provides:

- a procedure for selecting an appropriate wastewater treatment and disposal system
- definitions of applicable types of wastewater treatment and disposal systems
- a design guide for a type of system known as a vault toilet
- a design guide for a type of system known as an on-site wastewater treatment and disposal system.

# 2 Selecting a Wastewater Treatment and Disposal System

## 2.1 Flow Chart for Selecting a System

Figure 2.1 presents a flow path for the selection of an appropriate solution for managing wastewater from a waiting shed. Solutions are:

- sewerage connection, or
- vault toilet, or
- on-site system.

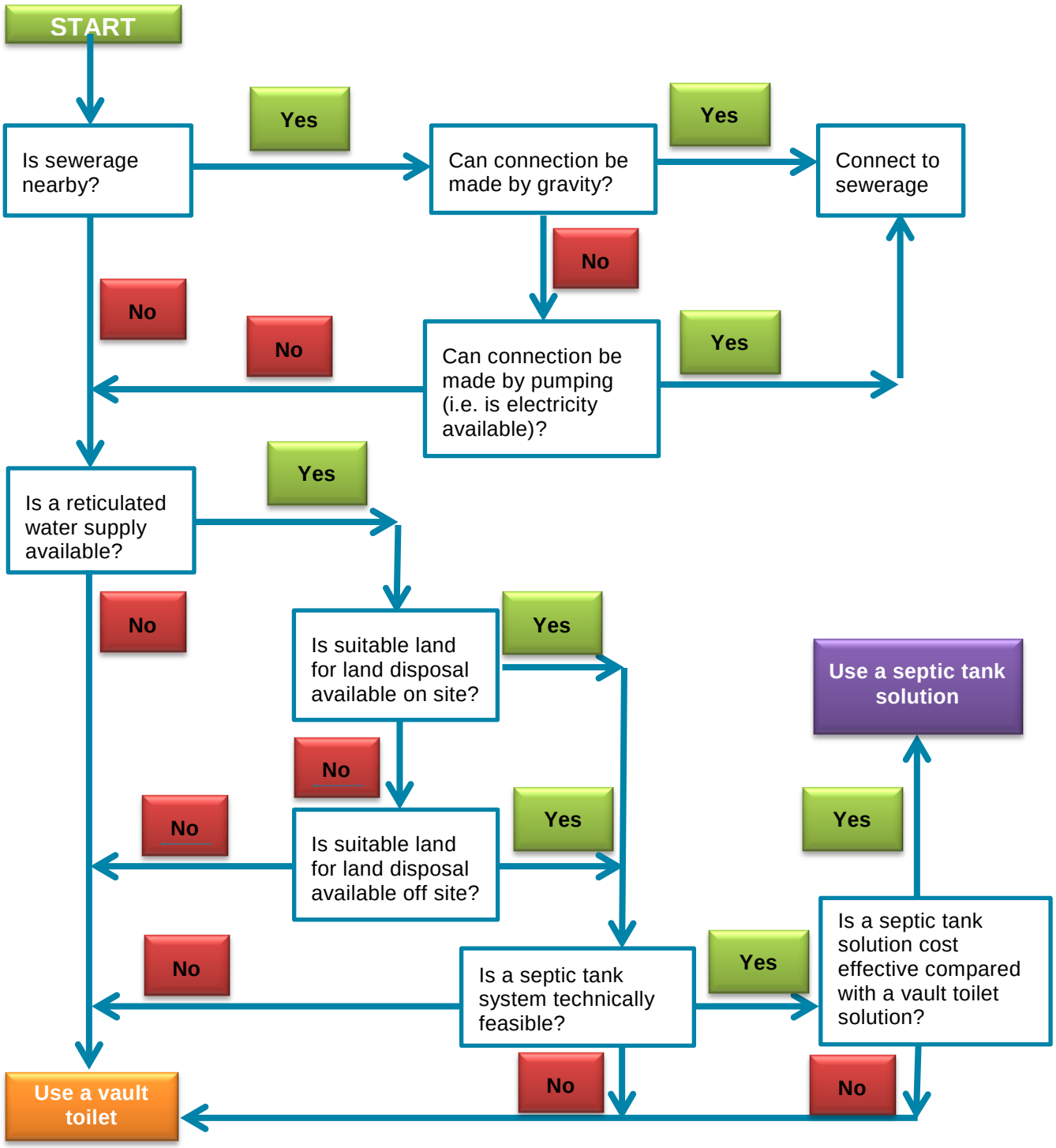



**Figure 2-1: Flow Chart for System Selection**

# 3 Definitions of Systems

## 3.1 Vault Toilet

A vault toilet consists of a sealed container buried in the ground with a building over it (Briar Cook, 1991[1]). Human waste is contained in the vault until it is removed by pumping. Generally, a vault toilet is suitable for environmentally sensitive areas and sites with limitations on the use of other types of wastewater treatment and disposal systems.

A vault toilet comprises:

- a watertight vault to receive and store human waste
- a toilet superstructure
- a ventilation system to ventilate the toilet cubicle and the vault.

A vault toilet and the associated airflow concept are illustrated in Figure 3.1.

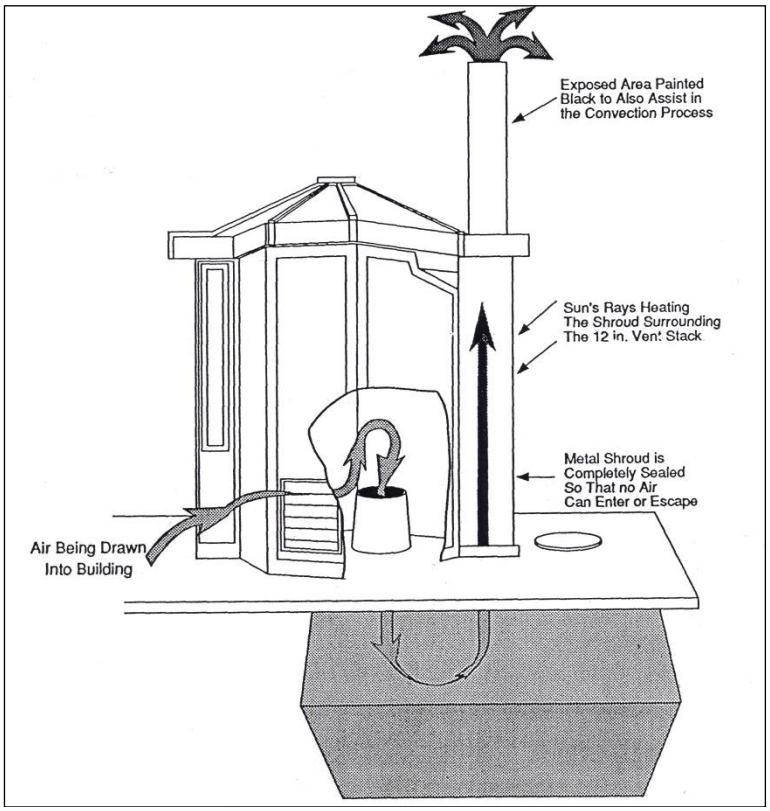



**Figure 3-1: Air Flow Process** (source Briar Cook, 1991)

## 3.2 On-site System

An on-site system is one that treats and disposes wastewater on the site that the wastewater is generated. An on-site system comprises built facilities (a wastewater treatment system and a land application system) and the soil beneath the land application system. The soil and other physical characteristics of a site fundamentally influence on-site system design and performance. An on-site system is illustrated conceptually in Figure 3.2.

