

**IMPACT OF FOREST DISTURBANCE,
FRAGMENTATION AND RESTORATION ON
EROSION AND SEDIMENT SOURCES AND
TRANSPORT WITHIN THE SEGAMA RIVER
CATCHMENT, EASTERN SABAH**



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UMS
UNIVERSITI MALAYSIA SABAH

**FACULTY OF SCIENCE AND NATURAL
RESOURCES
UNIVERSITI MALAYSIA SABAH
2015**

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**THIS IS SUBMITTED IN PARTIAL FULFILLMENT FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY**

**FACULTY OF SCIENCE AND NATURAL
RESOURCES
UNIVERSITI MALAYSIA SABAH
2015**

DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

28 August 2014



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CERTIFICATION

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AND RESTORATION ON EROSION AND SEDIMENT
SOURCES AND TRANSPORT WITHIN THE SEGAMA
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ABSTRACT

This research focuses on terrain of contrasting land-use in Eastern Sabah, Malaysian Borneo. Differences in soil erosion rate were assessed between primary forest (Danum Valley), naturally regenerating selectively logged forest and rehabilitated logged forest (Malua), and oil palm plantation land and adjacent forest fragments at the Sabahmas Plantation of Wilmar International. Second part of this research uses multi-proxy sediment fingerprinting approach to reconstruct changes in sedimentation rate and the relative contributions of different sub-catchments to the downstream sediment budget of the large Segama catchment over the past 150 years. Networks of 50-70 erosion bridge transect sites were established in the various land-use types on slopes of 0-50° to study on erosion pattern. Downstream evidence was derived from a sediment core on high lateral bench on the Lower Segama below the confluence of the Urik tributary. Bed-sediment samples were taken from channel-margin sites at low flow for the major upstream tributary catchments (the hypothesized sediment sources) of the Segama River. The core sectioned materials were analysed for (i) fallout radionuclides ^{137}Cs and ^{210}Pb (ii) particle size distributions and (iii) major and minor elemental composition (by X-Ray Fluorescence). Results indicated that logged forest rehabilitated by enrichment planting experienced much reduced erosion (1.22 mm yr^{-1} and less) compared with un-rehabilitated logged forest ($1.48\text{-}8.55 \text{ mm yr}^{-1}$) and primary forest 0.18 mm yr^{-1} . Within the oil palm areas, erosion rates at sites without conservational measures were high ($6.38\text{-}43.72 \text{ mm yr}^{-1}$), whereas sites with soil conservation practices, erosion rates were $0.31\text{-}5.31 \text{ mm yr}^{-1}$. Recent enrichment of the downstream sediment with alkali and alkaline earth elements were apparent. These elements are considered as mobile elements during weathering and are more susceptible to retention, sorption at top of the core may be linked to increased inputs from sections of the catchment that have been recently disturbed (e.g. converted to oil palm). Input of fallout ^{210}Pb in the middle and upper sections of the core profile marked dilution of activity concentration by periods of enhanced rates of accretion. Concentrations of ^{137}Cs were measured at mass depths of 8.86 and 58.64 kg m^{-2} , however a third peak was not achieved thus the dating using ^{137}Cs could not be performed. Using only results from ^{210}Pb dating, the peaks and troughs were found to tally with the known history of logging within the Segama catchment. The use of radiochronology in combination with sediment fingerprinting capable of revealing changes in the sedimentation rate and the relative contributions from different parts of the upstream catchment with their land-uses and land management practices.

Keywords: Erosion; sediment source fingerprinting; XRF geochemistry, Radionuclide fallout.

ABSTRAK

KESAN GANGGUAN HUTAN, FRAGMENTASI DAN PEMULIHAN HUTAN KE ATAS HAKISAN TANAH, SUMBER DAN PENGANGKUTAN SEDIMEN DALAM SISTEM SUNGAI SEGAMA, TIMUR SABAH.

Fokus penyelidikan adalah untuk mengkaji perbezaan kadar hakisan tanah di antara hutan yang telah dibalak dan di biarkan untuk regenerasi secara semulajadi, pemuliharaan hutan secara penanaman sivikultur (Malua), hutan primer (Lembah Danum), ladang kelapa sawit dan fragmen hutan di Ladang Sabahmas (Wilmar International). Bahagian kedua kajian ini menggunakan pendekatan cap jari sedimen multi-proksi untuk mengkaji sejarah perubahan kadar pemendapan dan sumbangan relatif sedimen di kawasan hilir Sungai Segama sejak 150 tahun yang lalu. Sebanyak 50-70 rangkaian transek jambatan hakisan telah dipasang di kawasan penggunaan tanah yang berbeza yang merangkumi pelbagai kecerunan dari 0 ke 50° untuk mengkaji corak hakisan. Bagi kajian cap jari sedimen, sampel teras sedimen di ambil dari hilir sungai Segama, berhampiran muara anak sungai Urik. Sampel sedimen juga telah diambil dari beberapa tributari utama Sungai Segama yang disyaki sebagai penyumbang utama sedimen ke Sungai Segama. Sampel teras dianalisis untuk (i) Radionuklida ^{137}Cs dan ^{210}Pb (ii) taburan saiz zarah dan (iii) major dan minor komposisi unsur (oleh X-Ray pendarfluor (XRF). Keputusan menunjukkan bahawa hutan yang telah dibalak dan dipulihkan oleh tanaman sivikultur mengalami kadar hakisan yang lebih rendah (1.22 mm thn^{-1}) berbanding dengan hutan yang telah dibalak yang dibiarkan untuk pulih secara semulajadi ($48-8.55 \text{ mm thn}^{-1}$). Hutan primer merekodkan kadar hakisan 0.18 mm thn^{-1} . Untuk kawasan kelapa sawit, kadar hakisan di kawasan tanpa langkah konservasi tanah adalah sangat tinggi ($6.38-43.72 \text{ mm thn}^{-1}$). Bagi lokasi di mana amalan pemuliharaan tanah diaplikasikan, hakisan adalah lebih rendah ($0.31-5.31 \text{ mm thn}^{-1}$). Input ^{210}Pb di bahagian pertengahan dan atasan profil teras menunjukkan proses pencairan kepekatannya yang menandakan kadar pertambahan endapan. Kepekatan ^{137}Cs telah dikesan pada kedalaman jisim 8.86 dan 58.64 kg m^{-2} dan tiada puncak dikesan bagi menandakan tahun 1963. Oleh yang demikian, pendekatan mengkaji tarikh menggunakan ^{137}Cs tidak dapat di laksanakan. Namun demikian, kesimpulan yang di perolehi dari keputusan ^{210}Pb , menunjukkan bahawa sungai yang mengalir dari kawasan yang telah di balak dan kawasan ladang kelapa sawit sebagai penyumbang sedimen utama ke Sungai Segama. Penggunaan kaedah radiokronologi dan kombinasi cap jari sedimen telah dapat mendedahkan perubahan kadar pemendapan dan sumbangan relatif sedimen dari tributari sungai dan boleh dikaitkan dengan penggunaan dan amalan pengurusan tanah.

