“ River Gravel and Sand Extraction - lessons from Fiji’s experience necessitating development of a management guideline”

Navua -River Nakavu-2018

Development Minerals

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Why is a guideline required?

There is increasing evidence of environmental problems associated with rivers and streams with gravel and sand extraction.

Extraction of river gravel and sand has potential for serious impact on many aspects of the environment.

Legislative control on river gravel and sand mining are administered by a number of government regulators with little provision to address the cumulative effect of multiple operations on any one river or stream.

Management decisions must be based on the principle of sustainable development not only for gravel and sand resources but also for also for communities that use rivers and streams and the values that come with healthy rivers and streams.

It is also recognised that it is an economically important resource being the principal source for the Transport (roads) and construction industries

Issues related river and stream mining

Environmental Impacts

Areas of National diversity here important to ensure no mining activity in rivers that conflict with the aims of preserving biodiversity, wilderness areas, recreational and rural areas where rural communities depend on rivers and streams for subsistence resources

River geomorhology- increased erosion, channel change and re-alignment, increased sedimentation, changes in flood size magnitude and frequency , bridge infrastructure impacts, dwelling loss.

River bed and bank erosion – source and sink processes if a net loss due to mining occurs the river responds with erosion of bed, banks or both.
Excavation below riverbed level may lead to river bank erosion.
Cumulative impacts of more than one operator on any one river compound impacts and needs to be controlled.

Estuaries and tidal rivers and streams – turbidity , saline intrusion , restricted navigation.

Groundwater quality and quantity - excessive river mining can result in flood plain aquifer impacts with reduced groundwater recharge rates.

Siltation and turbidity release of fines during mining result in higher turbidity issues with navigation and negate the use of the river by rural communities.

Water Quality an increase in suspended solids and siltation have major impact on urban water supply by increasing costs for treatment and filtration In particular river and stream extraction in watershed reserves for urban center supply. Changes in river flow with over extraction can result in algae growth due to reduced flow velocities.

Vegetation and Riparian habitats loss of riparian habitats on flood plains, construction of road access to rivers, trees falling into rivers deflecting water flows and causing or aggravating erosional problems.

Pollution release of hydrocarbons products from mechanical diggers, trucks etc into the waterways.

OBJECTIVES OF SUCH A GUIDELINE

To ensure that extraction of gravel and sand from the States rivers and streams is done on a sustainable basis.

To ensure that the management of the extraction minimises any detrimental effects on the river and stream environments and fundamentally protects other rivers users and values.

Before

After

Images Credit MRD

That the river and stream mining guideline is consistent with the aims of other Government policies and initiatives. For example:

National Biodiversity Strategy and Action Plan for Fiji 2020-2025

Strategic Area SUD4: Reducing major threats to inland waters (watershed, streams, rivers and lakes)such as dredging, floods, gravel extraction, mining,agriculture, deforestation, tourism, sugar,manufacturing, waste management.

Objective SUD4: Establish locally managed areas protected areas and/or Ramsar sites, at priority catchments, wetlands and key biodiversity areas and strengthen EIAs for all forms of development activity in inland waters.

Strategic Area SUD5: Reduce major threats to Fiji's coastal ecosystems such as reclamation,unsustainable tourism development, river dredging and pollution.

Areas the GUIDELINE sets out to address

The EIA report: In the UNDP Development mineral report study it was found that out of 58 EIA reports reviewed only one addressed the issue of sustainability with respect to river gravel mining

Typically the EIA's are generic often reflect a lot of cut and paste-material with little relevance to the core purpose of providing data that can fundamentally be used for monitoring upstream and downstream effects of river gravel and sand mining activities and long term change.

Some of the short comings are:

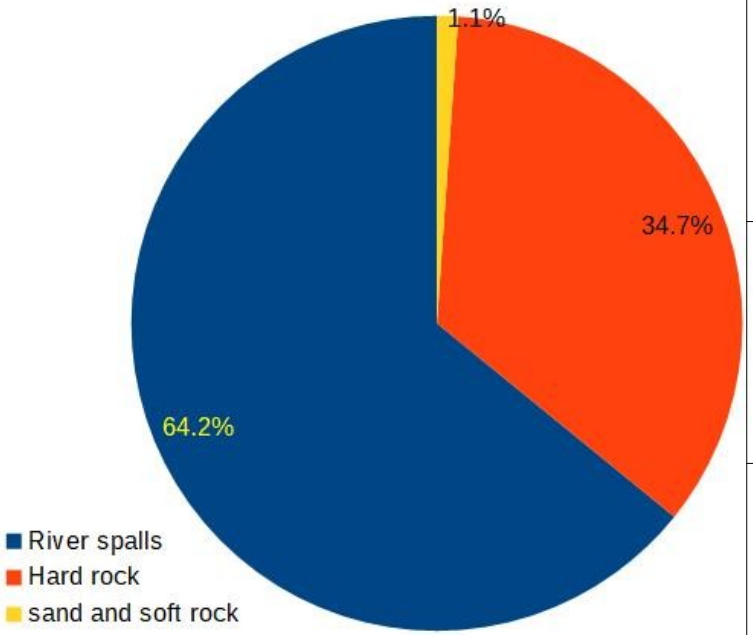
- Reports lack technical detail such as maps that detail the resource, are not to scale suitable for evaluation and do not record existing geomorhology and physical parameters such as river cross sections, depth as in bathymetry, aerial extent of gravel bars and sheets, river bed and river bank conditions.
- Do not recognize Infrastructure impacts or the potential impact off.
- Assessment of existing gravel deposits and river stability, flood plain channel re-alignment, increased sedimentation in estuarine zones.
- Accurate maps would prevent boundary problems, with cultural sensitives of LOU's and overlaps with multiple licenses on a single river system
- Limiting the number of extractors on a river system. Reports do not recognise that multiple licenses users on a single river, stream can compound problems and evaluation of the impacts perceived to have been caused by the extraction.
- Little or no assessment on bed load transport rates

The ability to monitor ; F**or the GUIDELINE to include such** measures and strategies implies an associated **COST to implement - and to who? - the State, Private sector or combination of both or paid through license process?**

A River Gravel and Sand Extraction Guideline 2021

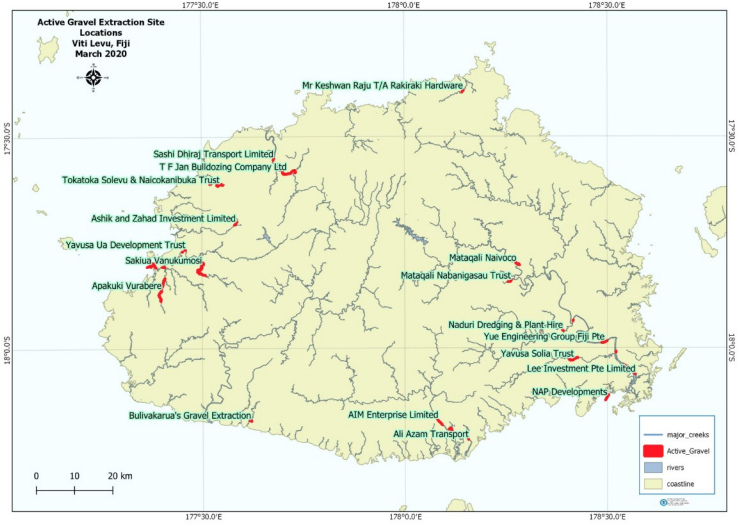
A River Gravel and Sand Extraction Guideline 2021