[1] Briar Cook, 1991. In-depth Design and Maintenance Manual for Vault Toilets. US Forest Service

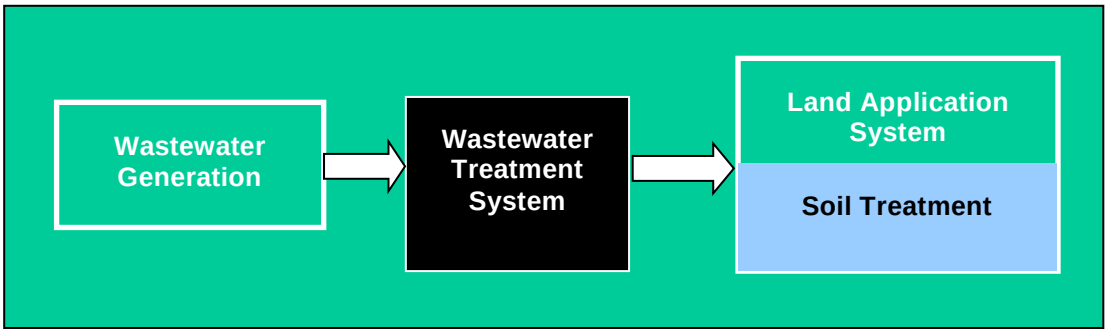



**Figure 3-2 On-site System Concept**

At waiting sheds, wastewater is generated by toilets, basins, and showers (if provided).

The wastewater treatment system may be a septic tank, a septic tank and an advanced treatment unit or an advanced treatment unit. There are many proprietary septic tank units and advanced treatment units available.

The land application system comprises soil soakage trenches, soil soakage beds, or a dripper system, and a facility that transfers the effluent from the wastewater treatment system to the land application system. Effluent may be transferred by:

- a gravity mechanism that comprises a distribution box, or other apparatus, and an associated pipe network; or
- a dosing mechanism that comprises a pumping station, dosing siphon, or other apparatus, and an associated pipe network.

Soil at the interface of the land application system and to some depth beneath the soil interface may further treat the effluent. Treatment is most effective where the soil is unsaturated (i.e. above the groundwater level) and has a fine sandy, loam or silt loam texture. Treatment in the soil occurs as a result of plant uptake, straining and filtration, adsorption, ion exchange, precipitation, biotransformation, attenuation, die-off, and predation by in-soil micro flora and fauna.

The components of an on-site system are illustrated in Figure 3.3.

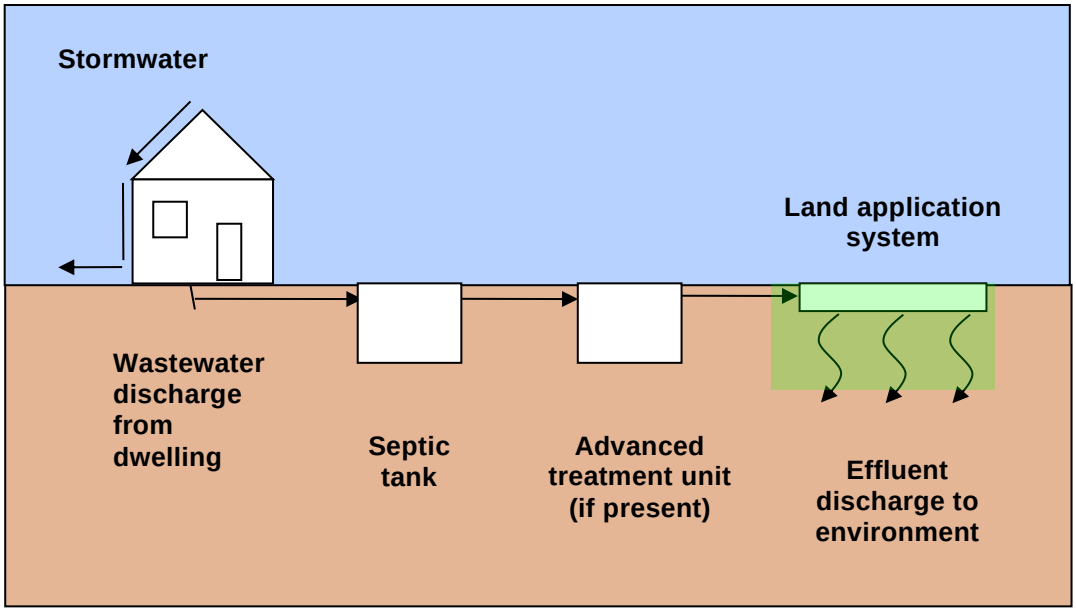



**Figure 3-3: Schematic Diagram of an On-site System and its discharge to the Environment**

It is considered that, for the waiting shed locations in Fiji, the most simplistic on-site system should be adopted. The use of a septic tank and a disposal system meets this requirement. Advanced treatment units are not considered further in this document.

## 3.3 Comparison of Vault Toilet and Septic Tank System

To assist in determining which system is more appropriate for a particular location vault capacities and septic tank capacities are compared. Design cases for this comparison are presented in Table 3.1.

**Table 3-1: Design Cases**

| Design Cases | Max person per sailing | Max person per day |
|---|---|---|
| 1 | 500 | 1,000 |
| 2 | 100 | 100 |

Vault toilet capacities have been determined for the two design cases presented in Table 3.1 based on:

- an allowance of 0.4 litres of waste per person per use
- an allowance of 1 use per person per sailing.

On the basis of the vaults being emptied once per year, the vault capacities are presented in Table 3.2.

**Table 3-2: Vault Capacities**

| Design Case | Max. no persons/ day | Sailing days / week | Max. no. persons / yr. | Vault Volume *litres* |
|---|---|---|---|---|
| 1 | 1000 | 7 | 364,000 | 145,600 |
| 2 | 100 | 3 | 15,600 | 6,240 |

Septic tank capacities have been determined for the two design cases presented in Table 3.3 based on:

- design provisions given in AS/NZS 1547: 2012
- 0.0274 litres of scum and sludge per use
- the use of low flush toilets (i.e. maximum flush volume of 7 litres)
- an allowance of 1 flush per person per sailing.

On the basis of a septic tank being emptied once every 3 years (the maximum frequency recommended in AS/NZS 1547), the septic tank capacities are presented in Table 3.3.

**Table 3-3: Septic Tank Capacities**

| Design Case | Max. no persons/ day | Sailing days / week | Max. no. persons / yr. | Septic tank volume *Litres* |
|---|---|---|---|---|
| 1 | 1000 | 7 | 364,000 | 36,918 |
| 2 | 100 | 3 | 15,600 | 1,982 |

This comparison illustrates that:

- the volume of waste removed every 3 years for a vault toilet system is 436,800 litres for Case 1 and 18,720 litres for Case 2
- the volume of waste removed every 3 years for a septic tank system is 36,918 litres for Case 1 and 1,982 litres for Case 2
- the volume of waste removed with a vault system is between 9 and 12 times that for a septic tank system
- the tank capacities with a vault toilet are between 3 and 4 times those for a septic tank system (based on 1 year emptying frequency of vaults; a higher frequency of emptying would result in smaller vault capacities).

Whether a vault toilet or septic tank system is used, there needs to be facilities for the removal and disposal of residual waste. These facilities comprise a pump-out tanker, or other pumping and transport facilities, and a wastewater treatment plant at which to dispose of the pumped out waste.

As a rule of thumb:

- a vault toilet is less costly to build because only vaults are required (a system for supplying water for flushing and a soil soakage system, which are needed for a septic tank system, are not required); and
- a vault toilet has higher waste disposal costs than those for a septic tank system because of the larger volumes of waste to be removed.

Typically, a septic tank system poses greater design and operational challenges than a vault system.

A septic tank system discharges treated wastewater to the environment. The discharge is potentially contaminating because it is high in disease-causing organisms, high in odour causing material, and high in nutrients which damage ecology. If adverse effects from these contaminants are to be avoided, the discharge must be into to a large area of suitable soil and well above groundwater. Such soil and groundwater conditions may be difficult to find near jetty waiting sheds.

A septic tank system has higher operational risks from, particularly:

- soil soakage bed failure (e.g. clogging of soils)
- septic tank effluent disposal pumping system malfunction (where pumping is needed).

# 4 Vault Toilet Design

## 4.1 Design Concept

A vault toilet comprises:

- a watertight vault to receive and store human waste
- a toilet building
- a ventilation system to ventilate the toilet cubicle and the vault.

Typically, the vault is located just below the ground surface with a toilet riser and pedestal above it. A ventilation stack is connected to the vault. There is one stack per vault. A building vent is located on the windward side of the toilet building. A manhole riser is located to the side or behind the toilet building for pumping out the effluent. The layout of a vault toilet is shown in Figure 4.1.

