CHAPTER 7: SYSTEMS DEVELOPMENT AND TECHNIFICATION

VOLUME CALCULATIONS

Introduction to Water Strategy and Intention

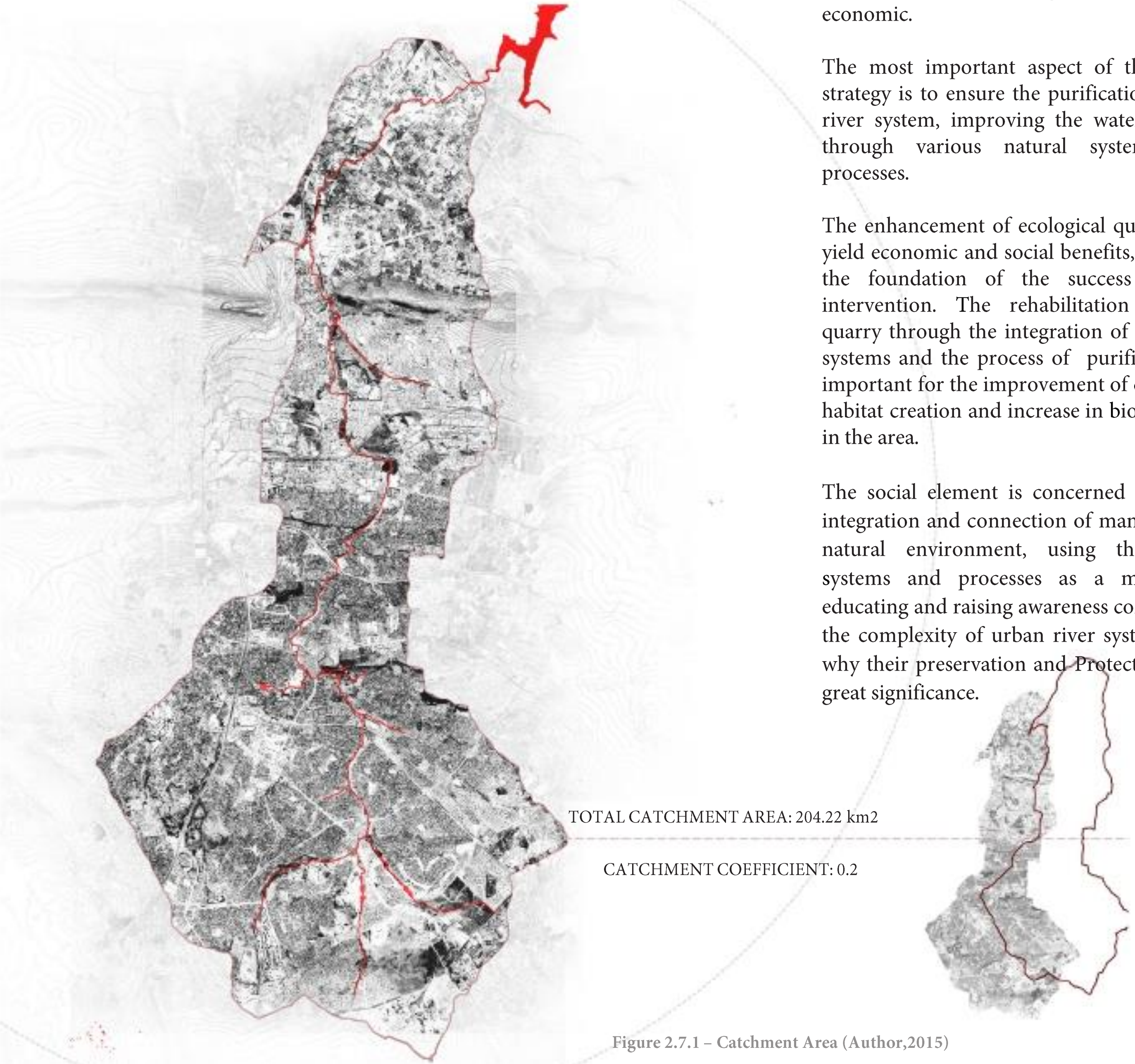


Figure 2.7.1 – Catchment Area (Author,2015)

The main intention for the water systems in the design intervention deals with the water on three levels, ecological, social and economic.