Kata Kunci: Hakisan, sumber sedimen cap jari, elemen geokimia XRF, Radionuklida

APPENDIX A

DAILY RAINFALL FROM 2009 UNTIL 2012 AT RESEARCH SITES

DANUM VALLEY FIELD CENTRE: DAILY RAINFALL 2009												
DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
1	27.5	7.0					44.7			5.8	25.7	
2	34.7	19.0	24.0	2.0	1.0	4.0	1.6		11.9	1.4	2.6	0.8
3	5.7	62.2	5.3	10.1	35.6						32.1	5.8
4	0.1	24.4	27.1	4.5	36.4	15.1	6.3					0.7
5	2.0	29.3	4.0	58.6	31.2	4.2	0.9	14.4		9.6		2.1
6	2.1	0.4		9.5	2.5	14.5		3.3		10.1	1.4	3.6
7		0.8	0.7		13.1		7.2				47.8	4.6
8	0.9	0.5	8.8	4.6	6.3		3.4	15.8			14.6	0.1
9	16.6	37.0	23.3							41.4		0.7
10		2.9	0.3	15.5	18.0		13.0		31.5	25.3		
11	6.0	0.5	16.2	8.3		6.5	22.2	2.9			3.3	
12	25.6	5.3	3.4	14.0		10.7		1.4			2.7	23.6
13	3.0		32.5	17.9		26.2				2.7		3.1
14	14.9		1.0	1.5				3.3		1.4	7.3	0.5
15	36.9	0.6	12.6		1.5	10.7	25.5	4.2		4.8	9.0	3.9
16	4.4		4.6	11.8	62.0	9.2	0.9	5.6	5.8	11.3	6.4	1.6
17	26.7	11.7	6.1	9.0	10.1	1.0			31.4		14.1	2.4
18	16.7		0.5	26.8	46.2	6.1	34.0		0.2	59.0	16.9	3.4
19	2.1		7.8		46.6	9.4	36.7		17.0	52.7	8.1	0.4
20	34.0	1.2			8.7	1.6		2.0	14.9		82.2	9.8
21	1.8	24.9	1.0	15.4	0.1	1.2	18.2	0.4		0.5	8.5	8.6
22	18.8	2.6	12.0	15.7	0.3	2.5	27.6	1.8			3.2	4.6
23	9.7			3.1	12.0	2.6	0.5	7.3		42.6	81.3	2.6
24	3.0	15.8	13.7		3.1	16.0	2.3	8.5		9.7		5.7
25	10.8	7.1	22.5		18.7	3.1	33.0	7.9	21.9	74.1		80.9
26	22.2	23.7		0.7	21.3		33.6	9.6	7.9		11.4	7.2
27	5.0	37.0		0.7				12.8	1.0	11.1		
28	10.7	24.7		0.4		56.7		5.0	2.0	25.3	1.7	
29	10.9			8.1		4.8	8.0	0.5			58.5	
30			25.4			20.2			2.7	0.8	6.6	14.1
31			1.4					26.7		7.5		1.9
TOTAL	352.8	338.6	254.2	238.2	374.7	225.3	319.6	133.4	148.2	397.1	445.4	192.7
RAINDAYS	27	22	23	21	20	21	19	19	12	20	22	25
DRY	4	6	8	9	11	9	12	12	18	11	8	6
MAXIMUM	36.9	62.2	32.5	58.6	62.0	56.7	44.7	26.7	31.5	74.1	82.2	80.9

DANUM VALLEY FIELD CENTRE: DAILY RAINFALL 2010												
DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
1	8.3					0.5	1.4	0.7		0.4	33.2	3.2
2	0.7					6.2	2.2	1.2	1.2	0.5	15.9	0.5
3				29.7	0.1		0.3	15.9	0.3		2.6	7.3
4				1.1	0.6	4.3	13.5	26.4	1.3		4.4	
5		2.1	1.8		2.0	18.8	6.9	1.8	0.7		0.6	4.5
6	3.6				7.5	4.3				19.0	10.3	2.8
7	1.9		25.5		15.4	3.3	1.3	22.0	5.2	5.9	0.8	
8	0.2			1.1	13.8	0.5	5.5	7.0	1.4	17.3	13.0	52.5
9	1.9		5.1		0.3	10.3	0.3				3.2	25.9
10					43.0	0.4	1.8	40.9	3.6	31.4	1.9	30.5
11	2.9		1.0		11.0	1.5			10.6	0.5		
12					9.1		17.1	1.9	26.5			
13	14.3				16.3		18.6	17.4	0.4		19.8	33.4
14	115.7	1.6				2.0	4.1	1.3	14.9	18.6	4.0	
15	73.3	0.9			2.9		0.1	19.7	4.1	11.6	4.6	20.6
16	24.1			0.2	12.0	16.9	1.3		11.6			0.7
17	1.5			5.7	6.0	1.3	7.8	3.9	6.9		5.6	2.2
18	3.6	0.4			4.6	40.9	1.7				13.6	0.6
19	7.2				28.3	10.3	4.8	0.1			16.8	23.2
20			4.5		0.1	0.1	8.9	0.1	1.3		1.9	1.0
21	14.8			19.2	5.8	5.7	23.1	1.6	0.1	6.8		20.7
22	9.4			2.7		5.4	2.6	6.9			12.6	2.4
23	0.7		1.2			2.0	9.8	2.4			0.8	3.0
24	5.7	6.5	39.3	1.1			6.8		5.2	21.3	15.0	34.4
25	21.0				16.1	15.3	4.4		0.4	0.5		6.8
26	4.8				22.6	30.5			1.6			21.5
27	28.5		7.0		0.5		3.2		1.6	2.1	2.8	12.5
28	0.8		2.8	43.7	0.3				10.2	1.3	0.7	28.8
29	15.0		3.3		3.2	9.7	12.4	16.2		1.2	0.2	0.3
30	0.4		2.9	0.1		2.2	4.5	68.9	38.3	9.3	20.0	4.4
31	0.3		0.1				7.7					
TOTAL	360.6	11.5	94.5	104.6	221.5	192.4	172.1	256.3	147.4	147.7	204.3	343.7
RAINDAYS	25	5	12	10	23	23	27	20	22	16	24	25
DRY	6	23	19	20	8	7	4	11	8	15	6	6
MAXIMUM	115.7	6.5	39.3	43.7	43.0	40.9	23.1	68.9	38.3	31.4	33.2	52.5

DANUM VALLEY FIELD CENTRE: DAILY RAINFALL 2011

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1	62.7	26.5	21.5	57.9	0.4		18.6			18.7	0.7	6.7	
2	7.1	5.5	1.7	2.8	12.2	0.9	37.5		1.0		9.8	54.6	
3	7.6	4.6	0.2	42.3	13.5		28.2	2.1	27.4	2.9	10.6		
4	2.1	13.2	5.5	4.5	0.8	18.8		7.9	7.6	0.5	0.2	8.7	
5	1.8	112.0	18.3	1.9	0.2	1.0	0.1			21.0			
6	0.2	0.5	0.1	1.2	1.1	7.9	2.0		9.1	31.6		1.3	
7	18.5	38.9	43.7	3.8	67.2	5.1	0.3		1.5	18.7		0.5	
8	1.1	18.7		25.4		2.8		9.6	6.7	17.3	4.4	3.4	
9	1.8		3.5	89.8	9.3	21.0	0.2	17.7	17.3		1.9		
10	6.8		25.6	32.9	0.1	66.4	1.2		0.5	2.0	15.5		
11	4.1	0.7	3.2		22.5	4.6	6.4	50.1	3.4	0.3	69.3	3.4	
12		10.6	35.9	25.7	0.2	2.1		0.5	0.6	21.0	11.3		
13	14.1	5.7	1.7	15.7	13.3	0.2	1.4	0.3	45.3	10.5	9.1	39.7	
14	8.7	4.4		0.7	26.9	2.3	8.9		0.1	23.4	0.5	0.6	
15	1.0	7.6	4.7	37.9	2.1	0.2		2.2		25.7	2.9	19.8	
16	6.3	3.6	2.3	1.4	0.3	78.1	0.8		18.3	0.2	16.4	2.1	
17	58.1	7.3	3.1	0.5	6.9		2.0	46.8	6.8	12.5	6.0	7.1	
18	1.2	2.0	6.3	0.3	0.2	11.0		0.2	32.2	8.3	0.4		
19	10.5	2.4	6.8		0.2		27.4	2.0	0.4	2.1	1.6	1.5	
20		2.6	48.3	23.2	9.3	0.3			10.1	0.5	0.5	0.8	
21		8.2		0.3	66.3		1.5	0.1	12.5		24.0	1.8	
22	2.4		17.6	34.4	83.3	14.1	40.2	5.2	9.4		4.7	1.2	
23	12.9	1.0	1.4	0.3	2.1		0.2	16.2	30.4		15.7	2.0	
24	4.3	3.3	56.7	6.4	10.8		2.8	2.5		7.0	16.7	28.9	
25	0.9		5.4	9.4	14.7			11.0		5.2	1.3	2.3	
26	47.2	5.8	45.2	10.0	28.7			3.5	3.9	1.4	0.3	27.5	
27	31.0		1.0	2.3	14.1		7.2		0.6	0.3	108.2	22.7	
28	0.6	5.4	22.7	0.8	0.5				4.7	9.2	4.9	10.9	
29	41.7		29.0		6.8	16.1	1.6	5.1	17.8	4.4	60.9		
30	14.5		13.2	5.7	13.7	1.2	27.3	28.4		0.5	1.0	3.8	
31	18.8		9.1		0.7		6.1	1.0		11.0		59.3	
TOTAL	388.0	290.5	433.7	437.5	428.4	254.1	221.9	212.4	267.6	256.2	388.8	310.6	3899.7
RAINDAYS	28	23	28	27	30	19	22	20	24	26	27	24	286
DRY	3	5	3	3	1	11	9	11	6	5	3	7	67
MAXIMUM	62.7	112.0	56.7	89.8	83.3	78.1	40.2	50.1	45.3	31.6	108.2	59.3	