Briar Cook (1991) provides condensed design criteria for vault toilets. These address requirements for:

- vault
- building interior floor surface
- interior building walls and ceiling
- toilet riser
- lighting
- air vent for the building
- vent to aspirate odours out of the vault, where each vault is to have its own vent
- placing the building on the site.

The location and orientation of the toilet building on a site are important for effective functioning of the ventilation system. The building should be orientated to take full advantage of the wind. For areas where there is a prevailing wind, the inlet vent should be located head high (when standing) toward the prevailing wind direction. In areas where there are variable winds, the vent should be located low to the ground.

The ventilation system is powered by energy from the sun, the wind or both. The radiant energy of the sun heats the air in the vent stack, causing it to rise. The wind through venturi action draws air out of the vent stack. The air rising out of the vent stack draws air out of the vault, which in turn draws air down the toilet riser from the toilet building and air into the toilet building through the building vent. This process of air flow is shown in Figure 3.1.

Photographs of vault toilets are in Attachment A.

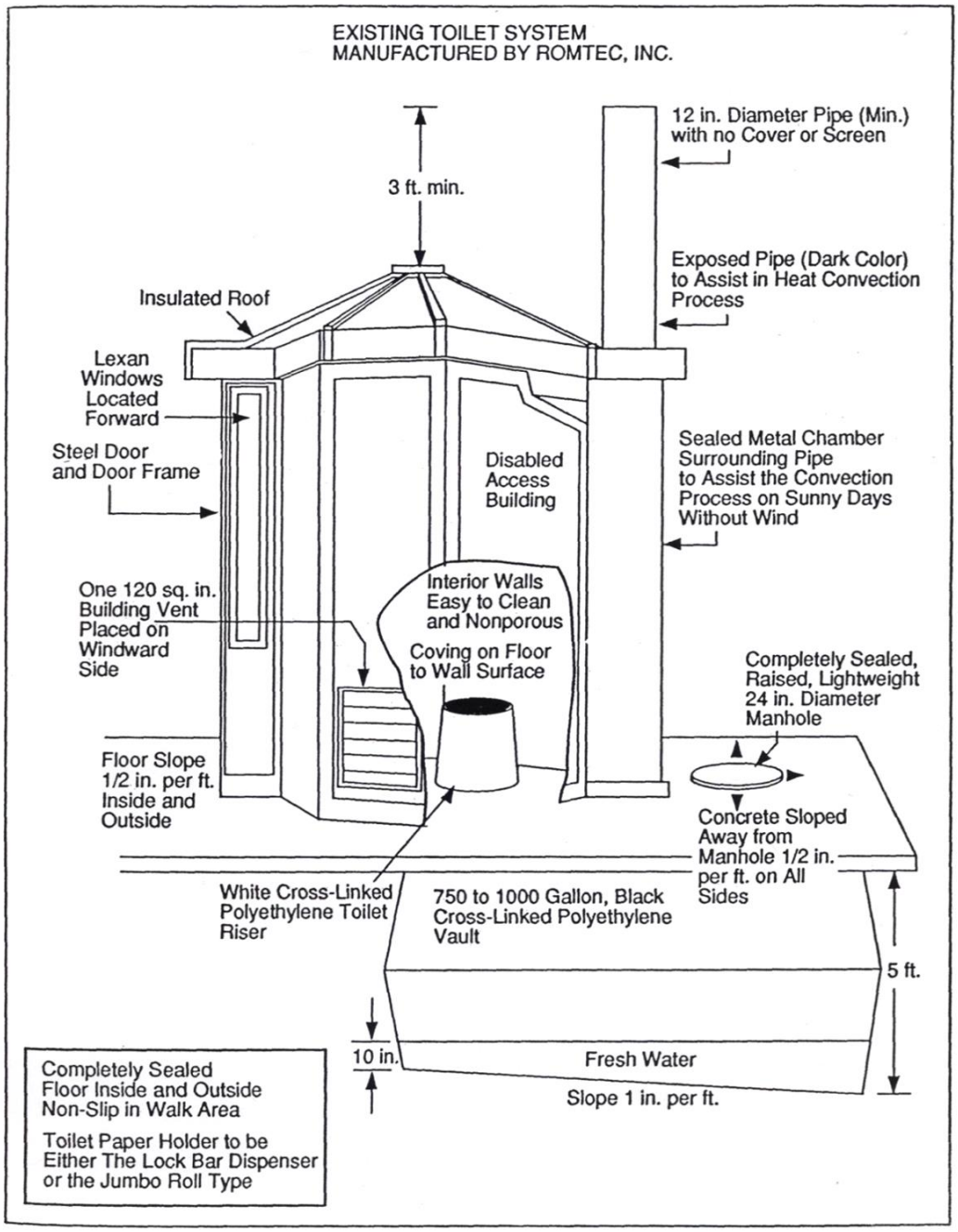



**Figure 4-1: Vault Toilet Layout** (source Briar Cook, 1991)

## 4.2 Regulations

The odour discharge from a vault toilet to the environment (i.e. to air) shall comply with the relevant statutory requirements.

The location and construction of a vault toilet shall comply with:

- requirements of the applicable local authority
- requirements of the Fijian National Building Code (NBC) or an alternative requirement acceptable to the FRA.

## 4.3 Design Factors

### 4.3.1 Material for Disposal

A vault toilet should receive human waste only. Preferably washing water from hand basins or showers should not be disposed to a vault toilet as this would increase the frequency of emptying the vault. Washing water may be able to be discharged directly to the environment or discharged via a septic tank, provided that the basins or showers are used only for washing of hands or the body. This would need to be checked with the relevant consenting authority.

Rubbish must not be disposed to a vault.

### 4.3.2 Human Waste Quantities

Reported[2] average human waste quantities are given in Table 4-1.

**Table 4-1: Reported Rates of Human Waste Generation**

| Material | Average (see note 1) |
|---|---|
| Total liquids, l/p.d:<br>• urine<br>• stool liquid | 2.15<br>2.07<br>0.08 |
| Total solids, g/p.d | 115 |
| Additional solids for women (see note 2), g/p.d | 70 |

**Notes:**
1. Trials undertaken by Parker and Gallagher
2. Add 70 grams for women as result of toilet paper, menstrual flow and menstrual pads (Parker and Gallagher)
3. Interpretation: l/p.d means litres per person per day; g/p.d means grams per person per day.

Liquid comprises urine and faeces fluid. Solids comprise urine solids, faeces solids, and toilet paper. On average a person goes to a toilet 5 times per day.

For the purpose of sizing vault toilets, it is assumed that:

- on average each person at a waiting shed goes to the toilet once
- the volume of human waste discharged by a person is 0.4 litres.

### 4.3.3 Number of Toilet Pans

The Fiji NBC provides guidance on the number of toilets in Table NF2.3.

Building Class 9b Sporting Venues etc. has been adopted for design. The provisions for spectators are:

| | |
|---|---|
| Males | 1 closet fixture per 250 people<br>1 urinal per 100 people |
| Females | 1 closet fixture per 75 people |

The basis of design is:

- 1 unisex toilet for waiting sheds serving up to 75 people per sailing
- 1 male toilet and 1 female toilet for waiting sheds serving up to 150 people per sailing
- 1 male toilet and 1 female toilet for waiting sheds + 1 unisex toilet for waiting sheds serving up to 225 people per sailing
- 2 male toilets and 2 female toilets for waiting sheds serving up to 300 people per sailing.

[2] Parker, D and Gallagher, S. K. Distribution of Human Waste Samples in Relation to sizing waste processing in Space.

The Code provides guidance on toilet requirements for disabled people.
Toilets for disabled people shall be provided in accordance with the provisions of the NBC.

### 4.3.4 Building Design Requirements

Matters to be addressed in determining the location of a toilet building include:

- Foundation requirements
- Prevailing wind direction – to aid the ventilation system
- Maximum sunlight – for effective convection and removal of odour
- Public safety
- Pump-out access for tanker – a tanker may be barge mounted or vehicle mounted
- Clearance from a walkway, a road or other infrastructure.