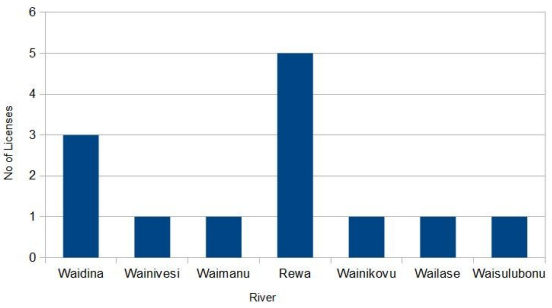
Aggregate production 2017

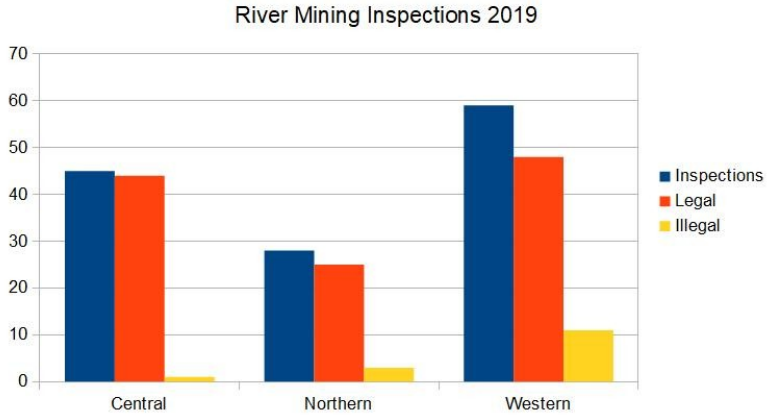


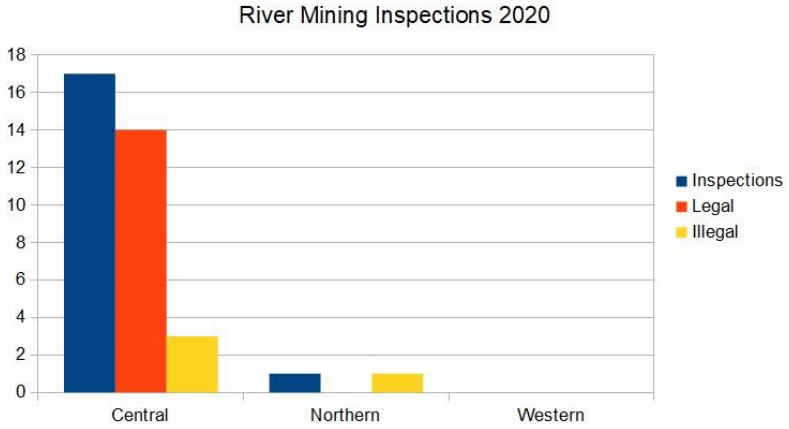
Product	Volume (m³)	Average price of various products per m³ (FJ$)	Estimated Value of Output (FJ$)
Various products (river extraction)	2,300,000	FJ$75	FJ$172.5M
Various products (hard rock quarries)	1,244,400	$100	FJ$124.4M
Various products (sand and soft rock quarries)	40,000	$35	FJ$1.4M
Gross Output			**FJ$298.3M**

Current river mining licenses and activity 2020-2021





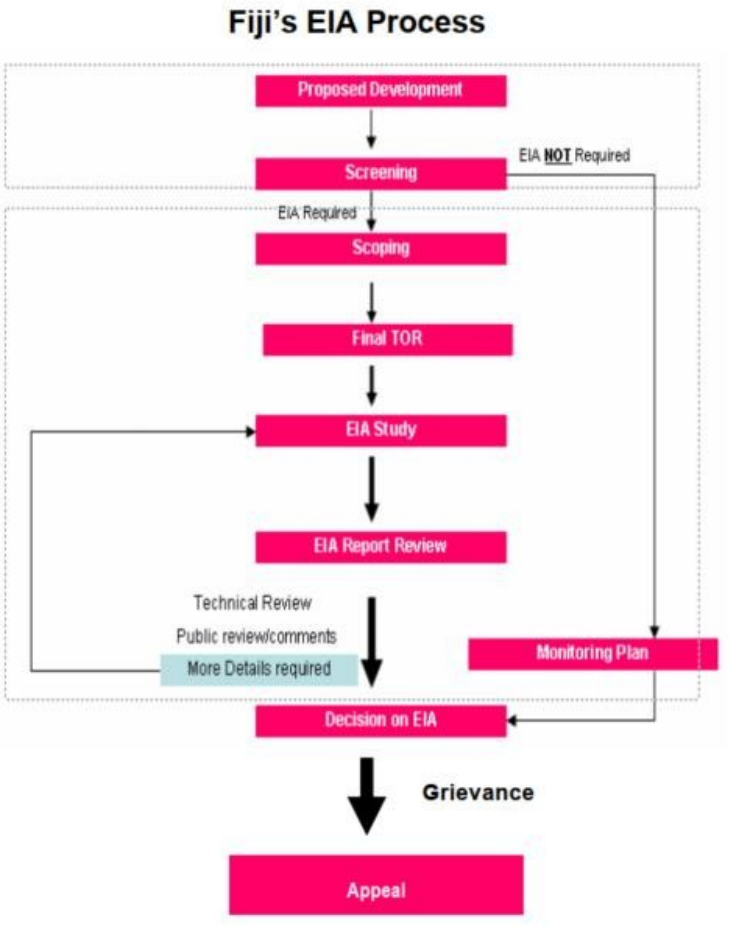




Social Impacts

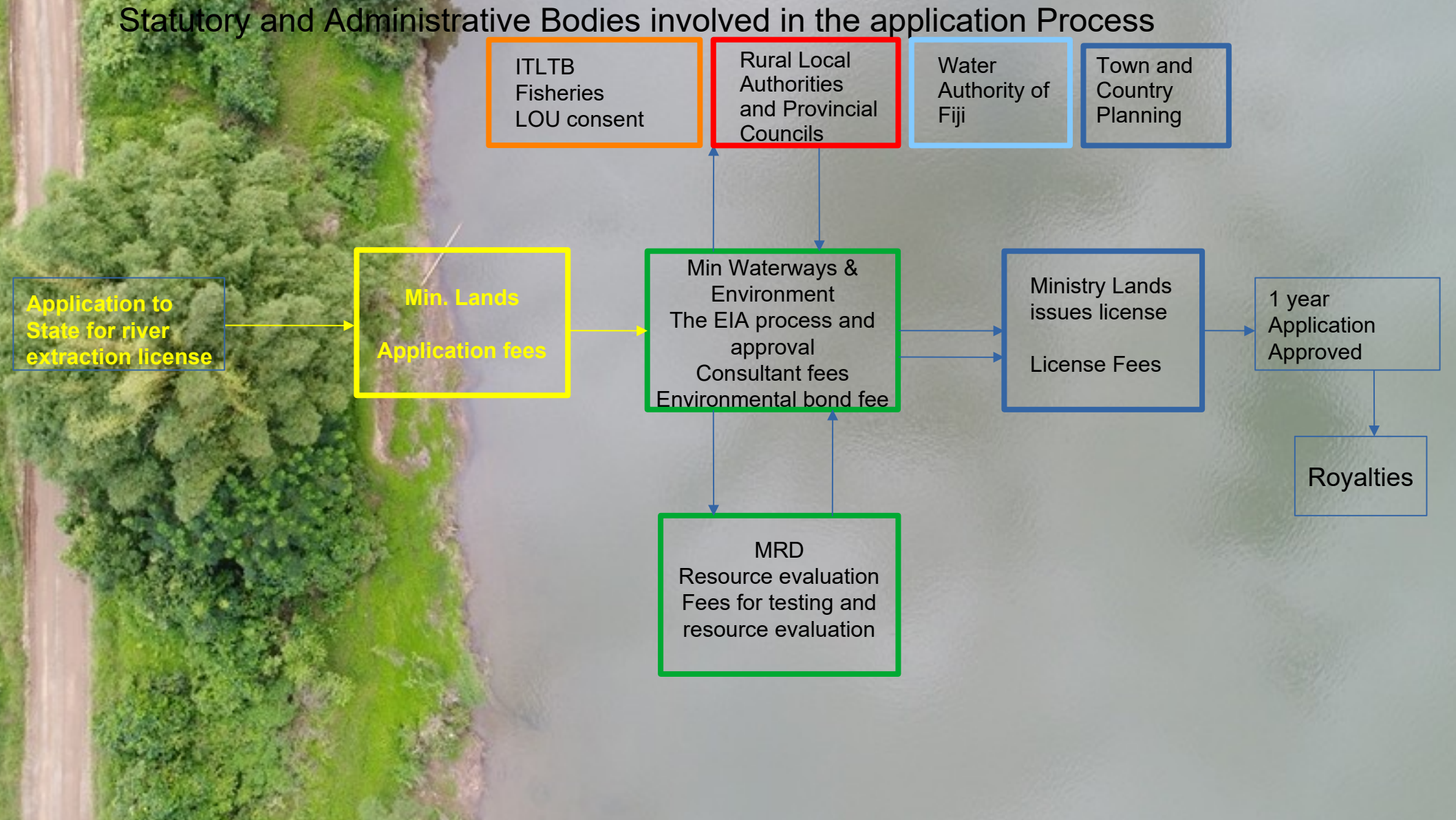
- Unsafe boat transport on river
- Depleted fisheries
- Sedimentation
- Contaminated drinking water
- Bathing/cleaning- hygiene and health issues
- Erosion and loss of land/agriculture
- Issues with royalty payments
- Lack of environmental compliance
- Lack of consultation- licensing and lease
- Resource ownership confusion- native vs state.
- Unclear process and regulatory framework

Chapter 3 The Statutory and Administrative Framework for river Extraction Management in Fiji



Fiji's EIA process as published in 2008 by the Department of Environment

Statutory and Administrative Bodies involved in the application Process



A River Gravel and Sand Extraction Guideline 2021

Chapter 4 River Gravel Management

Chapter 5 Principals to Mitigate Adverse Environmental Effects of Extraction on riverbeds, water quality and infrastructure