DANUM VALLEY FIELD CENTRE: DAILY RAINFALL 2012

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1	17.1		0.1		2.6	8.6	34.7		9.7		13.4	10.7	
2	62.7		3.3			19.6	1.0				12.9	4.0	
3	11.3	6.1	0.3		11.1		2.0			12.8	3.5	1.6	
4	5.5	9.7	25.0	30.1	8.5	3.5			0.2	0.1	1.6		
5	2.5		5.4	0.5			13.5					18.8	
6	2.8	0.1	39.0	2.4	3.0	13.0		15.5	0.6	31.2	15.3		
7	3.0	3.4	20.2	17.2	3.7		26.9	5.6	13.5	24.6	0.2		
8	0.9	0.8	0.8		18.4	4.9	2.6	9.3	3.9	45.9	3.9	25.1	
9	0.2	1.2	0.1	6.9	22.2		5.8		16.2	11.7	4.1	10.3	
10	0.2	19.7	0.7	22.8	0.2	46.4		1.1	3.9	44.3	1.3		
11	5.2		0.1	9.8	8.0		13.2	42.9	15.9	39.6	6.7	16.5	
12	6.6	11.0	4.7	13.7				19.6	2.7	1.2	0.5		
13	0.6	14.9	1.4	53.4			55.2	1.0	0.5			19.7	
14	2.9	11.3	0.1	8.8				6.6	0.7	30.2	28.4		
15		1.1	54.4		2.0		11.7			5.5	33.2	1.3	
16		5.7		1.9	4.5						3.9	10.7	
17		79.3		10.8	1.9			5.0			7.2	21.9	
18	1.8	3.4	0.3	35.4				30.5	25.8		8.5	4.0	
19		0.7	9.7	6.4			19.1	2.0	22.0	6.3	0.7	25.7	
20	1.1	32.8	32.9	22.2	0.3		0.5	2.2	2.8	5.9	0.7	23.7	
21		0.7	42.3	8.6	6.8			61.8	81.8	4.2	8.5	19.7	
22	3.2	4.4	23.7	50.1	4.7	9.0		49.6	16.9	32.7	3.5		
23	23.4	4.5	51.4	3.2			14.5			1.9		9.8	
24	19.8	0.1			2.0	3.7	2.1	0.5	0.4	0.4	3.9	4.1	
25	5.7		29.5	0.7		1.0	14.0	0.9	20.4		5.9	10.2	
26	20.3	0.9		65.2				7.4		0.7	7.8	0.1	
27	8.8	6.5	31.9	17.3				16.6	8.6	0.1	17.1	4.7	
28	1.4		0.3	1.8	23.6	8.2	0.4	9.9		32.1	0.4	5.8	
29	2.2	16.5	33.8	13.1		1.3		21.9	15.6	30.3		1.6	
30	2.8		4.3		8.3	2.0		14.7				42.1	
31			8.2		21.1							1.1	
TOTAL	194.8	215.3	443.7	341.3	220.0	121.2	247.7	250.7	285.9	347.4	223.0	297.2	3188.3
RAINDAYS	23	22	27	23	21	12	17	19	19	21	25	26	255
DRY	8	7	4	7	10	18	14	12	11	10	5	5	111
MAXIMUM	52.7	79.3	54.4	65.2	53.4	46.4	55.2	61.8	81.8	45.9	33.2	42.1	

MALUA: DAILY RAINFALL RECORD 2009

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1			15.6							5.4			
2			33.8	1.0			27.9						
3			63.2	45.3			6.7						
4			29.9	2.4			5.2						
5				12.6				31.7					
6				18.7	24.0								
7				8.2			5.3		0.3				
8			8.6	8.7			7.9		12.6				
9			15.6				18.9			12.2			
10				2.6					55.0	11.2			
11			18.1	19.5				27.3		1.6			
12			6.0	27.6									
13			3.5		8.2	30.0							
14			20.5		8.1			9.6		23.5			
15			5.3		11.8		24.6			14.5			
16			24.9	19.6	19.5	16.4				37.4			
17				23.4		8.7		8.8	12.6	7.2			
18				1.6	76.5		22.9	20.1	6.2	27.0			
19					20.7		37.4		49.7				
20		22.1	9.2		23.1	1.8			10.9				
21		9.7	12.4	10.1			1.3	3.7					
22		6.6		21.8	7.2		9.2						
23		8.6			37.6		14.8	7.0					
24			6.2			16.7	10.1			63.8			
25		6.4				9.6	30.0		3.2	34.6			
26		95.5		21.5			12.9	15.5	16.9				
27		15.5				19.6	37.4	36.5	8.9				
28				17.1		23.5		39.8	7.1	82.0			
29			20.5	8.5		27.1		5.5	12.6				
30			6.5			5.8			16.5	23.6			
31								6.6					
TOTAL	0.0	164.4	299.8	270.2	236.7	159.2	272.5	212.1	212.5	344.0	0.0	0.0	2171.4
RAINDAYS	0	7	17	18	10	10	16	12	13	13	0	0	116
DRY	31	21	14	12	21	20	15	19	17	18	30	31	249
MAXIMUM	0.0	95.5	63.2	45.3	76.5	30.0	37.4	39.8	55.0	82.0	0.0	0.0	

MALUA: DAILY RAINFALL RECORD 2010

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1	23.8		46.6	69.4	4.0		4.5	2.4	2.7	60.8			
2	4.4		6.8	9.2	10.5		6.4		6.7	29.2			
3				24.5	7.8		6.2	5.8	4.6	3.3			
4				16.3	4.0		2.2		4.7				
5						20.1	2.2		7.1	2.4			
6		2.1			15.2	15.7							
7	28.2					18.4	14.7	9.7	27.8	3.5			
8					11.0		7.7	52.3		5.8			
9					16.4	9.7	93.4						
10					4.1		4.1	6.0	16.1				
11	10.1	1.5			6.5	5.5		1.3	17.9	17.1			
12	3.0	2.0		13.3	19.0				15.1				
13	26.3					7.7	1.1	4.2	19.0	1.8			
14	96.2					2.0	4.5	7.2	16.8				
15	140.7	6.7			6.3			10.9		2.7			
16	55.5			4.5	13.9								
17					11.2				10.0				
18	2.2	20.3	5.5		26.6	31.3	8.0						
19	5.3				11.8	16.3	4.8		8.1	2.9			
20					25.0		30.1						
21				8.2			15.6	3.2	16.0				
22	8.8					11.8	7.7	5.6	0.5				
23	8.7	13.2	4.0	10.1			33.4	32.0	6.5				
24	31.8		37.6	2.6			7.4			6.6			
25	16.3					18.3	18.5						
26	15.2		45.8		18.3				6.3	3.5			
27	21.8		49.0		19.6	15.1	2.2	3.7		0.5			
28	5.4		54.4			5.9				2.6			
29	9.9			39.2	8.2	21.2	14.3		12.2	80.1			
30				3.2	2.4	15.1	2.2		2.2	73.1			
31	6.9						8.0	36.0		6.7			
TOTAL	520.5	54.9	249.7	200.5	241.8	214.1	299.2	180.3	200.3	302.6	0.0	0.0	2463.9
RAINDAYS	20	7	8	11	20	15	23	14	19	17	0	0	154
DRY	11	21	23	19	11	15	8	17	11	14	30	31	211
MAXIMUM	140.7	20.3	54.4	69.4	26.6	31.3	93.4	52.3	27.8	80.1	0.0	0.0	