A geotechnical investigation is required to assess ground conditions in terms of foundation requirements and any construction traffic limitations.

The vent stack consists of a large black conduit (300mm internal diameter or equivalent area). It should be located on the outside of the building so the heat of the sun causes the vault and interior of the building to vent through the stack.

Control of surface water is necessary so as to prevent ingress into the vault.

### 4.3.5 Number of Toilets and Vault Capacities

When designing a vault toilet for a waiting shed, it is necessary to determine values for the following design parameters.

***Number of toilets***
The number of toilets required is based on the maximum number of persons per sailing and determined in accordance with 4.3.3. Each toilet requires a separate vault.

***Capacity of vaults***
The capacity of a vault is determined on the basis of the desired frequency of emptying, a practicable vault capacity (commonly 5,000 litres), and the number of persons visiting the waiting shed during period between emptying events.

The number of visitors visiting a waiting shed during the period between emptying events can be determined using different methods such as:

- statistics on the maximum numbers of persons sailing during the desired period
- statistics on the maximum number of persons sailing at one sailing event and assuming this number for each sailing during the desired period.

The latter method is more conservative.

To determine vault capacity using the latter method, values should be determined for:

- the maximum number of person on a sailing from the waiting shed
- the number of sailings per day
- the number of sailings per week
- the number of weeks for the period.

If a 5,000 litre vault capacity is selected and the design is based on the maximum number of persons sailing from a waiting shed, then the number of toilets and number of vault emptying events per year should be as given in Table 4.2.

**Table 4-2: Number of Vault Toilets and Capacities**

| Design Case | Max. no. persons /sailing | No. of Vault toilets | Max. no persons/ day | Sailing days / week | Max. no. persons / yr. | Max. volume of waste/ yr. | vault emptying events/ yr. |
|---|---|---|---|---|---|---|---|
| | | | | | | *litres* | *no* |
| 1 | 500 | 7 | 1000 | 7 | 364,000 | 145,600 | 5 |
| 2 | 100 | 2 | 100 | 3 | 15,600 | 6,240 | 1 |

### 4.3.6 Location and Orientation of Toilet

A vault toilet shall be located:

- at least 3 metres from a waiting shed
- downwind of the waiting shed under prevailing wind conditions.

A vault toilet shall be orientated so that, if applicable, the cubicle vent faces prevailing wind.

To enhance the performance of vault toilet, consideration should be given to:

- taking maximum advantage of the wind flow and the sun's energy
- selecting a location that is not the lee side of a waiting shed, if practicable
- locating the vent in the relevant wall where a door vent does not face the wind.

Where two or more toilets are required the cubicles shall be located on the site so that:

- No cubicle vent is obstructed from the prevailing wind, and
- The vault vent stacks are offset to the prevailing wind by at least 1m.

### 4.3.7 Other Design Factors

#### 4.3.7.1 Ventilation

The vault shall be ventilated by a vent stack that:

- has a minimum internal diameter of 300mm
- extends to a minimum height of 1m above the highest point of the cubicle roof
- shall remain unscreened at the top (*Comment: To prevent rainfall entering the system, a 'top hat' should be fitted with 500mm vertical separation between the top of the vent stack and the underside of the 'top hat')*
- does not protrude below the vault soffit level (*Comment: This is necessary to enable venting of all gases from the vault*)
- is coloured black (*Comment: A ventilator is not required to be fitted to the top of the vent to induce adequate ventilation. There is a risk that in some conditions a ventilator may inhibit ventilation. There is no evidence that ventilators add over all to performance).*

A cubicle shall be ventilated by a single vent that:

- has a total area of 90,000mm$^2$ based on covering with a 5mm x 5mm insect mesh, and
- faces the prevailing wind (if applicable), and is located no more than 500mm above the cubicle floor level, or
- is located at head height (when standing) where winds are variable.

#### 4.3.7.2 Lighting and Insulation

Natural lighting shall be provided and shall be adequate for the visitor to see comfortably but not directed in a way that the waste can be seen down the toilet dropper.

Skylights shall not be used.

Windows, if provided, may be located in either the wall or door. Windows shall be non-opening.

The roof of the cubicle shall be insulated to a minimum R value of R1.8, with any lighting located in the walls or door and non-opening. (*Comment: Insulation is required to maintain a lower temperature inside the cubicle so that a reverse airflow (i.e. airflow from the vault into the cubicle) is not induced. Windows are required to be non-opening so that the stack effect is optimised between the entry point of air into the cubicle and the exit point of the air at the top of the vent). (Comment: R value is an industry recognised measure of the ability of a material such as insulation to retard heat flow).*

#### 4.3.7.3 Cubicle Construction

Interior floor and toilet seat surfaces shall be easily cleaned, and moisture resistant.

The floor surfaces requirement may be met by:

- float finished concrete with a non-slip finish
- ply flooring that has been treated in accordance with requirements of the NBC and finished with a moisture-cured polyurethane or a decking-grade oil, and
- no lip or raised threshold at the door.

The toilet seat shall be a proprietary seat with lid, and may be fitted to either a pedestal or bench, with the dropper into the vault being a minimum of 300mm diameter. (*Comment: The toilet seat shall have a gap between seat and lid to enable a free flow of air into the pit*).

The toilet pedestal or bench surfaces requirement may be met by:

- a proprietary pedestal of any impervious material
- a bench constructed of treated ply (in accordance with the requirements of the NBC) that has been finished with a moisture cured polyurethane or a decking-grade oil.

The NBC Section A.2 Acceptance of Design and Construction addresses the need for materials that are fit for purpose or suitability, and requires evidence in support of this. An application for a building permit will need to demonstrate that the materials used are suitable.

# 5 On-site Systems

## 5.1 What Needs to be Known?

A process for the planning, investigation and design of an on-site system is presented as stages 1 to 6 in Table 5.1. A description of information requirements is provided for each stage.

**Table 5-1: Process and Information Needed**

| | Stage / objectives | Required Information |
|---|---|---|
| 1. | **Defining needs & strategic planning** | **Local knowledge** |
| | What are the needs?<br>Where site and what is is its area? | Type and scale of wastewater generating activity<br>Certificate of title or similar cadastral information |
| | Are there known sensitive receivers- e.g. swimming or shellfish gathering? | E.g. Lagoon water, water supply |
| | Are there solutions other than an onsite system? e.g. pump to sewerage | Location of nearest sewerage scheme or wastewater treatment plant.<br>Availability of vault pump-out equipment and suitable disposal site. |
| | What regulations are applicable? | Applicable regulations: receiving water standards, discharge standards; building standards; if none available, then default to an applicable New Zealand standard of guideline. |
| | ***Output: Confirm type of solution*** | |
| | | |
| 2. | **Issues and Options** | |
| | Design population<br>Design wastewater flows | Maximum number of users of the public toilet<br>Standard design unit flow factors |
| | Regulatory approvals | Any applicable rules and timeframes for consents |
| | Issues & risks assessment | Local environmental issues, soil types and performance of other systems in locality from records, if available |
| | Options identification & comparisons | Examples of appropriate technology solutions and suitable design guide refer report<br>http://www.pacificwater.org/_resources/article/files/Fiji%20report%202009%20Final.pdf<br>http://iwlearn.net/iw-projects/3181/reports/an-option-for-wastewater-reuse-in-the-pacific-islands/at_download/file<br>http://www.pacificwater.org/userfiles/file/TR0288.pdf |
| | ***Output: Solution concept*** | |
| | | |
| 3. | **Site Investigations** | ***Assume jetty- beach or causeway example*** |
| | Land application method & location | Soil types and depths, groundwater depth and surface water runoff patterns and water bodies, topography; sensitive receivers and site |

| | Stage / objectives | Required Information |
|---|---|---|
| | | risks e.g. flooding |
| **3** | Treatment plant location | Potential locations and constraints at the site |
| | ***Output Information to enable design*** | |
| | | |
| **4.** | **Concept development** | |
| | System process design and sizing | Suitable design guide; locally available materials and products. |
| | ***Output: Concept design*** | |
| | | |
| **5.** | **Regulatory approvals** | |
| | Approval from Department of Environment as required after lodging Screening Application.<br>Building Permit from relevant local authority | With lodgement of the Screening application, the approving authority will make a decision on whether or not an EIA report is required.<br>Any information needed for completing applications if not already obtained. |
| | ***Output: Required regulatory approvals*** | |
| | | |
| **6.** | **Procurement: detailed design, construction & commissioning** | Suitable form of specification and drawings; identify a model set. Options include:<br>Detailed design / tender / build<br>Concept design and performance requirements than enable use of proprietary systems e.g.<br>www.biogill.com<br>http://www.reaman.co.nz/projects.html#<br>Standard detail/specification for jetties |
| | ***Output*: *An operational on-site system*** | |

## 5.2 Legislation and Regulations

Relevant legislation and regulations and identified requirements for wastewater are as follows.