Chapter 6 Operational Guidelines for gravel and sand extraction

EIA Reports Lack technical DETAIL

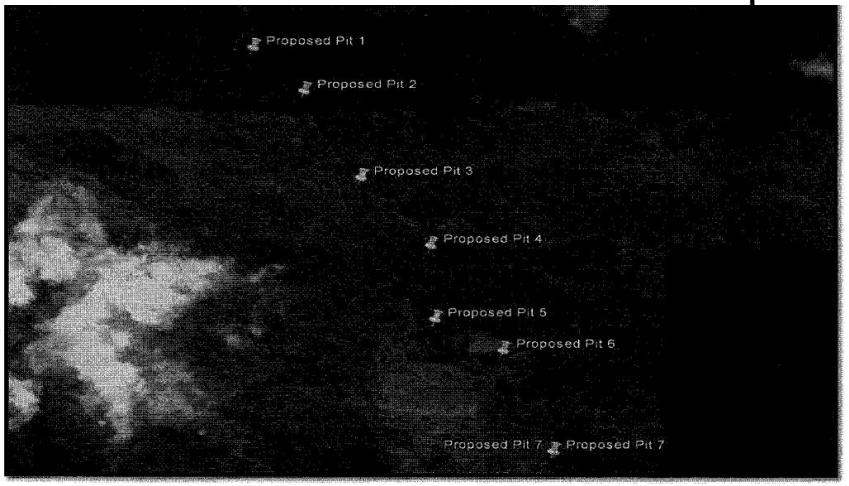


Photo 1: Ariel view of the 7 proposed gravel pit along the Waivou Stream. Source: Google Earth 2016

Wainibau crk

The proposed gravel extraction site is located along the Waivou Stream (between 17°43'49.71"S, 178°33'15.32"E and17°43'14.71"S, 178°33'08.52"E), at 8m to 33m above sea level approximately 6km South of Natovi Jety.

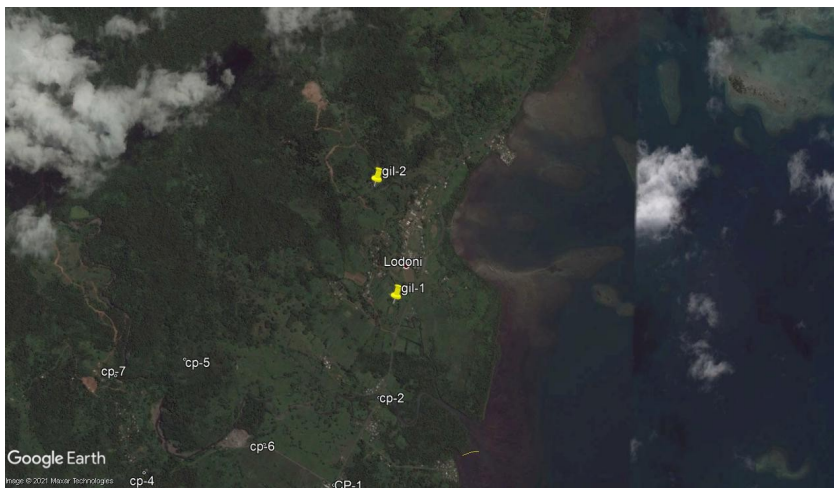
Gravel Pit	Estimated Volume (m^3)	Total Distance (m)
PIT 1	25 200	0.25
PIT 2	38 550	0.34
PIT 3	13 840	0.18
PIT 4	11 340	0.17
PIT 5	6 120	0.17
PIT 6	10 290	0.14
PIT 7	16 450	0.28
TOTAL	121 790	1.43

Table 1: Estimated aggregate potential for each proposed pit

	Average active width (m)	Average active width & flood plain (m)	Average depth (m)	Average water velocity (m/s)	Average high water mark (m)
Site 1	16	24	0.3	0.4	3
Site 2	9	27.6	0.45	0.8	2.5
Site 3	7.8	42.4	0.35	0.5	2.5
Site 4	13	20.4	0.42	0.6	2.5
Site 5	7.6	17	0.58	0.6	2.5
Site 6	9.4	27.8	0.56	0.5	2.5
Site 7	23	32.8	0.32	0.7	2.5

Table 9: Summary of the average width, depth and velocity of each of the 7 sites

In EIA 2017



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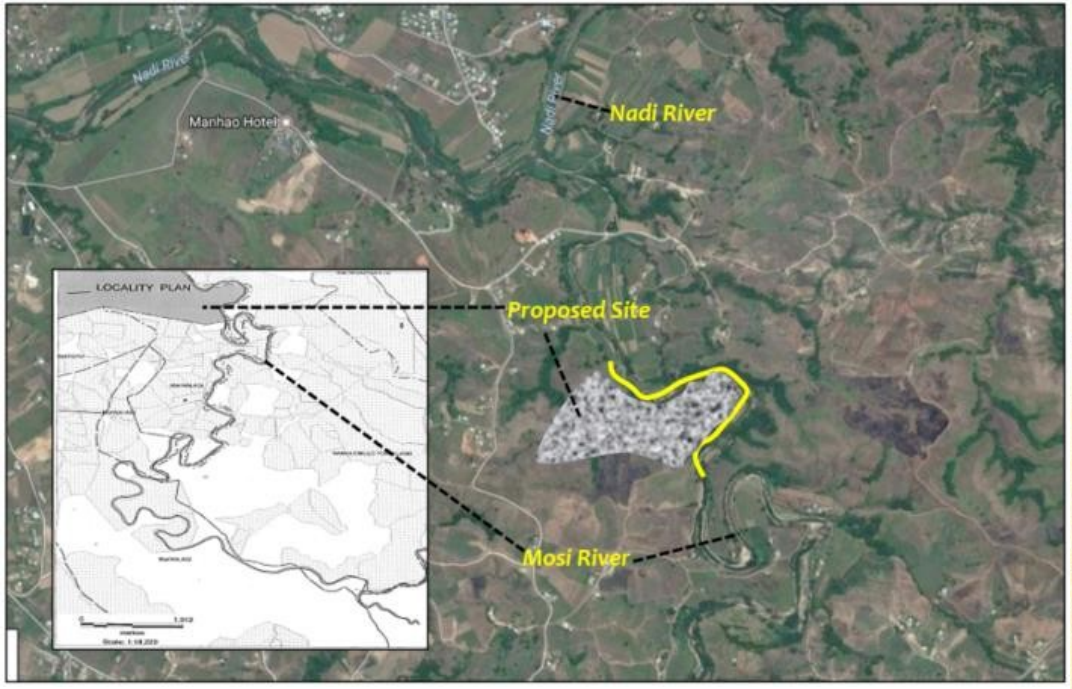
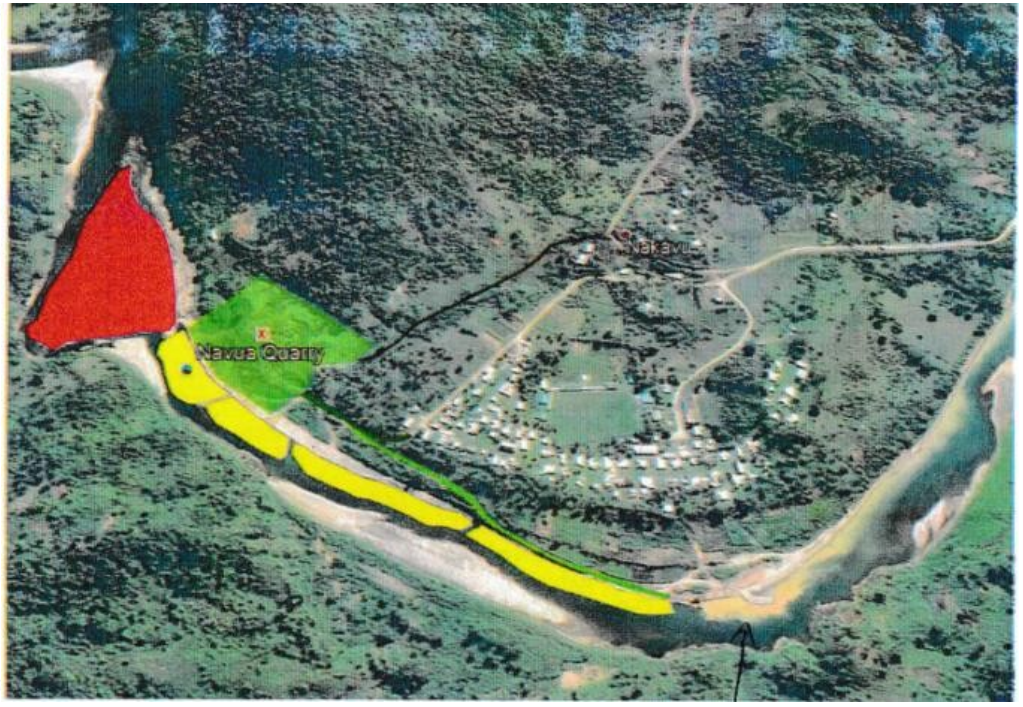
In EIA 2015

EIA report examples of resource maps for river excavation using mechanical digger





Whats wrong with these resource maps ??

Scale

Shaded area hides non existent resource??