MALUA: DAILY RAINFALL RECORD 2011													
DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1		46.8	40.2	40.0	1.8		17.4		5.7	11.7		7.1	
2	38.0	7.7			66.0	9.7	22.0		25.0		2.6	28.3	
3	4.8	38.4		15.1	9.3	11.2	33.5		58.6			12.1	
4	4.2		3.0	8.0	1.9				10.2		2.3		
5	6.7	21.4	29.2	26.0	20.4	8.9			2.8	40.1	9.8		
6		17.4		12.0	4.5	26.3				14.8		4.2	
7	8.1	9.0	18.6	4.7	72.5		2.8			48.6		1.7	
8				38.9			4.7	7.7	5.4	4.2	62.2		
9	7.6			31.5	8.2	5.6		8.1	4.6	12.0			
10	16.2	18.3	15.5	11.5		27.4			1.6	5.5	3.3		
11	1.7	6.2	5.0	9.3		2.0		1.3	7.2	12.0	6.3		
12	20.0	17.2	73.5		6.6	2.3				31.7	12.2		
13	5.9	25.3	3.1	6.5	11.2		7.4		3.9		7.5	4.2	
14		23.3		5.5	26.7				9.8				
15		3.2	2.4					12.4	3.0	28.5	16.1	2.2	
16	25.4	3.5	26.1	33.0		6.5		41.0			9.7	6.3	
17	54.3	2.9	17.1	2.5			4.8	25.8	2.7	4.6	3.0	31.7	
18		2.3	4.6	4.0	5.5	25.1	3.0			5.3			
19	5.8	2.2	2.7		13.5		22.1	2.8	8.0	3.4		5.8	
20	17.8	14.0	68.2	3.6	2.2		12.2		39.0	16.8			
21	11.2	13.7			6.0	2.5	25.9	3.0	13.1		8.1		
22	19.5		8.4		11.1	80.5		16.4	26.9	1.3		3.3	
23	18.3		4.2	20.0				7.4	21.8		24.4	1.0	
24	5.3					26.5	22.1				4.1	33.6	
25	19.6	7.9	28.2	10.8	9.1			2.6	21.1	9.4	8.6	22.8	
26	28.8	5.7	12.5	6.4				7.4		19.3		3.7	
27			27.1	8.1	28.8				41.8		17.5	6.7	
28	28.1	6.1	8.1		1.0			1.5	4.7	1.4	18.3	1.8	
29	8.5		3.8			25.7	14.0	2.6			30.6		
30	14.0		14.6	5.7	61.0	3.8	22.0	16.8	44.6		22.0	25.1	
31	26.0		7.6		6.6		1.3	6.5					
TOTAL	395.8	292.5	423.7	303.1	373.9	264.0	215.2	163.3	361.5	270.6	325.0	201.6	3590.2
RAINDAYS	24	21	23	21	21	15	15	16	22	18	20	18	234
DRY	7	7	8	9	10	15	16	15	8	13	10	13	131
MAXIMUM	54.3	46.8	73.5	40.0	72.5	80.5	33.5	41.0	58.6	48.6	62.2	33.6	

MALUA: DAILY RAINFALL RECORD 2012													
DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1	48.4		2.1		26.4	15.0			22.8	14.8		5.6	
2	53.8		7.3		1.5	11.8	13.2					7.7	3.8
3	84.6	9.9	3.3	3.3	29.3		2.9						
4	3.8	29.3	6.1	27.7	1.8				11.1		16.6	4.5	
5	5.0		40.1	38.4	24.6		16.5		35.1		8.0	12.4	
6			3.0		13.5	19.0		23.5	9.5	22.6	17.2	14.5	
7	17.8		1.6		3.5	2.8	52.3	12.0	65.1	97.5	63.3		
8	3.5		8.1	2.7	16.3	3.3	21.9	28.5	18.5	25.7		22.2	
9		60.5		25.1	6.2		5.8		4.2	4.8		31.0	
10	16.9	7.0	21.0			23.5	32.2		20.0	32.0	21.2		
11		17.8	9.2	43.9	14.9		7.5	51.3	23.0		27.1		
12		20.8	26.7	38.1	3.2		4.1	14.4	13.4	3.8	1.7	33.1	
13			13.4	14.2	43.9		34.5	17.7		15.7			
14		24.7		11.5							21.2	35.5	
15							3.1			6.8	33.0	4.9	
16				14.8		7.4					4.0	19.5	
17		72.4	4.2		3.1		1.2				3.8	5.6	
18		4.3		27.9			3.2				4.1	58.4	
19		1.9		2.8				5.2	9.0	3.4	5.9	28.6	
20	3.7	22.0	32.0	7.9					2.2	62.7		35.5	
21			8.0	14.2	73.4				86.1	38.3	30.0	23.8	
22	2.9		7.4	8.8	10.0	5.5		17.2	23.2		21.0		
23	30.9	13.9	12.8	6.7	4.7		26.9	14.1		5.0	22.1	21.2	
24	33.5	0.8			43.3	18.4	45.9	12.4			6.7	37.3	
25	19.1		2.1	2.4	25.5		27.0	1.2	12.5			3.5	
26		0.5	9.1	47.9	22.8			4.0		13.3			
27	15.5	1.9	14.3	33.3	7.9				3.5	8.0	43.2	31.5	
28	7.0	18.6						8.8		1.5	21.6	2.0	
29	9.2		17.8		3.0			2.5	15.5	3.2	10.1	6.0	
30								38.1	2.0	9.6	3.2	11.2	
31			14.5					7.3		18.3			
TOTAL	355.6	306.3	264.1	371.6	378.8	106.7	288.2	258.2	376.7	387.0	392.7	451.6	3947.5
RAINDAYS	16	16	22	19	21	9	16	16	18	19	22	23	217
DRY	15	12	9	11	10	21	15	15	12	12	8	8	148
MAXIMUM	84.6	72.4	40.1	47.9	73.4	23.5	52.3	51.3	86.1	97.5	63.3	58.4	