***Fiji Public Health Act***
The Public Health Act states, under Part III (Buildings), that sanitary conveniences of buildings are to be either connected to a sewerage system, where available, or a septic tank[3].

The Public Health Act and Local Government Act do not apply to Fijian villages as they are governed by the Fijian Affairs Act. This Act also does not have requirements for village households to have septic tanks.

***Sewerage (Amendment) Act 1974***
No sewer connection to be connected without approval.

***Environment Management Act 2005***
A facility operated by the government, including the Fiji Road Authority (FRA), or operated commercially, such as a restaurant, industry, mine, animal farm, workshops or resort, needs to apply for a permit in order to discharge liquid or solid waste to the environment.

The Act includes provisions for an Environmental Impact Assessment (EIA). An EIA is required for a proposed activity that is likely to have significant adverse impact on the environment.

The flow chart of the EIA process is in Attachment B.

MWH has prepared a report[4] that provides a summary of the Environmental Impact Assessment process required under Fiji legislation, which the FRA is obligated to follow as part of the refurbishment or new construction of roads, bridges and jetties.

***Building Regulations***
Local authorities may have building approval requirements. For example, the Savusavu Town Council requires that it gives its permission for a development. A copy of its application form for development permission is provided in Attachment C.

## 5.3 Design Guidelines and Standards

***Fijian Guidelines and Standards***
The NBC for the Fiji Islands provides guidance for the sizing and the structural design of septic tanks for dwellings and outbuildings (Specification 2.1; Annexure 2) and for public buildings and group dwellings.

The NBC provides guidance on the number of toilets in Table NF2.3.

Building Class 9b Sporting Venues etc. should be adopted for design except where the regulatory authority requires otherwise. The provisions for spectators are:

| | |
|---|---|
| Males | 1 closet fixture per 250 people |
| | 1 urinal per 100 people |
| Females | 1 closet fixture per 75 people |

The basis of design is:

- 1 unisex toilet for waiting sheds serving up to 75 people per sailing
- 1 male toilet and 1 female toilet for waiting sheds serving up to 150 people per sailing
- 1 male toilet and 1 female toilet for waiting sheds + 1 unisex toilet for waiting sheds serving up to 225 people per sailing
- 2 male toilets and 2 female toilets for waiting sheds serving up to 300 people per sailing.

The Code provides guidance on toilet requirements for disabled people.

[3] Fiji National Liquid Waste Management Strategy and Action Plan, August 2006

[4] Environmental Impact Assessment of Road, Bridge and Jetty Projects (DRAFT), December 2013.

Guidance needs to be sought about any requirements for disabled people from the applicable regulatory authority.

The Code was published in 1990. Compared with the New Zealand Building Code provisions (which nominates AS/NZS 1547: 2012 *On-site Domestic Wastewater Managemen*t as the verification method for on-site systems), the Fijian Code is significantly out of date, particularly with respect to sizing septic tanks and soil disposal areas (likely to undersize these) and by including soak pits (which are regarded as not good practice except in special circumstances).

***New Zealand Guidelines and Standards***
Prior to the use of New Zealand Building Code and New Zealand Standards, permission of the FRA must be received on a case by case basis.

The New Zealand Building Code gives Sections 5.1 to 5.5 and 6.1 (and associated appendices) of AS/NZS 1547: 2012 *On-site Domestic Wastewater Managemen*t as the verification method for on-site systems. This standard includes unit flow factors for single dwellings and other facilities, a method for sizing septic tanks and soil soakage fields, and septic tank effluent loading rates for different soil types.

Related standards are:

AS/NZS 1546.1: 2008 *On-site Domestic Wastewater Treatment Units part 1: Septic Tanks*
AS/NZS 1546.2: 2008 *On-site Domestic Wastewater Treatment Units part 2: Waterless Composting Toilets*
AS/NZS 1546.3: 2008 *On-site Domestic Wastewater Treatment Units part 3: Aerated Wastewater Treatment Systems*

## 5.4 Other Information

Other important information includes:

- soils maps
- topographical maps
- hazards maps, particularly flooding
- suppliers of materials and products (e.g. pipe, prefabricated septic tanks, package plants).

Such information should be collated and utilised. Sources of information include:

- government departments include Department of Environment, Ministry of Health, and local councils
- South Pacific Regional Environmental Programme (SPREP)
- Pacific Islands Geoscience Commission (SOPAC)
- Landcare New Zealand, soils information
- GNS New Zealand, geological information
- Foundation for the Peoples of the South Pacific International
- Fiji School of Medicine
- Institute for Applied Science at the University of the South Pacific (IAS-USP)
- UNESCO- Institute for Water Education.

A useful reference about onsite wastewater management and associated issues is *Review and Recommendations for Reduction of Nitrogen Export to the Coral Coast of Fiji*, NIWA 2004.

Manufacturers of septic tanks include:

Humes Industries, Hume Street, Lami. P.O Box 133, Suva, Fiji Islands.
Tel: (+679) 336 1755
Fax: (+679) 336 1419

# 6 Standard Design Procedure

The procedure for planning and designing an on-site system comprises:

- Project Manager (PM) identifying the need for the planning and design of an on-site system
- Specialist/s working with the PM and characterising the requirements for the on-site system (e.g. gathering information about wastewater generation and the environment in which it will be installed)
- Specialist/s working with PM and providing specified deliverables.

A standard procedure, which follows the stages given in Table 5.1, is presented as Table 6.1. Forms are provided in Attachment D to assist with the gathering and recording of information. Table 6.1 correlates information requirements and forms.

**Table 6-1: Procedure, Responsibilities and Associated Forms**

| | Stage | Responsible Person | Forms / Outputs / References |
|---|---|---|---|
| **1.** | ***Defining needs & strategic planning*** | **PM** | **Task Plan** |
| | What are the needs?<br>Where site and what is its area? | | Generator information Form D1<br>Desktop Study Form D2 |
| | Are there known sensitive receivers? | | Generator information Form D1 |
| | Are there solutions other than an onsite system? e.g. pump to sewerage | | Generator information Form D1 |
| | What regulations are applicable? | | See 2 below |
| | ***Output: Confirm type of solution*** | | |
| **2.** | **Issues and Options** | **Specialist** | |
| | Design population<br>Design wastewater flows | | Generator information Form D1<br>Unit flow factors from AS/NZS 1547: 2012 *(note 1)* |
| | Regulatory approvals | | |
| | Screening approval<br>Environmental Impact Assessment (EIA) – *if required following screening application* | | Screening Application needs to be submitted to the Department of Environment (DoE). |
| | Building Permit | | Refer to local council requirements |
| | Issues & risks assessment | | Generator information Form D1; |
| | | | Desktop Study Form D2 |
| | Options identification & comparisons | | Adopted design guide *(note 1)* |
| | ***Output: Solution concept*** | | |
| **3.** | **Site Investigations** | **Specialist** | **Site Investigation Form D3** |

| | Stage | Responsible Person | Forms / Outputs / References |
|---|---|---|---|
| | Land application method & location | | Generator information Form D1 |
| | Treatment plant location | | Desktop Study Form D2 |
| | | | Bore log Form D4 |
| | ***Output Information to enable design*** | | |
| **4.** | **Concept development** | **Specialist** | **Forms D1, D2, D3** |
| | System process design and sizing | | Adopted design guide *(note 1)* |
| **5.** | **Regulatory approvals** | **Specialist** | **Application/s for approval/s** |
| | ***Output: Required regulatory approvals*** | | Refer to 2 above |
| **6.** | ***Detailed design, construction and commissioning*** | **Specialist** | **Specifications and Drawings** |
| | ***Output: An operational on-site system*** | | Adopted design guide *(note 1)*<br>Adopted form of specifications |