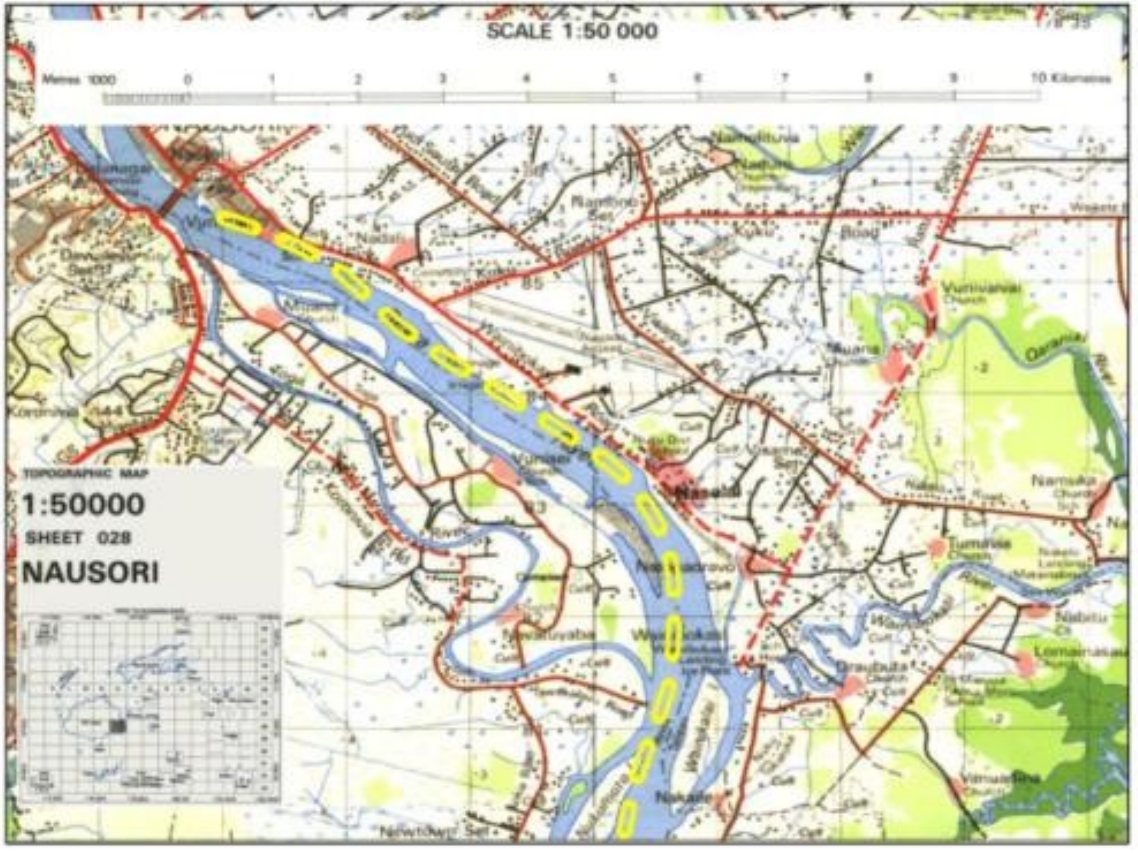

Nakavu-06-07-2017


Nakavu
Nakavu 20-06-2018

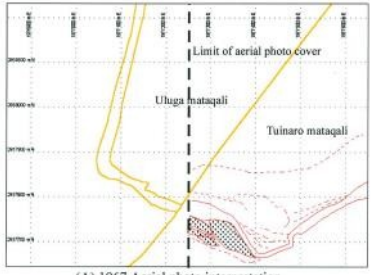

Nakavu
Navua River
Nakavu-10-03-2021


Nakavu Nov2022

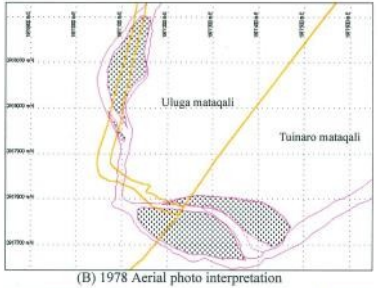
Example resource maps for river dredging from EIA reports



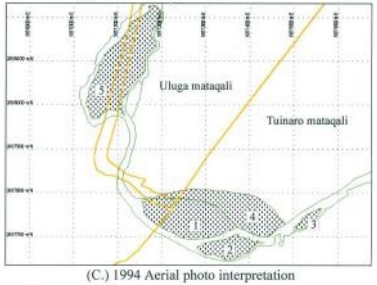
Poorly referenced and technical input into understanding resources and environment are non existent in EIA's which lead to LOU problems through misunderstanding CASE example Waivou River Tailevu



(A) 1967 Aerial photo interpretation



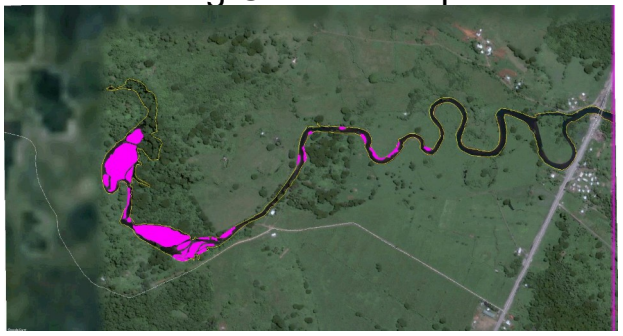
(B) 1978 Aerial photo interpretation



(C.) 1994 Aerial photo interpretation

Figure 4 Migration of gravel 1967, 1978 and 1994 at the Waivou Creek gravel resource site

From Rahiman T. 2002 MRD Note BP79/18



2004

2005

2011

2013

2014

2016

02-05-2018

Yellow outline of river represents river position in 2004

12-04-2021

From P-1 to bridge the river has shorten its course by 600 m since 2004

The closure of a number of meanders potentially removed a reservoir volume of around 50-100,000 m^3 for floods, sediment catchment resulting in increased estuary sedimentation and village flooding

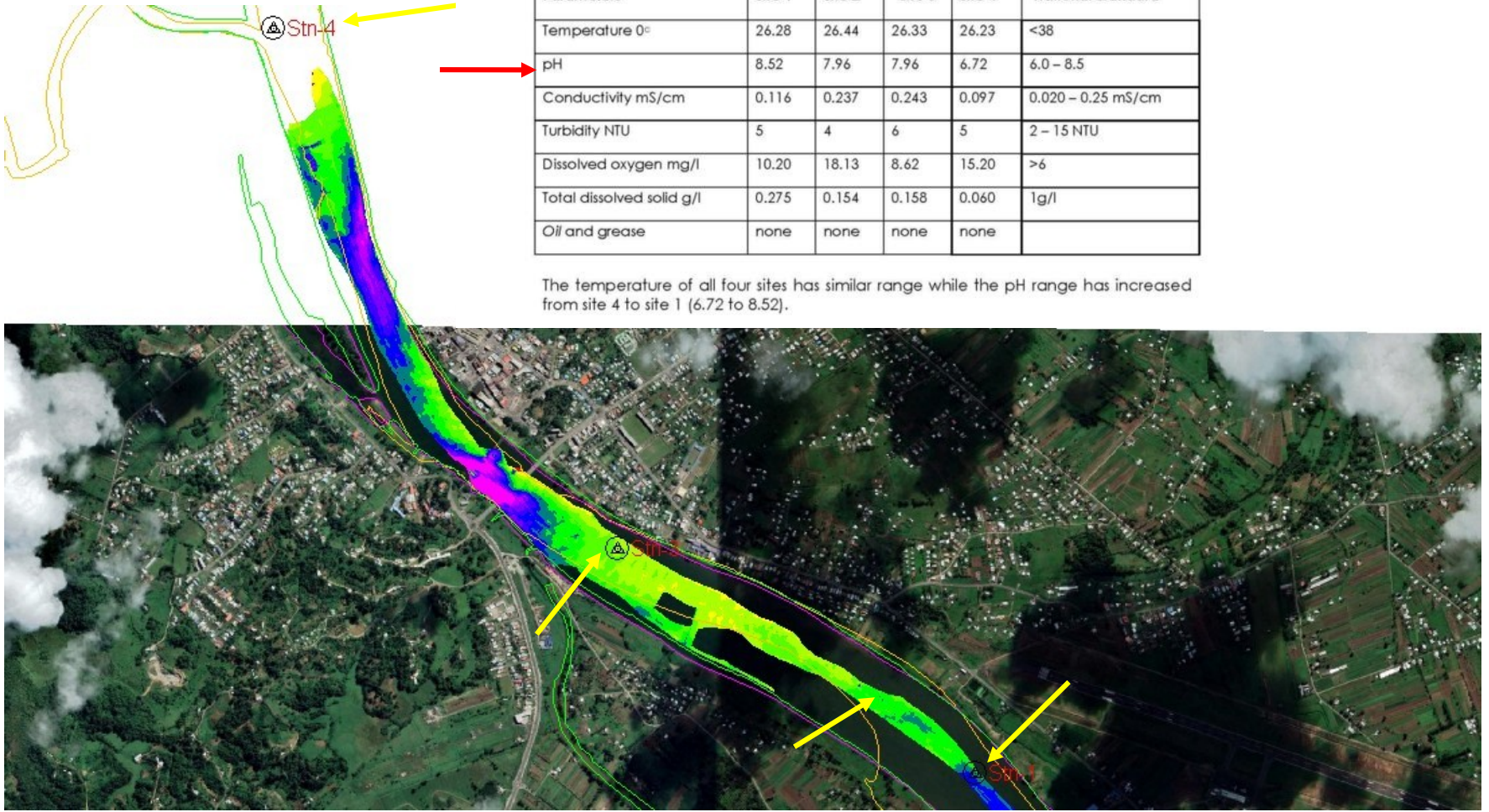
Water Quality Sampling

The physical water quality parameter results are given in the table below:

Table 2. Water Quality Results

Parameters	Site 1	Site 2	Site 3	Site 4	National Standard
Temperature 0□	26.28	26.44	26.33	26.23	<38
pH	8.52	7.96	7.96	6.72	6.0 – 8.5
Conductivity mS/cm	0.116	0.237	0.243	0.097	0.020 – 0.25 mS/cm
Turbidity NTU	5	4	6	5	2 – 15 NTU
Dissolved oxygen mg/l	10.20	18.13	8.62	15.20	>6
Total dissolved solid g/l	0.275	0.154	0.158	0.060	1g/l
Oil and grease	none	none	none	none	

The temperature of all four sites has similar range while the pH range has increased from site 4 to site 1 (6.72 to 8.52).