SABAHMAS: DAILY RAINFALL RECORD 2009

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1		3.0	18.3	6.0					9.0	4.0		4.3	
2	21.5	12.5	8.3	5.8	5.0	5.0	5.8			2.3	9.0	9.3	
3	1.0	79.8	11.3	16.5	19.3						9.5		
4	2.3	190.3	8.8	16.8	7.0	2.0	4.8			3.5	43.8	2.3	
5		139.0	33.3	26.3	2.0	15.8	5.8	13.8			11.0	1.0	
6	1.3	20.6	4.8	32.3	1.0	20.5	9.6	4.5		1.0	5.5	2.3	
7	1.0	2.8	29.8	11.3	1.0	4.5	8.6			16.0	2.3	1.5	
8	1.0	1.0	9.8	11.8			1.5		10.0		17.0		
9			20.8	10.8			1.8			4.0	39.3		
10		6.0	11.5				6.1		10.5	19.3	3.3		
11		1.0	39.5	7.0	3.5	2.0	3.3			13.8	26.3		
12	13.5		9.8	18.0	26.3	20.6	8.5			9.8	34.0	11.7	
13	8.3		21.0	6.8	1.0	1.0	1.0	2.0		28.0	12.0	10.5	
14	33.5		13.8	2.3	2.3	11.8	7.8	10.0	1.0	8.5	27.0	16.5	
15	3.5	20.5	21.5	3.3	8.0	2.0	2.0	9.5	1.5	6.8	9.8	17.3	
16	6.8		3.0	10.8	4.0	10.8	9.4	2.3	10.0	1.3	22.0	1.0	
17	68.3	2.3	1.0	13.8	3.3	53.8	12.8		2.5		47.0	20.3	
18	48.5		32.0	7.3	12.5			1.8	5.5		18.8	3.3	
19	31.8	1.0	9.3	2.3	8.0		6.3		5.3		1.0	10.3	
20	15.5	10.5	1.0	1.5	4.5				8.3		21.5	27.5	
21	3.8	4.5	9.5	28.5	1.0			9.3	3.5		34.8	5.8	
22	1.6	33.8	6.3	1.0	6.3		1.5	1.0			1.0	1.5	
23	11.3	1.0	1.0	21.8	8.0	13.5	6.5				1.0	3.0	
24	8.3	25.0				1.3	2.0	37.3		20.0		3.3	
25	11.8	16.8	16.8		13.0	2.5	9.8	4.3	2.5	1.0		14.3	
26	10.0		3.3				7.1		4.3		3.3	3.9	
27	3.0	2.3	19.8			1.0	1.0		4.8	1.0	3.0		
28	11.5	13.8				11.3	3.3	30.8		12.8	6.5		
29	1.0			11.8		1.8	1.5	1.5		2.0	3.5	4.3	
30	2.8			7.8		3.5			12.3	6.5	5.5	4.3	
31	1.0		8.0					6.5		1.5		4.3	
TOTAL	323.9	587.5	361.8	283.1	137.0	184.7	127.8	134.6	91.0	163.1	418.7	183.8	3007.0
RAINDAYS	26	21	26	25	20	19	24	14	15	20	27	24	261
DRY	5	7	5	5	11	11	7	17	15	11	3	7	104
MAXIMUM	68.3	190.3	39.5	32.3	26.3	53.8	12.8	37.3	12.3	28.0	47.0	27.5	

SABAHMAS: DAILY RAINFALL RECORD 2010

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1	8.7			1.0	4.3						14.0		
2	4.3						24.7	1.0			12.7	26.7	
3	12.3				12.3		10.7		9.0	2.0	1.0	4.7	
4	8.3	6.3		8.0		1.0	40.3		21.3	6.0	5.3	17.7	
5		1.0		1.7	14.3		13.7	5.0	19.0	9.7	8.0	18.7	
6		1.0		13.3	13.3	2.7	2.3	1.7	1.0	38.3	11.3	9.3	
7		3.3	4.0	2.3		1.7			17.7	24.7	4.7	7.7	
8	1.3			4.0	1.7	4.0		11.7		23.7	8.3	2.3	
9			5.7	1.0	1.3	26.3	13.7	2.0	6.0		6.3	20.0	
10		3.7			22.3	25.0				2.7	7.0	8.3	
11	11.0				11.3	26.3	3.0		30.7	2.3		1.0	
12	5.3		1.0		13.0	5.0			3.3	1.0			
13	24.7		6.3		29.0	8.0		1.0	3.3		3.3		
14	34.0			14.0	18.7	15.3	1.7				1.0	8.0	
15	69.3			5.0	38.0	20.3	7.7	49.3			20.3	5.7	
16	99.7	1.7	1.3	4.7	21.7	13.3			2.0		16.0	58.7	
17	31.0			1.0	25.3	9.7	35.7				8.7	12.3	
18					16.3	2.0	66.7	10.7	3.3		3.0	11.7	
19	1.0				25.7		19.7	1.7	13.7	7.0		21.0	
20	1.0			1.3	10.0	54.3	7.0	14.0	12.3			10.3	
21				1.0	2.3	8.7	3.3		9.7		6.0	1.0	
22	6.7		28.3	1.7		4.0	1.0	4.7	1.0	5.3	2.7	1.0	
23			30.3	13.3		4.0	27.7					17.7	
24			20.7		19.0	2.3	2.0	5.7	17.7	3.7	14.3	3.0	
25	13.3								50.0	1.0	13.7	39.7	
26	1.3				2.3	1.0	4.3		70.7		36.0		
27	1.7		1.0		1.3	10.3	42.0	13.3	23.3	4.7	1.0	4.3	
28	3.3		12.3	16.7		1.3	11.5		5.7	34.7	6.7	10.3	
29			1.0		10.0	22.0	10.2		1.0	11.3	11.0	63.3	
30						1.3	1.7		27.3	13.7	7.7	3.0	
31			1.3		1.7								
TOTAL	338.2	17.0	113.2	90.0	315.1	269.8	350.6	121.8	349.0	191.8	230.0	387.4	2773.9
RAINDAYS	19	6	12	16	23	24	22	13	22	17	25	26	225
DRY	12	22	19	14	8	6	9	18	8	14	5	5	140
MAXIMUM	99.7	6.3	30.3	16.7	38.0	54.3	66.7	49.3	70.7	38.3	36.0	63.3	

SABAHMAS: DAILY RAINFALL RECORD 2011

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1		63.7	11.7	5.0	6.7		12.0				34.7	5.0	
2	3.3	47.7	8.7	2.7	17.0	14.0	4.0			1.0	4.3	3.0	
3	5.7	23.0		12.3	18.7		21.0			1.0	2.0	1.0	
4	27.0	9.3	1.0	14.7	1.7			4.0					
5	11.3	1.0	7.0	7.0	26.3			1.0		44.7		1.0	
6		2.0	4.3	21.7	11.0					2.3		9.0	
7	2.3	27.3	1.0	4.7	42.7	9.3						2.3	
8		4.7	2.0	12.0	2.7		4.0	4.0	3.0	1.7	6.0		
9		8.3	28.0	119.7	3.7					1.0		1.0	
10		2.0	8.0	1.7	4.7	21.7				26.0	6.0		
11	1.0	20.7	39.7	11.7	3.7	3.3		5.3		2.7	4.7		
12		6.0	167.3	5.3	24.3	1.0		21.7	6.7	5.0	6.7		
13	10.0	4.0	4.0	15.3	4.3			5.7	2.7	2.3	12.7		
14	1.3	1.0	1.0	17.7	5.7			2.0					12.3
15	10.3	3.7	33.0	1.0	4.7					1.0		4.3	
16	6.7	4.7	12.0	1.0	5.7	1.7			2.3	2.0	2.3	3.3	
17	17.7	9.3	7.7	7.0	1.7				19.0	18.0	2.0	1.0	
18		1.0	9.0	1.0		15.7		2.3		30.3	1.3		
19	8.0	1.0	4.3		40.0					11.7	5.0		
20	1.0	4.3	1.0		2.7		30.3			21.7	17.7	12.7	
21	3.0	6.3			8.3		3.7		5.3	11.0	14.3	47.7	
22		1.7	54.3	2.3	22.0		6.0	10.7	9.0	8.7	4.3	12.7	
23	42.7	7.7	2.3	2.3	1.0		14.7			5.0	9.7	46.3	
24	13.0	8.7	18.0	10.0	6.3		1.0			15.3	14.3	21.3	66.0
25	17.3	1.3	10.0	9.0					12.0	10.0	9.3	53.3	
26	56.7	1.3	10.7	5.3	16.0			5.7		21.0	17.7	69.7	
27	56.3		3.0	14.7	5.3				11.3	9.7		19.0	
28	19.7	3.7	14.0	4.3	2.0	15.3			7.3	6.7	21.0	56.0	
29	6.7		13.7	5.7	5.7	1.0	8.3			6.3	6.0	4.0	
30	40.0		13.7	6.7		1.7				16.3	30.7	36.3	
31	16.3		4.7							4.7		36.0	
TOTAL	377.3	275.4	495.1	321.8	284.6	84.7	105.0	62.4	93.9	286.1	239.7	502.9	3138.9
RAINDAYS	23	27	29	27	27	10	10	10	11	27	22	23	246
DRY	8	1	2	3	4	20	21	21	19	4	8	8	119
MAXIMUM	56.7	63.7	167.3	119.7	42.7	21.7	30.3	21.7	19.0	44.7	34.7	69.7	