**Note:**

1. Use only with written permission of the FRA

# Attachment A: Photos of Vault Toilets

**Figure A1: Vault Toilet Interior New Zealand**

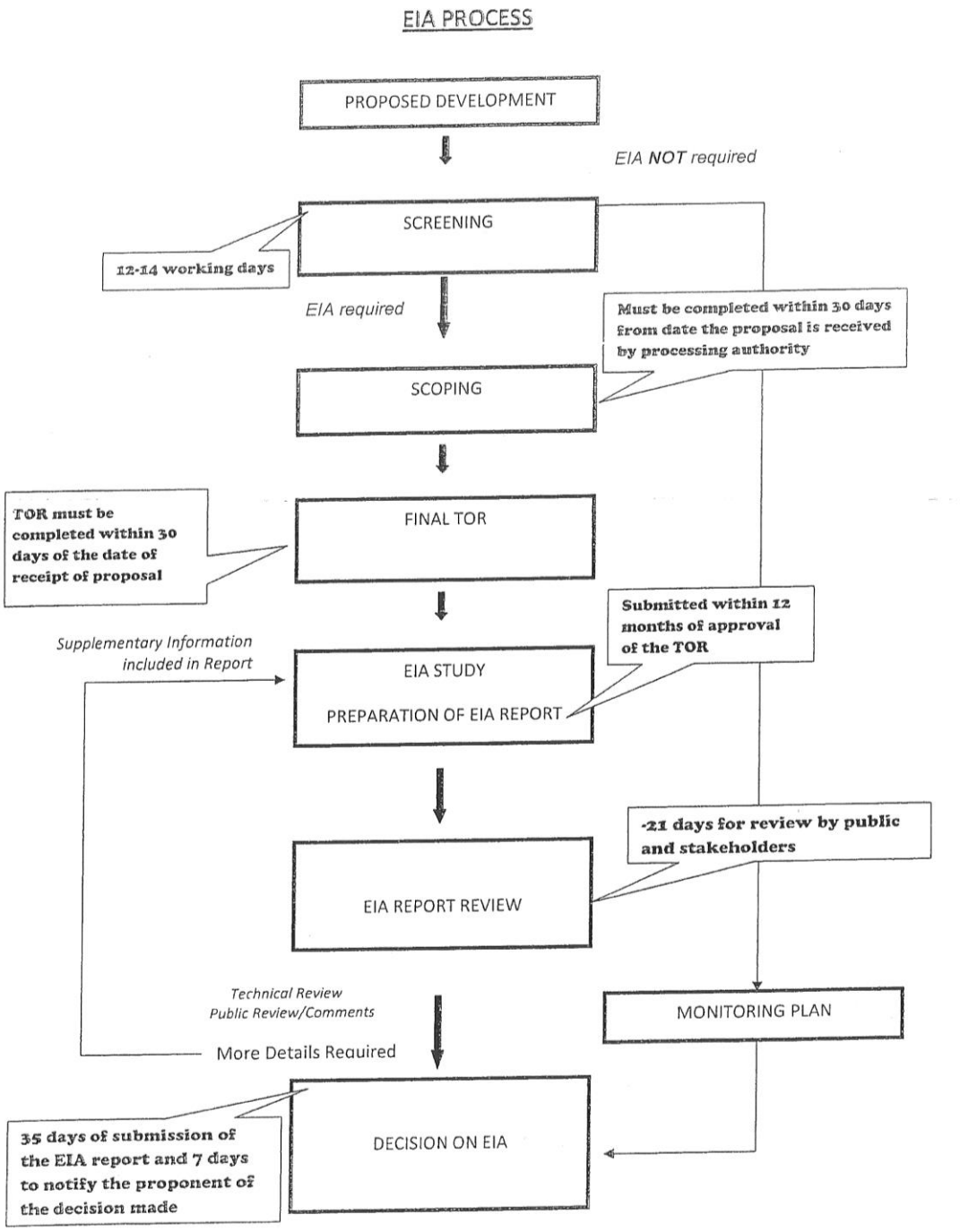
**Figure A2: Single Vault Toilet New Zealand**

**Figure A3: Multiple Vault Toilet New Zealand**

**Figure A4: Multiple Vault Toilet New Zealand**

**Figure A5: Vault Toilet USA**

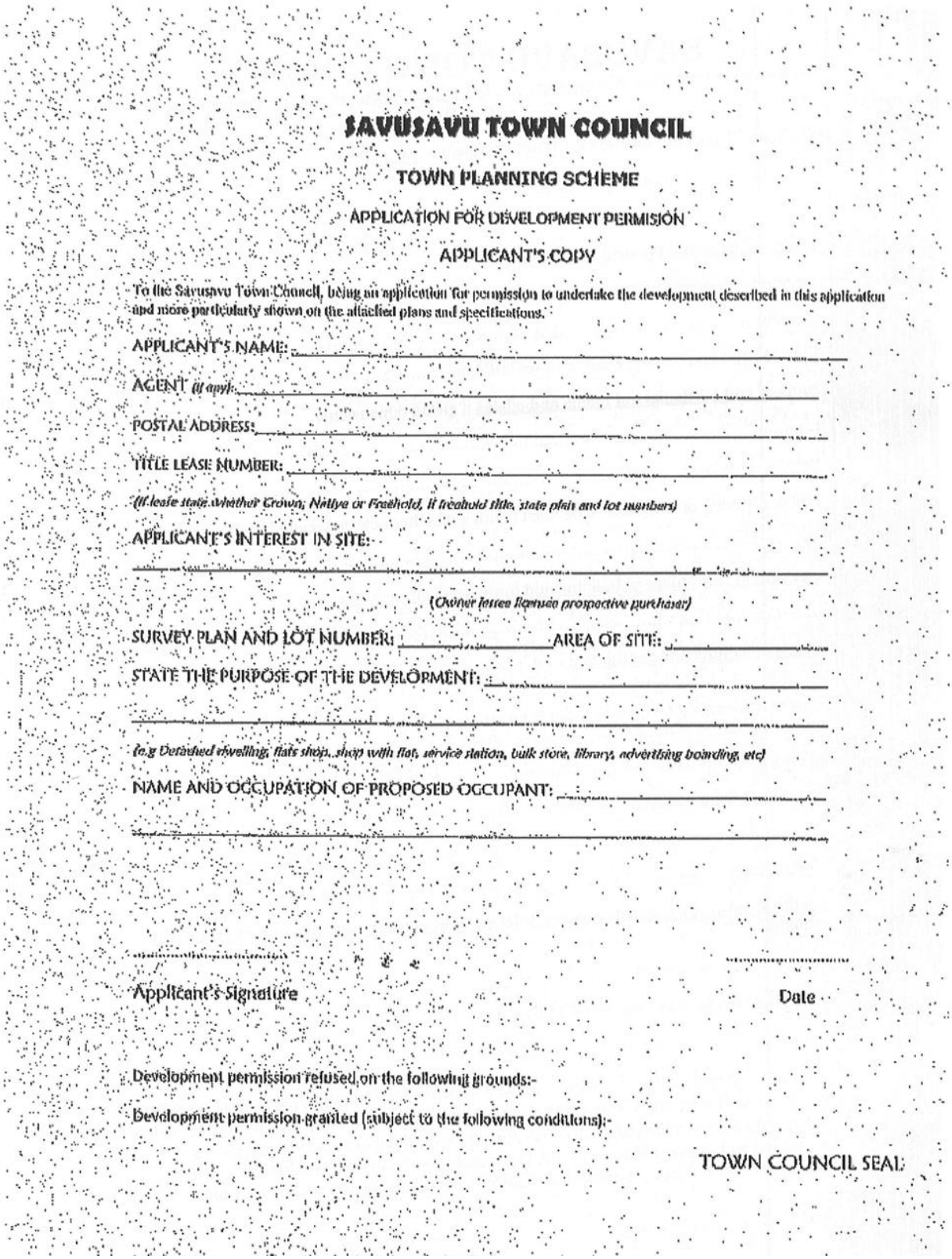
# Attachment B: Flow Chart of EIA Process




Note:

TOR = Terms of Reference

# Attachment C: Savusavu Town Council - Application Form for Permission for a Development



**SAVUSAVU TOWN COUNCIL**

**TOWN PLANNING SCHEME**

APPLICATION FOR DEVELOPMENT PERMISION

APPLICANT'S COPY

To the Savusavu Town Council, being an application for permission to undertake the development described in this application and more particularly shown on the attached plans and specifications.