Data from NSR report 1995

Table 4.2

Physico-chemical results

Site	Sample no.	Date	Time	Gauge m	pH	Cond µS/cm	Temp °C	DO mg/L	DO % saturation		Turb NTU		TSS mg/L	Comments
Waisoi Ck East	1	2/8/94	8:55	0.55	7.32	79	19.9	8.5	93	<	1.0	<	0.5	Water very clear, swiftly flowing
	2	5/8/94	12:30	0.54	7.47	98	24.0	8.5	101	<	1.0	<	0.5	Algal mat U/S, with gas bubbles
	3	11/8/94	9:00	0.54	7.45	81	20.1	8.6	96	<	1.0	<	0.5	
	4	12/8/94	8:37	0.541	7.62	88	20.1	8.0	89	<	1.0	<	0.5	
Waidina River at Nabukaluka	1	1/8/94	14:45	0.295	7.12	98	24.8	8.6	104	<	1.0		2	Dead dog 10m D/S
	2	5/8/94	10:24	0.279	7.53	100	22.5	7.5	86	<	1.0	<	0.5	
	3	9/6/94	12:30	0.29	7.20	80	25.0	9.8	119		2.0		0.6	
	4	12/8/94	10:30	0.255	7.31	99	22.9	9.7	113		1.0	<	0.5	
Rewa River at Nausori Bridge	1	4/8/94	11:40	na	7.73	139	24.2	8.0	96	<	1.0		2.6	Low tide at 10:20
	2	6/8/94	13:20	na	7.75	222	25.0	8.2	99	<	1.0		1.9	Low tide at 11:47
	3	9/8/94	8:30	na	7.37	479	24.1	7.3	87		2.0		3.5	High tide
	4	13/8/94	13.58	na	7.51	180	24.8	8.2	99		1.0		11	High tide
Rewa River at Navolau	1	2/8/94	12:15	0.26	7.69	111	24.3	8.6	103		1.0		2.8	
	2	5/8/94	8:20	0.25	7.77	109	23.0	8.0	93	<	1.0		2.3	Intermittent oily film on surface
Waimanu River at Waimanu PS	1	1/8/94	12:30	0.175	7.22	86	23.8	8.8	104	<	1.0		1.2	
	2	5/8/94	16:15	0.14	7.35	87	24.9	11.1	135	<	1.0		1	
Rewa River at Drekeinakelo	1	4/8/94	10:40	0.728	7.74	111	24.3	8.1	97	<	1.0		0.8	
	2	6/8/94	12:10	0.7	7.89	111	24.8	8.4	102	<	1.0		1.6	
	3	9/8/94	7.35	1.62	7.15	118	24.3	7.3	87	<	1.0		1.1	
	4	13/8/94	13:14	1.64	7.87	108	24.8	10.0	121	<	1.0		1.3	

na = not available

Infrastructure damage

19-05-2019

Gabion basket and protective sheet piling exposed and eroded from behind

05-04-2021

Gabion basket has subsided presumably undermined and erosion under sheet piling increasing foundation vulnerability of the bridge