SABAHMAS: DAILY RAINFALL RECORD 2012

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1	48.7				11.3	4.7			17.0	18.7	18.0	19.3	
2	94.0		15.7			15.7	14.7			1.0	13.3	1.0	
3	15.7	1.7	1.0	8.7						7.0	35.0	3.7	
4	27.0	20.0	14.0	2.7	3.0				1.3	4.0	8.7	1.7	
5	6.3	1.0	5.7	8.0	8.3		1.0		11.3	44.7	11.7	1.0	
6	15.3	3.0	14.3	2.0	37.7	2.3	7.3			2.0	27.0	4.7	
7	3.7	1.0	17.0	26.3	1.3		45.3			2.3	4.3	13.0	
8	3.3		5.3	5.0	8.3	1.7	3.3	8.7		12.7	16.7	4.3	
9	19.7	2.0	30.3	5.7	23.3	1.0	1.0		17.3	24.7	15.0	9.7	
10	1.0	3.0	21.0	1.3	1.0	7.3	1.7		16.7	28.3	20.3		
11	10.7	99.3	1.0	7.0	13.3			3.0	1.0	23.3	17.3	1.0	
12	4.3	8.0	13.7	6.3	13.7		1.7			4.7	4.7	8.3	
13	16.7	7.7	25.3	14.3	20.3		16.0	1.0	1.0	2.3	1.3	11.0	
14		2.3	20.7	8.0			4.0				6.3	1.7	
15		1.0	1.0	13.3	6.7	1.7	44.0		1.0	1.0	41.7	4.0	
16		8.0	2.3	25.0		1.0				23.3	28.3	2.0	
17		42.3	4.7	9.3	18.0				1.0	14.7		5.3	
18		9.7	3.3	20.3	10.0		23.3		3.3	13.0	1.3	1.0	
19	4.7	11.7	34.3	5.0	1.0				20.3	11.3	31.7	8.0	
20	7.3		11.0	4.7				2.7	16.0	55.0	5.3	21.0	
21	1.7	7.7	1.0	7.3	17.7				79.7	7.0	8.7	9.0	
22	4.3	4.3	18.7	14.0	16.3				33.0	3.3	35.3	6.7	
23	79.0	35.7	11.7	6.3	3.0	1.0				4.3	17.3	10.7	
24	20.3	6.7		6.7	11.7				2.3	11.0	6.3	8.0	
25	5.0	9.0		13.0			5.0	44.7	13.3	9.7	8.0	2.7	
26	19.0	4.3				14.3		4.3		18.7	14.0		
27	8.7	10.7	43.3	3.3	9.7			5.0	5.0	6.3	17.0	2.0	
28	14.3	5.7	19.7	2.7	7.3		2.7			12.3	28.0	43.3	
29	17.7	4.0	23.7	2.0					59.3		46.7	34.7	
30	3.3		1.0		4.7			4.0		25.0	9.3	4.3	
31	7.3		1.0		15.7					12.7		13.7	
TOTAL	459.0	309.8	330.0	247.2	276.0	53.4	171.0	73.4	299.8	404.3	498.5	256.8	3379.2
RAINDAYS	26	25	25	26	25	11	14	8	18	29	29	29	265
DRY	5	3	6	4	6	19	17	23	12	2	1	2	100
MAXIMUM	94.0	99.3	43.3	26.3	37.7	15.7	45.3	44.7	79.7	55.0	46.7	43.3	

APPENDIX B

SUMMARY OF XRF RESULTS

Location		Cd	Ag	Pd
Urik	Mean	10.9	63.0	3.2
	Median	<LOD	54.9	<LOD
	Minimum	<LOD	20.5	<LOD
	Maximum	65.9	123.9	27.7
	Std. Deviation	20.5	32.0	7.6
Purut	Mean	31.9	139.1	12.2
	Median	29.6	151.3	21.0
	Minimum	<LOD	74.4	<LOD
	Maximum	65.5	207.7	24.8
	Std. Deviation	25.6	38.5	11.9
Longgom	Mean	5.0	54.6	1.0
	Median	<LOD	47.9	<LOD
	Minimum	<LOD	<LOD	<LOD
	Maximum	32.5	132.0	16.7
	Std. Deviation	11.4	33.7	4.1
Teranggan	Mean	<LOD	44.2	<LOD
	Median	<LOD	41.0	<LOD
	Minimum	<LOD	31.1	<LOD
	Maximum	<LOD	69.8	<LOD
	Std. Deviation	<LOD	12.0	<LOD
Upper Segama				
	Mean	<LOD	<LOD	<LOD
	Median	<LOD	<LOD	<LOD
	Minimum	<LOD	<LOD	<LOD
	Maximum	<LOD	<LOD	<LOD
	Std. Deviation	<LOD	<LOD	<LOD
Sepagaya	Mean	<LOD	73.3	<LOD
	Median	<LOD	66.1	<LOD
	Minimum	<LOD	57.2	<LOD
	Maximum	<LOD	96.6	<LOD
	Std. Deviation	<LOD	20.7	<LOD
Taliwas	Mean	<LOD	<LOD	<LOD
	Median	<LOD	<LOD	<LOD
	Minimum	<LOD	<LOD	<LOD
	Maximum	<LOD	<LOD	<LOD
	Std. Deviation	<LOD	<LOD	<LOD
Kawaq	Mean	107.2	204.2	49.8

	Median	106.6	195.9	49.1
	Minimum	106.1	187.5	44.7
	Maximum	109.0	229.3	55.7
	Std. Deviation	1.5	22.1	5.5
Bole	Mean	<LOD	30.1	<LOD
	Median	<LOD	32.4	<LOD
	Minimum	<LOD	<LOD	<LOD
	Maximum	<LOD	49.16	<LOD
	Std. Deviation	<LOD	17.2	<LOD
Bilong	Mean	<LOD	<LOD	<LOD
	Median	<LOD	<LOD	<LOD
	Minimum	<LOD	<LOD	<LOD
	Maximum	<LOD	<LOD	<LOD
	Std. Deviation	<LOD	<LOD	<LOD
Palum Tamban	Mean	<LOD	56.9	<LOD
	Median	<LOD	62.1	<LOD
	Minimum	<LOD	<LOD	<LOD
	Maximum	<LOD	87.5	<LOD
	Std. Deviation	<LOD	24.2	<LOD
Danum	Mean	<LOD	38.8	<LOD
	Median	<LOD	43.8	<LOD
	Minimum	<LOD	<LOD	<LOD
	Maximum	<LOD	59.0	<LOD
	Std. Deviation	<LOD	16.7	<LOD

Location		Zr	Sr	U	Rb	As	Zn	Cu
Urik	Mean	300.9	77.6	8.5	61.1	20.7	50.9	38.0
	Median	289.4	80.8	10.4	61.2	20.6	52.2	39.0
	Minimum	192.8	53.4	<LOD	43.6	13.3	36.6	<LOD
	Maximum	448.8	92.1	14.7	76.6	24.4	64.7	48.7
	Std. Deviation	64.6	9.8	4.6	8.9	2.7	7.4	9.7
Purut	Mean	445.8	129.8	1.2	30.0	19.1	39.5	34.3
	Median	453.3	132.7	<LOD	28.8	18.7	37.8	32.0
	Minimum	243.2	104.9	<LOD	22.2	15.7	22.4	22.5
	Maximum	679.3	156.8	9.3	40.4	22.1	61.2	48.0
	Std. Deviation	157.8	16.3	3.2	5.6	2.0	10.1	7.5
Longgom	Mean	560.0	69.2	6.2	49.8	14.5	39.5	23.0
	Median	564.8	69.0	8.0	50.4	14.7	40.2	24.4
	Minimum	407.9	57.3	<LOD	41.6	10.1	28.0	<LOD
	Maximum	691.3	78.6	13.5	55.6	18.5	49.3	37.1
	Std. Deviation	86.0	4.9	5.0	4.2	2.2	5.6	8.2
Teranggan	Mean	534.5	72.2	7.1	54.8	20.3	42.4	37.6
	Median	483.9	72.3	9.3	51.9	21.1	39.6	38.1
	Minimum	436.0	68.3	<LOD	48.7	17.3	36.6	26.5
	Maximum	690.8	76.4	12.1	64.3	22.3	51.8	46.2
	Std. Deviation	102.6	2.8	5.5	5.6	1.7	6.0	6.0
Upper Segama	Mean	180.1	19.0	<LOD	<LOD	5.7	2.0	<LOD
	Median	193.0	20.2	<LOD	<LOD	5.7	<LOD	<LOD
	Minimum	147.5	16.5	<LOD	<LOD	5.7	<LOD	<LOD
	Maximum	199.8	20.3	<LOD	<LOD	5.9	6.0	<LOD