APPLICANT'S NAME: _____

AGENT *(if any)*: _____

POSTAL ADDRESS: _____

TITLE LEASE NUMBER: _____

*(If lease state whether Crown, Native or Freehold, if freehold title, state plan and lot numbers)*

APPLICANT'S INTEREST IN SITE:

_____

*(Owner lessee licensee prospective purchaser)*

SURVEY PLAN AND LOT NUMBER: _____ AREA OF SITE: _____

STATE THE PURPOSE OF THE DEVELOPMENT: _____

_____

*(e.g Detached dwelling, flats shop, shop with flat, service station, bulk store, library, advertising boarding, etc)*

NAME AND OCCUPATION OF PROPOSED OCCUPANT: _____

_____

.....  .....

Applicant's Signature  Date

Development permission refused on the following grounds:-

Development permission granted (subject to the following conditions):-

TOWN COUNCIL SEAL

# Attachment D: Investigation Forms

| | |
|---|---|
| Generator information Form | **D1** |
| Desktop Study Form | **D2** |
| Site Investigation Form | **D3** |
| Bore Log Form | **D4** |

# D.1 Generator Information Form

**COMPLETE ONE FORM FOR EACH ON-SITE SYSTEM**

**Generator Information and Contact Details:**

Name: _____

Street Address: _____

Postal Address: _____

Phone: _____Email: _____

Proposed development: _____

Nearest sewerage scheme: _____

Property size/area: _____

## Wastewater Generation Details:

***Water supply type***: Roof water tank / Rural scheme / Urban scheme / Bore (circle answer)

***Design Usage of Toilets:***

Max No. per sailing: _____

No. of sailings per day No. of sailings per week

*Public toilets*

Design occupancy: Estimated total no. people/day:

***Information about Existing Toilets and On-site System:***

Connections: Black water (toilet)
(circle answer) Grey water (basins, shower)

Septic Tank Information: (if more than 1 tank record size of each)

Tank Size_____$m^3$ Tank Material_____

No. of Tanks: _____

Location_____

Depth below ground_____

Tank last cleaned: 0-1yr 1-5yr 5-10yr 10+yr (circle answer)

***Additional Treatment Information:***

Method: Aerated Secondary Treatment
Oxidation Pond
Sand Filtration System
Other (circle answer)

Capacity of System_____

Dimensions of system_____

***Disposal Information:***

Capacity/Dimensions: _____

Method: Soakhole (Vertical well in ground)
Drainage field (buried pipes or field tiles that drain over an area)
Surface spray irrigation

Other (circle answer)

If other, then specify: _____

Dimensions: _____

Dosing Method: Pump Dosed

Gravity Flow (circle answer)

Location: _____

***Records, if Available***

Does the system have a regulatory approval? If yes, provide copies.

Provide a copy of site plan, as built plans for onsite system, and relevant correspondence with regulatory authority if available.

***Maintenance and Monitoring Information, if Available***

Provide a copy of current maintenance and monitoring procedures and records for the treatment and disposal system.

***Problems***

Have problems been experienced with odours from the onsite system? Yes / No. If Yes, explain

_____

_____

Have problems been experienced with ponding or surface flooding at disposal field? Yes / No; if Yes, explain

_____

_____

***Stormwater and Surface Water Runoff Information (e.g. roof water, pavement runoff), if Known***

Describe management system(s) and disposal method(s).

_____

_____

_____

## Services: If Known

Describe and show on plan the location of:

- Wastewater pipes
- Stormwater pipes, drains etc.
- Electrical services
- Phone/Communications services
- Water supply services

## Soil Information: If Known

What is the soil type of the site? (e.g. clayey, gravelly, sandy, peat)

_____

_____

How deep are limiting horizons (e.g. clay layers, hard pans), if any?

_____

_____

## Hydrogeological Information: If Known

Is there any watercourse, spring or well close to the site?

_____

_____

Is there any watercourse, spring or well within 50m from the site?

_____

_____

What is the depth of the ground water table?

_____

_____

## Flooding

Has flooding of the site been reported? If yes, provide information about source, depth and extent of flooding.

_____

_____

## D.2 Desk Top Study Form

| | | | |
|---|---|---|---|
| **Project Name:** | | **Project Number:** | |
| **Prepared by:** | (name) | | (signature) (date) |
| **Reviewed by:** | (name) | | (signature) (date) |

| | |
|---|---|
| ***1 Site Information*** | |
| Client Name | |
| Physical Address | |
| Certificate of Title(s) & Legal description(s) | |
| Grid reference, or longitude and latitude for jetty | |
| Previous relevant site investigations, reports and correspondence with regulators | |
| ***2 Regulatory Information*** | |
| Approvals required (list) | |
| | |
| | |
| | |
| Regulatory requirements e.g. | Separation distances to surface water |
| | |
| Distance of nearest sewerage scheme | |
| ***3 Site Environment*** | |
| ***Site Maps*** | |
| Aerial photograph attached | *Y/N* |
| Topographic map attached | *Y/N* |
| Site Development Plan attached | *Y/N* |
| Site Drainage Plan attached | *Y/N* |
| ***Soil type and major soil considerations*** | (reported information e.g. soil maps) |
| Soil category/categories and structures (AS/NZS 1547)[5] | |
| Any limiting horizons expected (e.g. hard pans, impermeable layers) | |

[5] Use AS/NZS 1547 as the appropriate standard in default of an applicable Fijian guide

| | |
|---|---|
| Indicative soil drainage expected at site[6] | |
| ***Geology of site*** (from geological map series) | |
| Likely nature and depth to bedrock | |
| ***Topography*** (from topographic map) | |
| ***Climate*** | |
| Annual rainfall (mm) | |
| Annual evaporation (mm) | |
| Seasonal Soil Moisture Content (%) i.e. winter, summer, episodic | |
| General comment (rainfall intensities, seasonal variation, etc.) | |
| ***3 Site Environment (continued)*** | |
| ***Groundwater*** | |
| Location, depth and use of wells and groundwater bores within 1km (record location on Site Plan) | |
| Information about depth to seasonal groundwater i.e. winter, summer, episodic | |
| Local groundwater flow direction | |
| Likelihood of groundwater use | |
| Is underlying aquifer sensitive? (e.g. unconfined, gravels or sands) | |
| Describe hydrogeology | |
| ***Surface Water – Natural watercourses*** | |
| Location, description and use of surface water bodies within 50m of site boundary | |
| Flood potential, flood frequency and levels | |
| Local surface water flow direction | |
| ***Surface Water – Man made watercourses*** | |
| Location of any drainage infrastructure on site (record location on Site Plan) | |
| Main surface drainage/runoff patterns on site | |
| **Local water supply** | |
| Location and nature of water source for site (e.g. reticulated, roof water tank, bore) (record location on Site Plan) | |
| Location and nature of water source | |