Nubukavesi Bridge 21-04-2021

Leading to expensive remedial works

Downstream Changes

19-05-2019

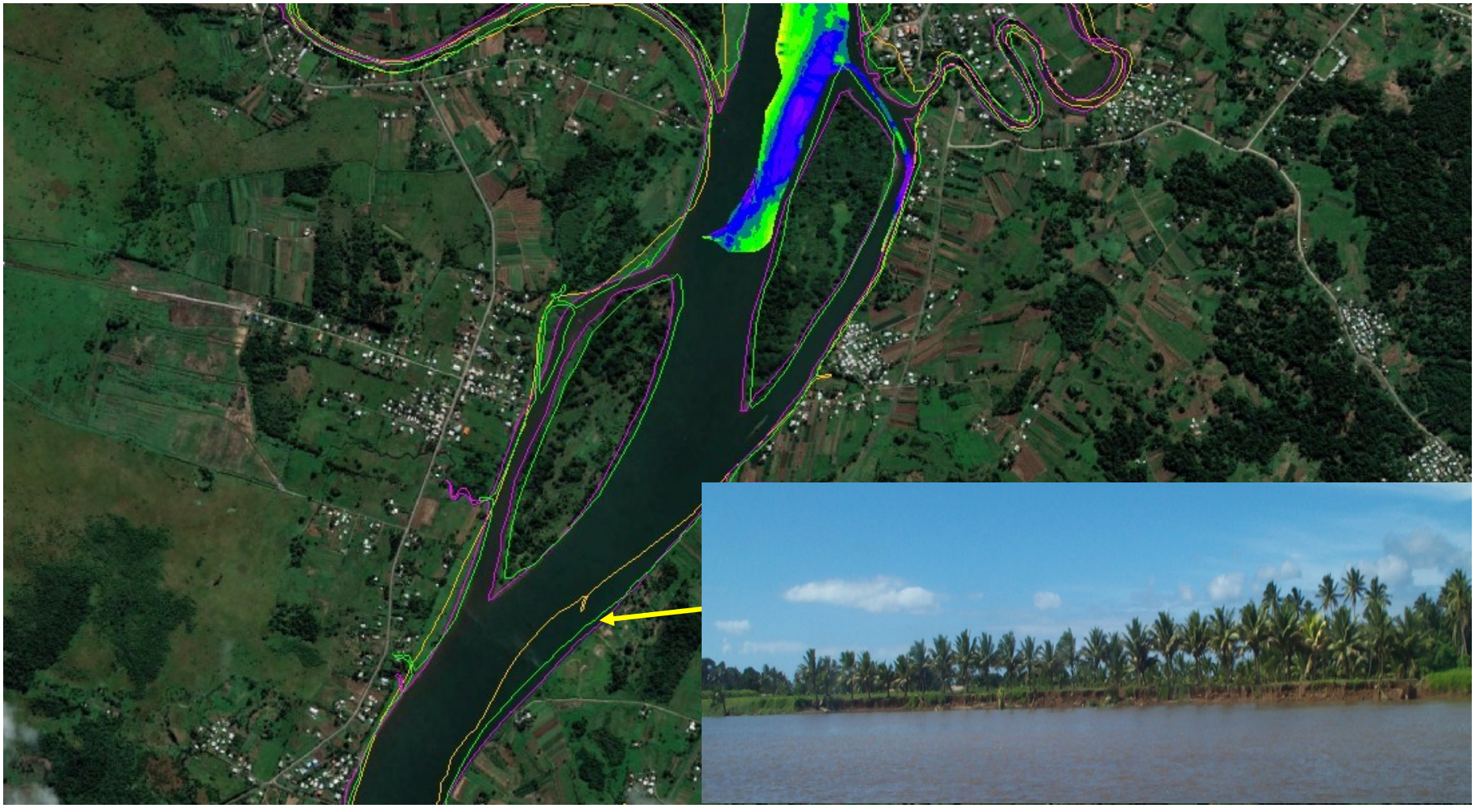
05-04-2021

Upstream changes

19-05-2019

05-04-2021

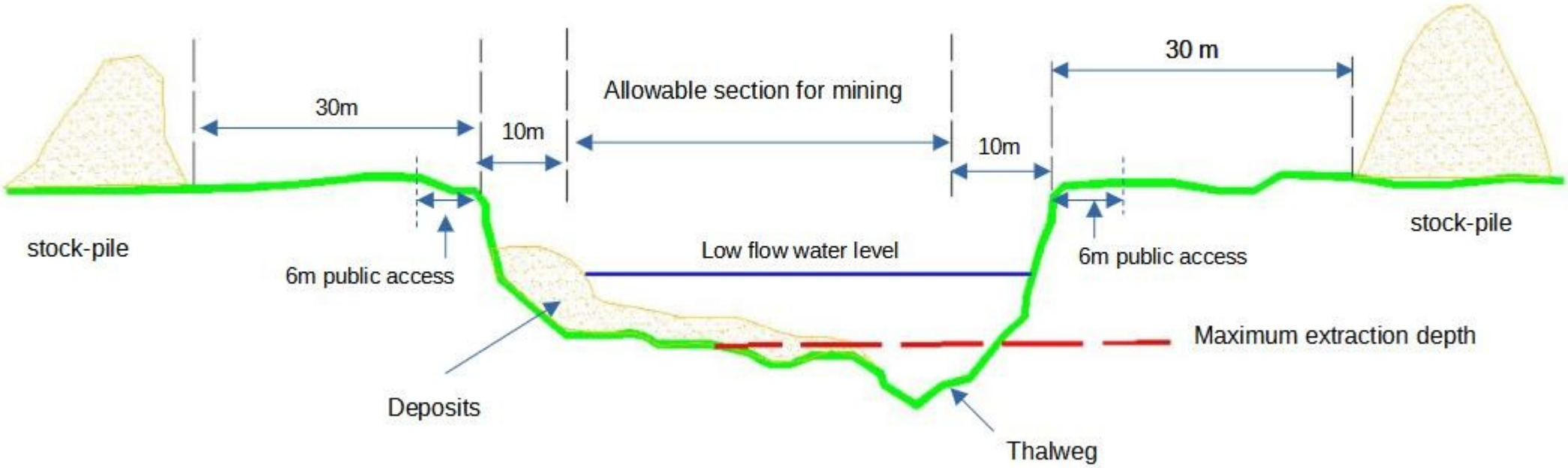
Rewa River – mapped changes loss of agricultural productivity



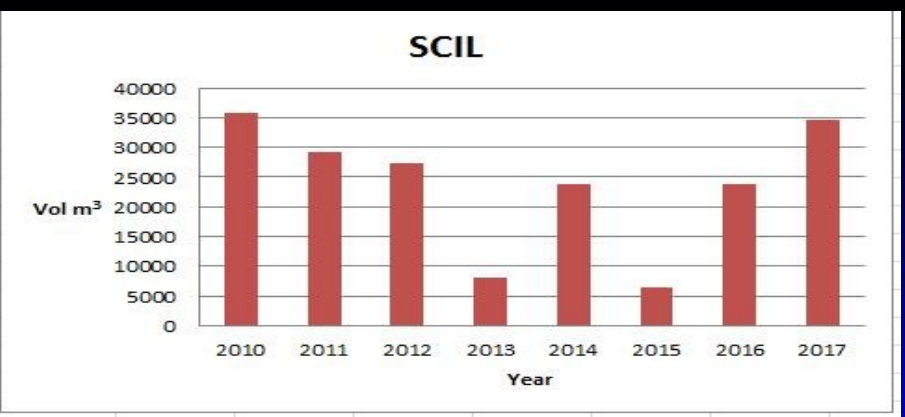
Light orange -1977 Green – 2011 magenta - 2021

Gravel and Sand Management

Data collection and methods to be used to monitor gravel and sand extraction



Multi licenses for extraction on single river systems



First 6 months of year

Extraction estimated for Navua 2017
158, 000 m^3

Monthly production approx. 2000-2500 m^3/
potential 24000- 30000m^3

Monthly production approx. 5000 m^3
potential 60,000m^3 per year

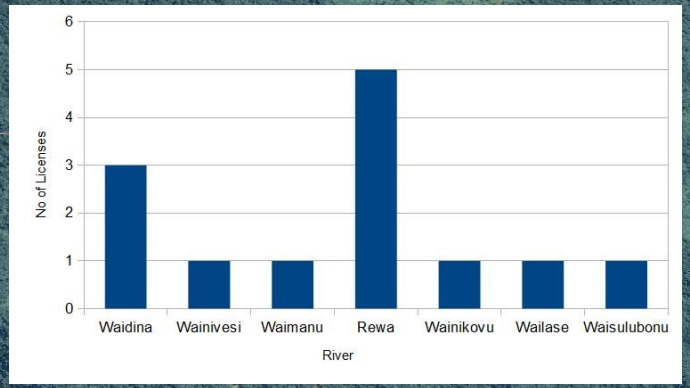
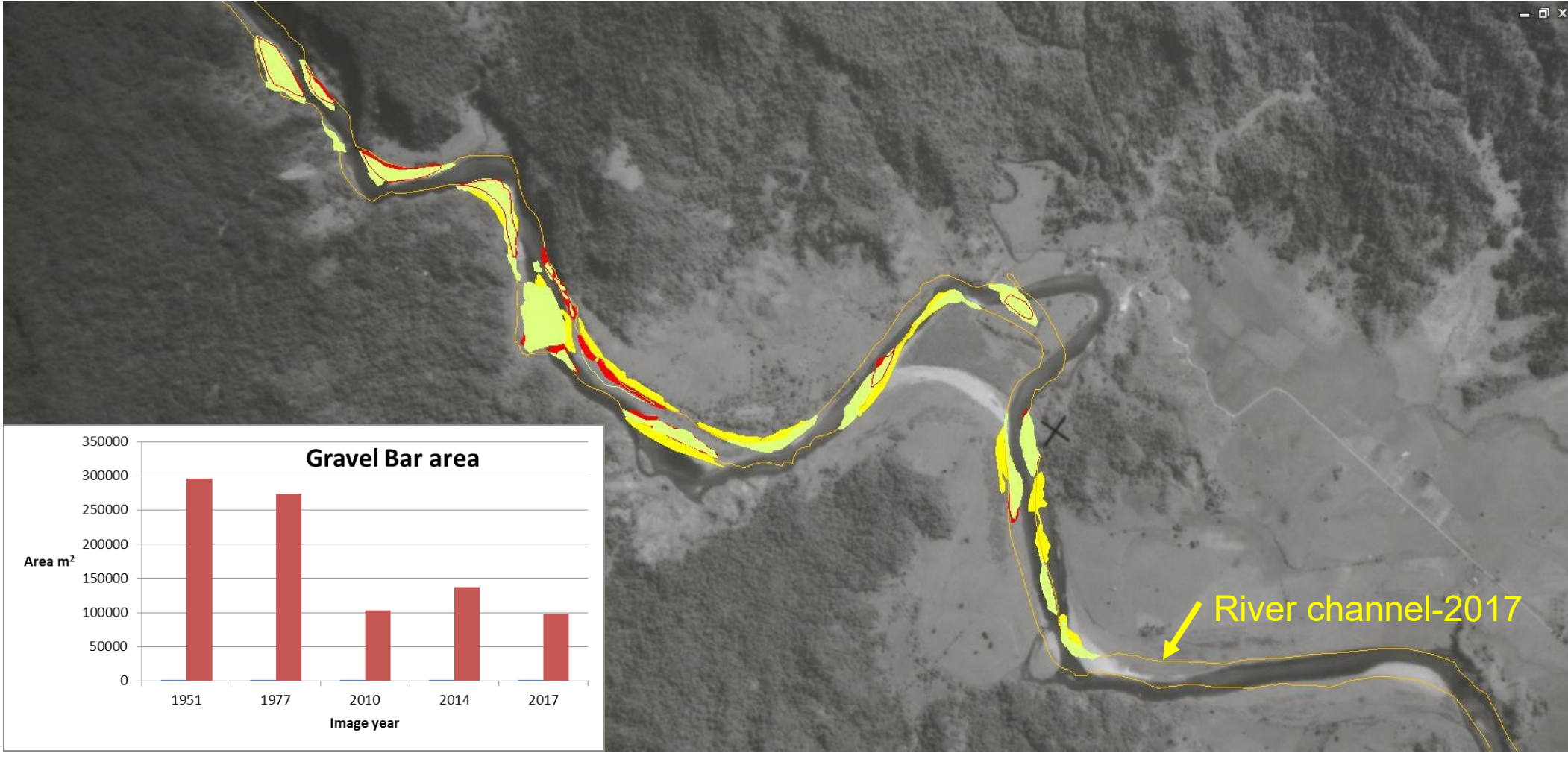


Image backdrop GE 26052017


Cross section profiles for monitoring and for dredging measurements and payment volume calculations
Nakavu
Google Earth