	Std. Deviation	28.4	2.2	<LOD	<LOD	0.1	3.5	<LOD
Sepagaya	Mean	195.7	83.4	12.2	67.8	20.3	62.3	45.1
	Median	200.7	84.4	11.6	69.0	19.2	64.5	48.3
	Minimum	180.9	78.4	8.6	63.8	18.5	57.0	31.9
	Maximum	205.4	87.3	16.4	70.8	23.1	65.5	55.2
	Std. Deviation	13.0	4.6	3.9	3.6	2.5	4.7	12.0
Taliwas	Mean	138.7	380.9	<LOD	<LOD	26.5	41.7	81.3
	Median	137.7	381.4	<LOD	<LOD	25.9	41.2	81.7
	Minimum	137.1	377.3	<LOD	<LOD	23.4	40.0	74.9
	Maximum	141.4	383.9	<LOD	<LOD	30.3	44.0	87.4
	Std. Deviation	2.4	3.3	<LOD	<LOD	3.5	2.1	6.2
Kawaq	Mean	148.4	125.4	<LOD	3.3	14.2	18.5	19.8
	Median	152.0	125.3	<LOD	3.3	14.6	18.8	18.6
	Minimum	141.3	122.6	<LOD	3.1	13.2	17.0	17.4
	Maximum	152.0	128.3	<LOD	3.5	14.8	19.8	23.4
	Std. Deviation	6.2	2.9	<LOD	0.2	0.9	1.4	3.2
Bole	Mean	306.7	115.0	<LOD	27.0	23.1	36.0	41.3
	Median	325.1	116.6	<LOD	27.4	23.5	34.9	40.0
	Minimum	196.3	104.0	<LOD	22.0	18.7	29.3	<LOD
	Maximum	371.1	127.6	<LOD	33.4	26.3	44.4	67.9
	Std. Deviation	59.0	7.4	<LOD	3.4	2.0	4.9	15.4
Bilong	Mean	66.9	13.7	<LOD	9.7	4.8	8.0	<LOD
	Median	60.9	14.0	<LOD	9.1	4.9	9.0	<LOD
	Minimum	40.8	9.5	<LOD	5.5	3.1	<LOD	<LOD

	Maximum	98.8	17.6	<LOD	14.5	6.3	14.9	<LOD
	Std. Deviation	29.5	4.1	<LOD	4.5	1.6	7.5	<LOD
Palum Tamban	Mean	397.6	93.8	<LOD	50.8	22.5	66.2	34.3
	Median	399.4	94.0	<LOD	54.2	21.9	68.1	32.7
	Minimum	278.3	88.5	<LOD	27.7	18.8	47.0	26.7
	Maximum	527.7	100.1	<LOD	61.2	26.1	77.0	44.8
	Std. Deviation	83.3	3.4	<LOD	10.4	2.1	9.0	6.0
Danum	Mean	228.7	85.8	<LOD	31.7	22.4	67.7	42.6
	Median	224.2	85.4	<LOD	32.3	22.3	66.7	42.4
	Minimum	167.1	79.3	<LOD	27.0	19.0	59.4	23.2
	Maximum	311.6	92.3	<LOD	34.0	25.2	77.5	62.3
	Std. Deviation	53.3	3.7	<LOD	2.2	2.0	5.3	11.3
Location		Ni	Fe	Mn	Cr	V	Ti	Sc
Urik	Mean	118.9	31896.5	925.2	180.6	176.6	5794.5	16.2
	Median	120.6	33755.7	968.5	187.5	175.5	5845.7	<LOD
	Minimum	83.0	22827.0	537.2	125.8	136.6	5140.4	<LOD
	Maximum	158.8	37908.4	1183.8	238.8	219.2	6372.2	97.9
	Std. Deviation	21.0	4049.7	188.1	33.6	25.5	353.1	30.5
Purut	Mean	114.0	35554.9	833.4	126.8	219.0	5722.4	125.4
	Median	117.2	37295.0	822.3	132.2	220.9	5656.2	129.1
	Minimum	79.9	28886.6	679.1	43.3	175.8	5067.5	92.0
	Maximum	152.8	39919.3	977.1	191.8	254.9	6713.5	189.1
	Std. Deviation	21.0	3765.4	96.9	38.2	22.8	423.8	27.8
Longgom								

	Mean	85.1	21846.5	545.9	132.7	142.7	4365.0	10.7
	Median	84.8	21795.3	537.0	131.1	143.6	4361.6	<LOD
	Minimum	59.2	18849.9	482.2	80.3	120.9	3807.9	<LOD
	Maximum	116.2	24738.7	640.9	208.4	165.6	4904.8	72.0
	Std. Deviation	16.2	1764.6	42.4	34.0	15.3	306.5	24.1
Teranggan	Mean	134.8	34071.5	682.5	297.3	206.7	5650.5	59.7
	Median	140.6	33137.9	696.4	285.2	208.0	5642.1	78.8
	Minimum	90.1	32127.6	582.1	252.9	178.9	5357.7	<LOD
	Maximum	173.8	37083.2	759.4	364.8	232.7	5969.7	118.5
	Std. Deviation	24.9	2200.5	64.7	40.8	16.6	199.6	46.4
Upper Segama	Mean	<LOD	13545.9	233.6	131.9	146.9	6650.6	178.6
	Median	<LOD	14411.5	245.9	164.5	157.0	6697.4	180.4
	Minimum	<LOD	11759.0	179.9	<LOD	110.5	6035.1	172.0
	Maximum	<LOD	14467.2	275.0	231.2	173.4	7219.4	183.5
	Std. Deviation	<LOD	1547.8	48.7	119.0	32.6	593.5	5.9
Sepagaya	Mean	116.8	35707.1	635.0	205.2	242.1	5945.0	19.2
	Median	115.7	36732.6	646.7	197.9	237.6	6052.7	<LOD
	Minimum	109.2	33556.3	585.3	190.9	233.7	5598.3	<LOD
	Maximum	125.5	36832.4	672.9	226.7	254.9	6184.1	57.7
	Std. Deviation	8.2	1863.3	45.0	19.0	11.3	307.4	33.3
Taliwas	Mean	<LOD	63980.0	1634.0	241.6	346.5	5583.6	237.5
	Median	<LOD	64076.9	1666.7	248.5	348.7	5579.0	229.1
	Minimum	<LOD	63777.5	1544.6	193.3	318.6	5558.6	223.7
	Maximum	<LOD	64085.6	1690.7	283.2	372.3	5613.3	259.7
	Std. Deviation	<LOD	175.4	78.3	45.4	26.9	27.7	19.4