[6] Refer to AS/NZS 1547 or obtain specialist advice

| | |
|---|---|
| for neighbours | |
| **Existing Infrastructure** (record locations on Site Plan) | |
| Location of nearest stormwater drain or pipe | |
| Location of existing dwellings, on-site systems | |
| Any issues with on-site systems less than 10 years old | |
| Existing and planned buildings on site | |
| Location of any underground services (e.g. stormwater, wastewater, water, power, phone, fibre optic, gas, petroleum) on site | |
| **Site History** | |
| Attach information if available | |
| **Natural and Social Environment** | |
| Sensitive ecosystems and receptors within vicinity of site | |
| Nature of terrestrial environment (vegetation, surface covering, wildlife) | |
| Neighbouring land use | |
| ***4 Assessment of Soils Investigation Requirement*** | |
| No. of bore holes and proposed locations (attached site plan) | |
| ***5 Existing System Information and Assessment of On-site System Investigation Requirements (if applicable)*** | |
| Completed Generator information sheet attached | *Y/N* |
| Information provided by client checked for completeness | *Y/N* |
| Does system have regulatory approvals | *Y/N* |
| As built drawings attached | *Y/N* |
| Type of on-site system (basic, advanced, advanced with drainage) | |

# D.3 Site Investigation Form

| | | | |
|---|---|---|---|
| **Project Name:** | | **Project Number:** | |
| **Prepared by:** | (name) | (signature) | (date) |
| **Reviewed by:** | (name) | (signature) | (date) |

| | |
|---|---|
| *Desktop Study Attached* | *Y/N* |
| *Soil Category (1-6)*[7] | *1-6* |
| *Technical reviewer confirmed Risk Category* | *Y/N* |
| *Subsurface services location checked* | *Y/N* |
| *MWH Health and Safety plan sighted, signed and on-site during investigation* | *Y/N* |
| *Personal Protective Equipment (PPE) Required* | *Mandatory: High visibility vest, steel cap boots, hard hat*<br>*May be required: Sunglasses (for dust), sunblock, rubber gloves)* |

**ALL INFORMATION ON THIS SHEET MUST BE FILLED OUT.**

**IF A SECTION IS LEFT BLANK, AN EXPLANATION MUST BE GIVEN.**

| ***1 Site Information*** | |
|---|---|
| Client Name | |
| Physical Address of Site | |

| ***2 Equipment Checklist*** | |
|---|---|
| General | Camera, PPE (above), Health and Safety Plan, |
| Information recording | Copy/s of site plans; ***pencil, waterproof paper, clipboard*** |
| Soil investigation | Spade, soil auger,Tape measure, rubber gloves, plastic bags (for soil samples), vivid marker, spray paint (for numbering test pits), pencil, shovel or trowel, waterproof paper, clipboard |

### 3.0 ON-SITE EVALUATION

### 3.1 Work Undertaken

Details:

Date:

Weather (on day and preceding week):

[7] Based on AS/NZS 1547: 2012

Photocopy of desktop study and site plans attached: YES/NO

**3.2 Site Boundaries and Land Use**

Boundaries identified: YES/NO (Delete one)

Existing buildings: details marked up on attached site plan

Current land use:

_____

Past land use:

_____

Waterways:

_____

**3.2 Topography**

Slope:

_____

Groundcover:

_____

Geology confirm: YES/NO (Delete one)

Soil landscape confirmed: YES/NO (Delete one)

Drainage patterns: details marked up on attached site plan

Waterways:

_____

**3.3 Site exposure**

Site aspect:

_____

Pre-dominant wind direction:

_____

**3.4 Environmental concerns (**e.g.: lagoon water and nutrients, native plants intolerant of phosphorus load, high water-table, swamp, waterway etc.):

_____

**3.5 Site Stability**

Is expert assessment necessary? YES/NO (Delete one)

**3.6 Drainage controls**

Depth of seasonal water-table: *Winter*……mm; *Summer*…….mm; .*Perched*…..mm

Need for surface water cut-off drains/diversion banks?

**3.7 Photographs attached**: YES/NO (Delete one)

**3.8** **Site sketch attached**: YES/NO (Delete one)

*mark available areas for land application*

## 4 SOIL INVESTIGATION

**4.1** **Soil profile determination** (refer to Bore Log Form, D4)

Method: Test pit/ Borehole

Other (specify)

**4.2** **Indicators of poor drainage** (supported with notes and photos):

Type of foliage YES/NO (Delete one)

Soil mottling YES/NO (Delete one)

Soil gleying YES/NO (Delete one)

**4.3** **Reporting**: (Attach detailed soil/report as appropriate)

**4.4** **Estimated Soil Category (from AS/NZS 1547: 2012)**:

Summary:

| Site test | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Soil category | | | | | | | |

Remarks:

**4.4** **Recommended Soil Design Loading Rate (DLR)**[8]

Reasons for DLR recommendations:

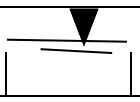
## 5.0 GENERAL COMMENTS

[8] Refer to AS/NZS 1547: 2012

# D4 Bore Log Form

| | | | | | | |
|---|---|---|---|---|---|---|
| MWH | | | **LOG OF BOREHOLE** | Job No: | | |
| | | | | Hole No: | | |
| | | | | Sheet: | | |
| Client: | | | | Started: | | |
| Project: | | | | Finished: | | |
| Location: | | | | Logged By: | | |
| Test Method: Excavator | | | | RL Surface: | - | |
| Borehole Dimensions[1]: 1.5mx1mx 2.5m deep | | | | Datum: | - | |
| General Observations & comments (e.g. weather, odours): fine, no wind | | | | | | |
| Depth (m) | | Description | | Moisture Condition | Groundwater | Comments - notes, structure and additional observations, sample taken |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **1. Minimum dimensions for borehole: 2m deep, 1.5m long x1m wide. First 1m of borehole must be either scraped out slowly using an excavator or excavated by hand using a spade or shovel.** | | | | | | |
| **2. Describe soils and rocks using "Guidelines for the Field Description of Soils and Rocks in Engineering Use" (New Zealand Technical Society)** | | | | | | |
| | | | | | | |

# Bore Log Example

| | | | | | | |
|---|---|---|---|---|---|---|
| MWH | | | **LOG OF BOREHOLE** | Job No: | z1256700 | |
| | | | **EXAMPLE** | Hole No: | Test Pit 1 | |
| | | | | Sheet: | 1 of 1 | |
| Client: | D. G. Hatfield & Associates | | | Started: | 24-Aug-05 | |
| Project: | Jacks Bay Subdivision: On-site Sewage Disposal | | | Finished: | 24-Aug-05 | |
| Location: | Jacks Bay, Catlins | | | Logged By: | Dusk Mains | |
| Test Method: Excavator | | | | RL Surface: | - | |
| Borehole Dimensions[1]: 1.5mx1mx 2.5m deep | | | | Datum: | - | |
| General Observations & comments (e.g. weather, odours): fine, no wind | | | | | | |
| Depth (m) | Graphic Log | Description | | Moisture Condition | Groundwater | Comments - notes, structure and additional observations, sample taken |
| **0** | | TOPSOIL- Loamy sand, loose, | | Dry | | |
| | | medium sand with some gravel, black | | | | |
| | | | | | | |
| | | SAND- loose medium sand | | Moist | | |
| | | | | | | |
| **0.5** | | | | | | |
| | | | | | | |
| | | Bouldery SAND- large boulders up to 0.8 m | | Moist | | |
| | | in a sandy (medium-coarse sand) matrix | | | | |
| | | loose, moist | | | | |
| **1** | | | | | | |
| | | | | | | |
| | | | | |  | |
| | | | | | Groundwater | |
| | | | | | South Side | |
| **1.5** | | | | | 1.2m | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| **2** | | | | Groundwater | |
| | | | | North Side | |
| | | | | 2m | |
| **2.5** | | | | | |
| | | ROCK- Murihiku sandstone and siltstone | | | |
| | | | | | |
| | | Pit terminated at 2.5 m | | | |
| | | | | | |
| | | | | | |
| | | Notes:<br>1) Groundwater entering pit at 1.2 m (below ground level) on south side and 2 m on north side<br>2) Pit walls loose | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **Notes:** | | | | | |
| **1. Minimum dimensions for borehole: 2m deep, 1.5m long x1m wide. First 1m of borehole must be either scraped out slowly using an excavator or excavated by hand using a spade or shovel.** | | | | | |
| **2. Describe soils and rocks using "Guidelines for the Field Description of Soils and Rocks in Engineering Use" (New Zealand Technical Society)** | | | | | |
| | | | | | |