Assessment of bedload transport

Gravel bars 1977, 2010, 2014, 2017 Image back drop 1951

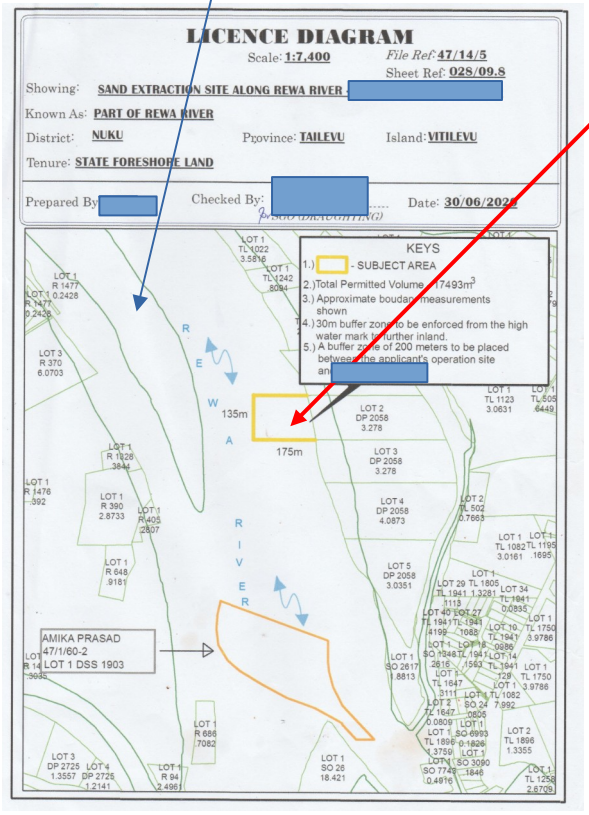


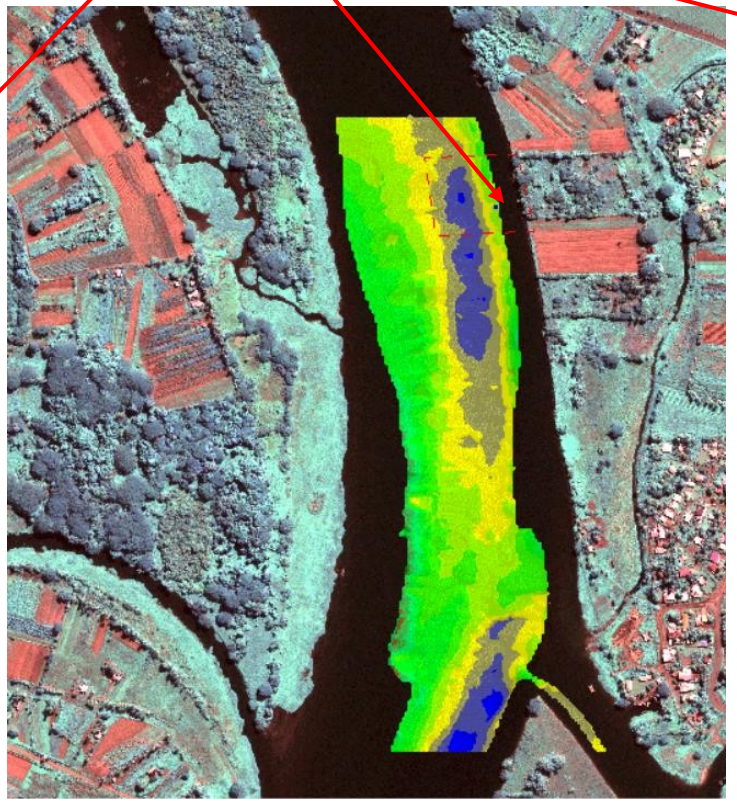
Island in river

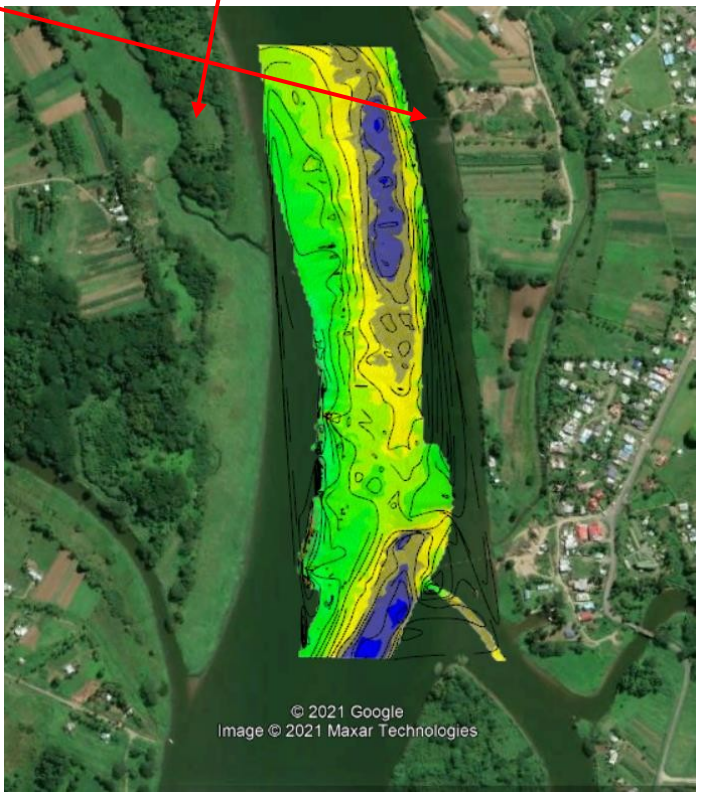
River bathymetry and cross section profiles