Kawaq	Mean	93.7	32946.3	666.5	460.1	322.8	7823.6	250.3
	Median	86.1	33210.0	671.1	462.1	316.0	7819.9	243.0
	Minimum	83.3	32324.9	654.4	433.0	314.6	7465.6	230.6
	Maximum	111.8	33304.2	674.2	485.1	337.9	8185.4	277.4
	Std. Deviation	15.7	540.3	10.6	26.1	13.1	360.0	24.2
Bole	Mean	<LOD	47792.6	1035.5	443.0	275.4	5868.4	148.0
	Median	<LOD	45038.5	920.0	447.2	270.5	5838.5	180.1
	Minimum	<LOD	42129.8	831.1	277.3	205.7	5314.2	<LOD
	Maximum	<LOD	57729.1	1437.1	536.4	381.1	6558.0	272.0
	Std. Deviation	<LOD	5244.2	220.1	67.0	46.1	316.1	99.0
Bilong	Mean	<LOD	9427.3	277.6	196.8	72.7	4245.5	64.7
	Median	<LOD	9302.1	286.9	201.0	80.3	4217.6	84.4
	Minimum	<LOD	7254.5	206.9	<LOD	<LOD	3982.4	<LOD
	Maximum	<LOD	11725.4	339.0	389.5	137.9	4536.5	109.6
	Std. Deviation	<LOD	2238.1	66.5	194.8	69.2	278.1	57.4
Palum Tamban	Mean	<LOD	40028.1	826.8	187.8	254.4	6080.3	<LOD
	Median	<LOD	40352.9	717.9	194.8	260.1	6006.2	<LOD
	Minimum	<LOD	36056.2	627.5	123.1	178.6	4721.6	<LOD
	Maximum	<LOD	46916.2	1563.1	250.1	319.8	7000.8	<LOD
	Std. Deviation	<LOD	3218.4	292.3	30.7	37.1	515.8	<LOD
Danum	Mean	<LOD	41226.5	856.2	328.2	234.9	5989.6	<LOD
	Median	<LOD	41065.5	862.3	332.7	234.9	5937.7	<LOD
	Minimum	<LOD	40240.3	769.9	222.2	175.4	5564.5	<LOD
	Maximum	<LOD	42465.8	969.5	394.7	289.0	6552.4	<LOD

	Std. Deviation	<LOD	794.7	59.4	50.2	33.8	297.6	<LOD
Location		Ca	K	Ba	Cs	Te	Sb	Sn
Urik	Mean	4028.8	15421.8	252.9	40.4	65.5	38.5	33.6
	Median	4036.0	15402.5	227.6	29.2	36.3	<LOD	<LOD
	Minimum	2997.9	12882.1	127.3	<LOD	<LOD	<LOD	<LOD
	Maximum	4822.5	17771.9	459.9	114.4	248.8	160.5	138.8
	Std. Deviation	488.1	1331.4	97.1	36.4	80.6	53.3	45.5
Purut	Mean	17100.5	10282.6	490.0	111.9	197.8	119.0	111.5
	Median	16806.6	9993.8	531.1	127.7	223.0	127.8	125.7
	Minimum	13816.1	8702.7	274.4	40.7	<LOD	<LOD	28.9
	Maximum	19467.5	12097.9	676.1	171.9	322.0	203.7	189.3
	Std. Deviation	1610.5	1015.8	129.2	43.5	105.2	72.8	53.1
Longgom	Mean	4815.6	12830.1	226.0	32.1	44.7	25.6	18.8
	Median	4508.7	12861.7	188.5	26.5	<LOD	<LOD	<LOD
	Minimum	3915.8	10714.8	113.6	<LOD	<LOD	<LOD	<LOD
	Maximum	6085.3	14238.0	431.1	92.6	179.6	116.7	100.3
	Std. Deviation	764.1	832.9	99.5	29.9	63.7	41.2	34.2
Teranggan	Mean	9200.0	14375.3	188.8	14.3	7.9	<LOD	4.8
	Median	9757.1	13552.9	182.3	16.1	<LOD	<LOD	<LOD
	Minimum	7233.5	12786.7	128.9	<LOD	<LOD	<LOD	<LOD
	Maximum	10504.5	17169.1	245.0	41.4	71.0	<LOD	43.5

	Std. Deviation	1328.2	1592.9	33.8	13.3	23.7	<LOD	14.5
Upper Segama								
	Mean	25178.4	5481.4	<LOD	<LOD	<LOD	<LOD	<LOD
	Median	25802.3	5725.8	<LOD	<LOD	<LOD	<LOD	<LOD
	Minimum	22086.5	4954.2	<LOD	<LOD	<LOD	<LOD	<LOD
	Maximum	27646.6	5764.1	<LOD	<LOD	<LOD	<LOD	<LOD
	Std. Deviation	2832.0	457.0	<LOD	<LOD	<LOD	<LOD	<LOD
Sepagaya								
	Mean	4137.4	15567.7	294.1	33.5	50.1	15.0	16.1
	Median	4300.3	15515.8	255.9	29.1	44.3	<LOD	<LOD
	Minimum	3734.5	14752.2	254.5	20.6	<LOD	<LOD	<LOD
	Maximum	4377.3	16435.1	371.9	50.8	106.0	45.0	48.2
	Std. Deviation	351.0	842.7	67.4	15.6	53.2	25.9	27.8
Taliwas								
	Mean	32455.2	3161.5	<LOD	<LOD	<LOD	<LOD	<LOD
	Median	32432.4	3140.0	<LOD	<LOD	<LOD	<LOD	<LOD
	Minimum	32367.9	3081.4	<LOD	<LOD	<LOD	<LOD	<LOD
	Maximum	32565.3	3263.1	<LOD	<LOD	<LOD	<LOD	<LOD
	Std. Deviation	100.7	92.8	<LOD	<LOD	<LOD	<LOD	<LOD
Kawaq								
	Mean	35330.8	5545.2	653.5	186.0	420.4	281.4	220.4
	Median	35778.3	5560.5	642.8	189.1	419.6	280.7	221.9
	Minimum	33431.1	5427.6	639.5	176.0	412.0	267.1	201.0
	Maximum	36783.1	5647.6	678.3	192.9	429.7	296.4	238.4
	Std. Deviation	1720.2	110.8	21.5	8.9	8.9	14.7	18.8
Bole								
	Mean	24709.6	7718.6	110.8	3.5	<LOD	<LOD	9.0
	Median	24466.8	7565.6	105.0	<LOD	<LOD	<LOD	<LOD
	Minimum	19830.1	6573.2	80.3	<LOD	<LOD	<LOD	<LOD

	Maximum	31523.3	9124.9	174.6	18.9	<LOD	<LOD	53.1
	Std. Deviation	3451.5	750.5	26.9	7.3	<LOD	<LOD	19.1
Bilong	Mean	7907.5	13939.3	<LOD	<LOD	<LOD	<LOD	<LOD
	Median	7984.2	14064.3	<LOD	<LOD	<LOD	<LOD	<LOD
	Minimum	7108.4	13220.1	<LOD	<LOD	<LOD	<LOD	<LOD
	Maximum	8629.8	14533.5	<LOD	<LOD	<LOD	<LOD	<LOD
	Std. Deviation	763.6	665.5	<LOD	<LOD	<LOD	<LOD	<LOD
Palum Tamban	Mean	56035.9	13820.1	182.1	25.4	33.5	7.9	40.4
	Median	56209.7	15235.9	208.7	28.6	42.9	<LOD	46.4
	Minimum	45780.3	6237.9	<LOD	<LOD	<LOD	<LOD	<LOD
	Maximum	65515.8	16478.9	247.2	43.4	75.1	49.2	72.0
	Std. Deviation	6315.2	3482.3	75.7	13.0	27.7	16.1	24.1
Danum	Mean	60478.0	9647.4	110.8	3.2	<LOD	<LOD	9.7
	Median	58842.7	9673.9	119.3	<LOD	<LOD	<LOD	<LOD
	Minimum	51770.6	8969.0	<LOD	<LOD	<LOD	<LOD	<LOD
	Maximum	73208.2	10286.8	163.3	20.9	<LOD	<LOD	44.5
	Std. Deviation	7292.6	412.6	44.9	7.6	<LOD	<LOD	17.7