XXX license area

Major accretion and channel closing





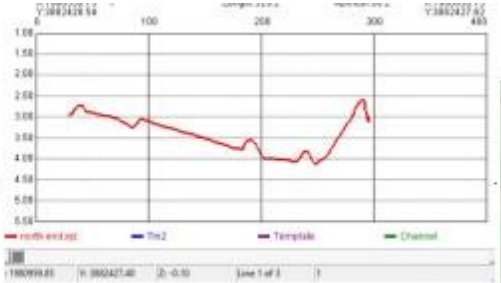


License map 2020

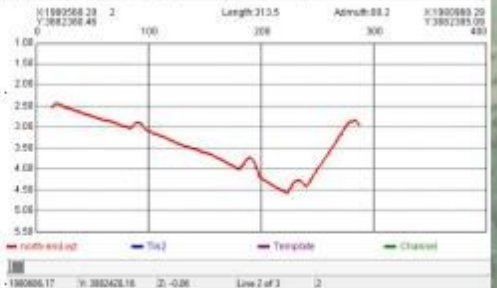
Image 2011

Image 2020 GE

Cross section 1

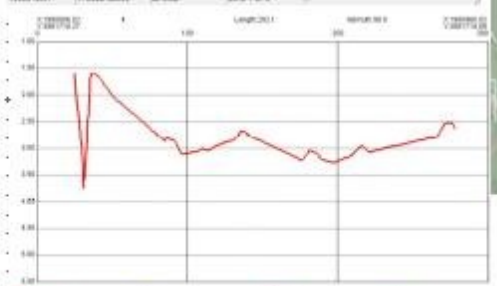


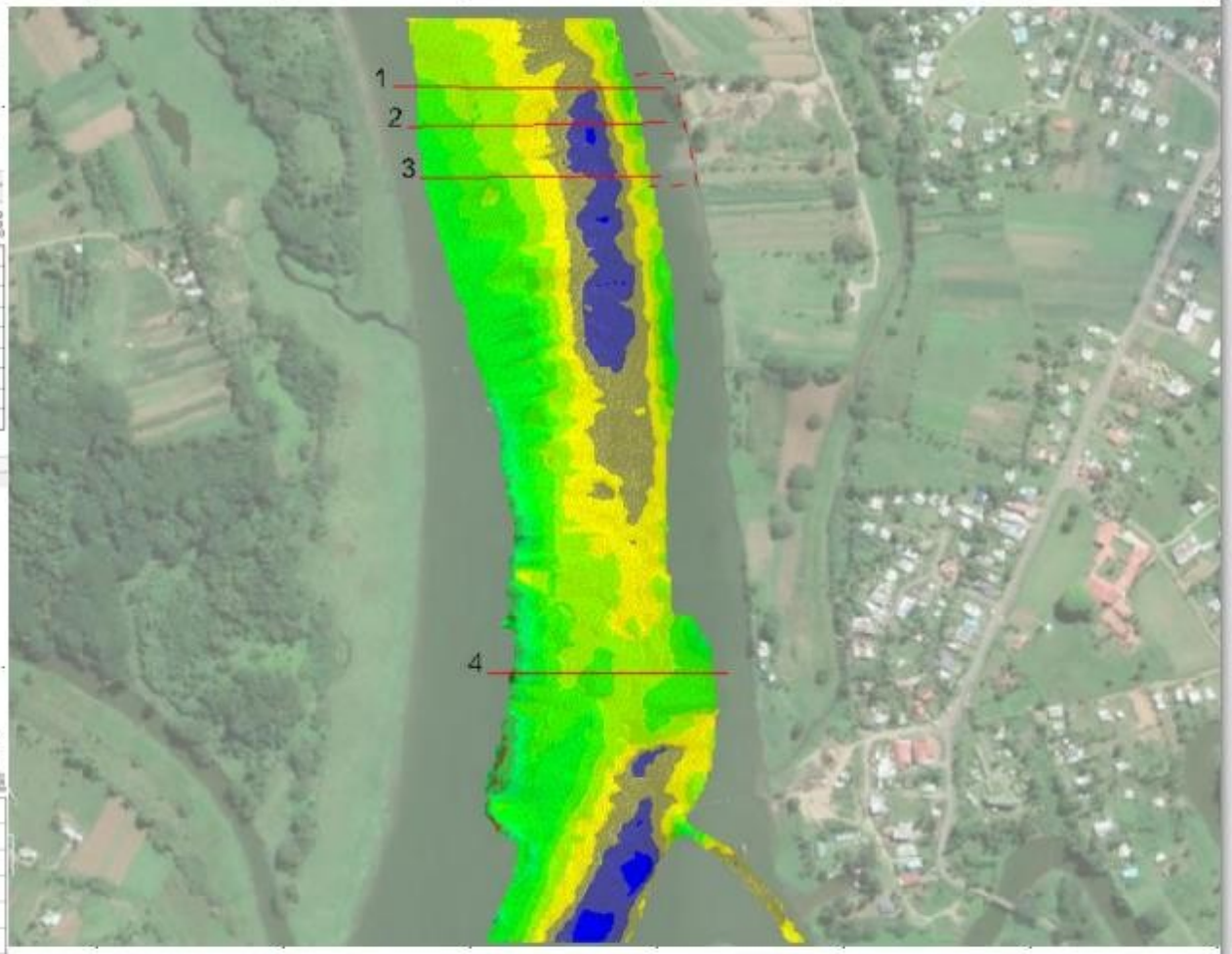
Cross section 2

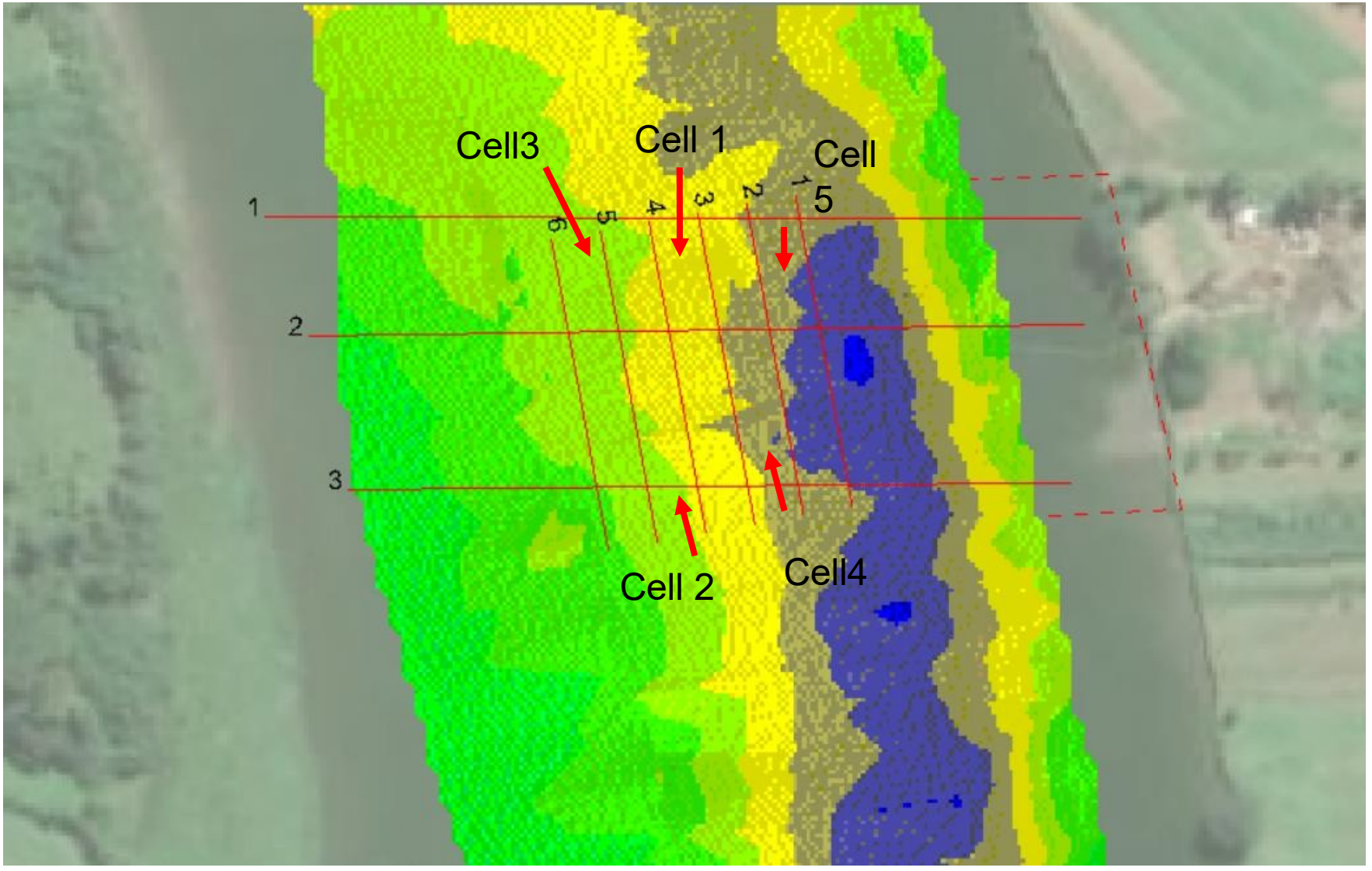


Cross section 3

Cross section 4






Cell3
Cell 1
Cell 5
Cell 2
Cell4
1
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6
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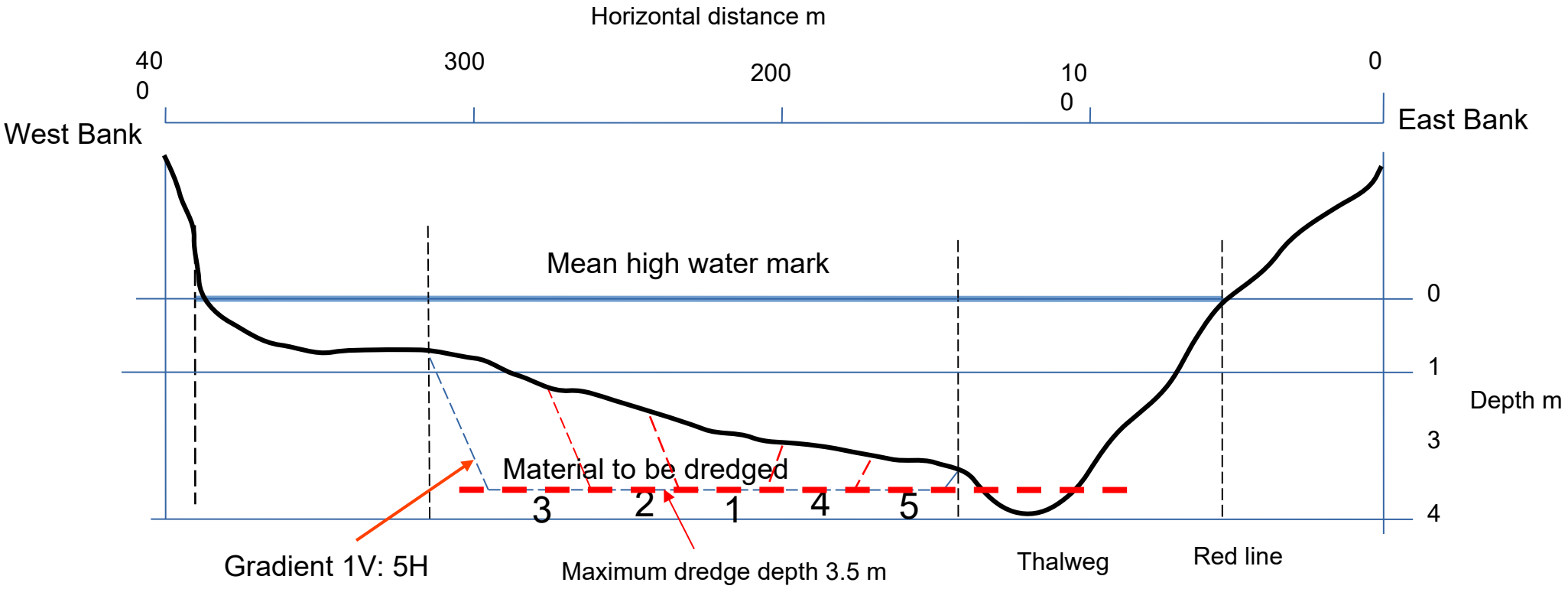

Typical Cross section showing extraction plan

IN CONCLUSION

For effective guidelines we need the support of all stakeholders but also a willingness to take ownership of the guidelines as well. In other words sharing responsibility and good stewardship for sustainable extraction of these resources.

For this to occur:

To strengthen the technical content of environmental impact assessment reports that provide sufficient data that can be used for MONITORING of the extraction and recovery of resources promoting sustainable exploitation.

Liaison and better co-operation within regulatory bodies

The private sector and the LOU communities working together to minimise illegal activity.

A goal to manage, protect, and restore the equilibrium condition of Fiji rivers to resolve or avoid conflicts between human investments and river dynamics in a manner that is technically sound, and both economically and ecologically sustainable.

VINAKA VAKA LEVU