The most important aspect of the water strategy is to ensure the purification of the river system, improving the water quality through various natural systems and processes.

The enhancement of ecological quality will yield economic and social benefits, forming the foundation of the success of the intervention. The rehabilitation of the quarry through the integration of the river systems and the process of purification is important for the improvement of ecologies, habitat creation and increase in biodiversity in the area.

The social element is concerned with the integration and connection of man and the natural environment, using the water systems and processes as a means of educating and raising awareness concerning the complexity of urban river systems and why their preservation and Protection is of great significance.

The connection of societies as well as an and nature will influence and inform the use and structure of the water system.

The choice of a decommissioned post-industrial landscape, a wasted space in the urban environment aids in the further connection of urban and natural environments on an economic and industrial level.

The transition between urban industrial and natural industrial will be created through the incorporation and use of the river system as a means of production for the surrounding environment.

The approach to the water systems was making use of natural systems and processes for purification, limited technological input into the system but used in a sustainable manner when required.

The design is intended to be able to harvest and make available through use of the river system and urban runoff, enough water to sustain all activities and meet all demands on site as a result of social and economic activities.

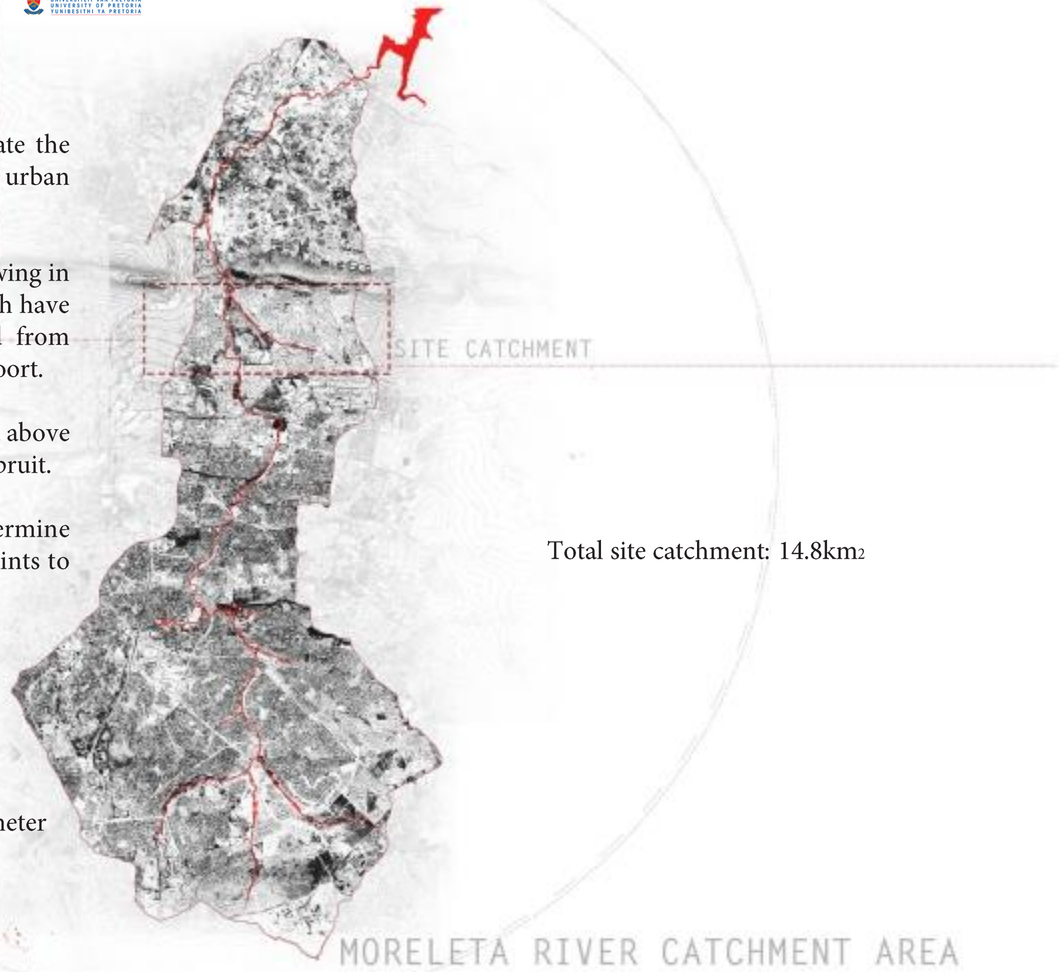
CALCULATION OF WATER CATCHMENT

The success of the design depends on the ability to Understand and manipulate the water systems in order to be able to purify and incorporate them into the urban environment as a resource for a number of activities.

The chosen site includes the main Moreleta Spruit, the Rietspruit tributary flowing in to the site from the east, as well as the Era Brick quarry. These three elements each have their own catchment in terms of runoff. The water readings given were obtained from the Department of Water Affairs water meter placed at Baviaanspoort in Derdepoort.

These readings are not able to be directly applied to the site as the meter is located above the site and after the point of convergence of the Moreleta Spruit and the Rietspruit.

These readings were however used in the calculations which were able to determine the water volumes of both the Rietspruit and the Moreleta Spruit at the entry points to the site.



Total site catchment: 14.8km_2

Figure 2.7.2 – Location of site catchment in relation to Moreleta Spruit Catchment Area (Author, 2015)

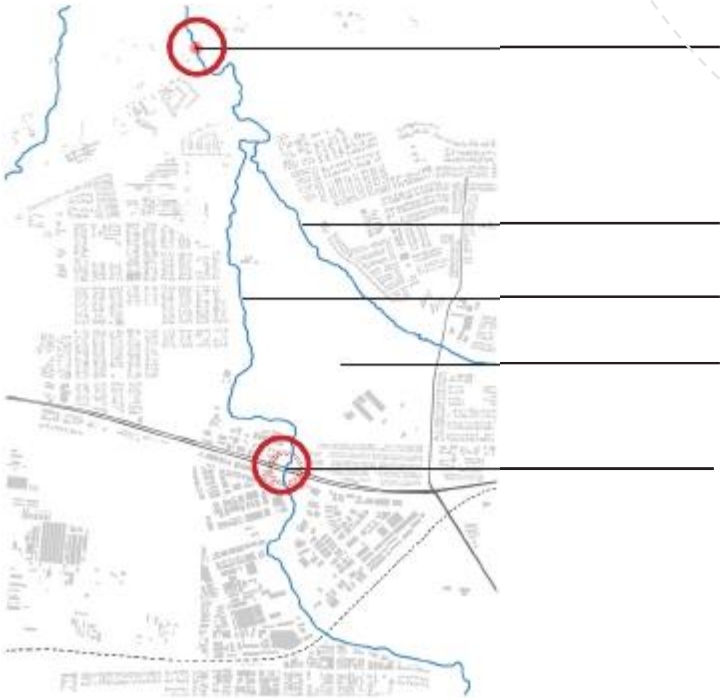


Figure 2.7.3 – Catchment Location Map (Author, 2015)

To calculate the available water at Stormvoel road, the smaller catchments of the Moreleta Spruit, Rietspruit and quarry on site need to be calculated as a percentage of the entire river catchment.

The percentage of area that the site catchment is of the entire river catchment will determine the percentage of water that is accumulated in these three catchments. The percentage of water will be removed from the total water volumes accumulated from the DWA meter located at Derdepoort.

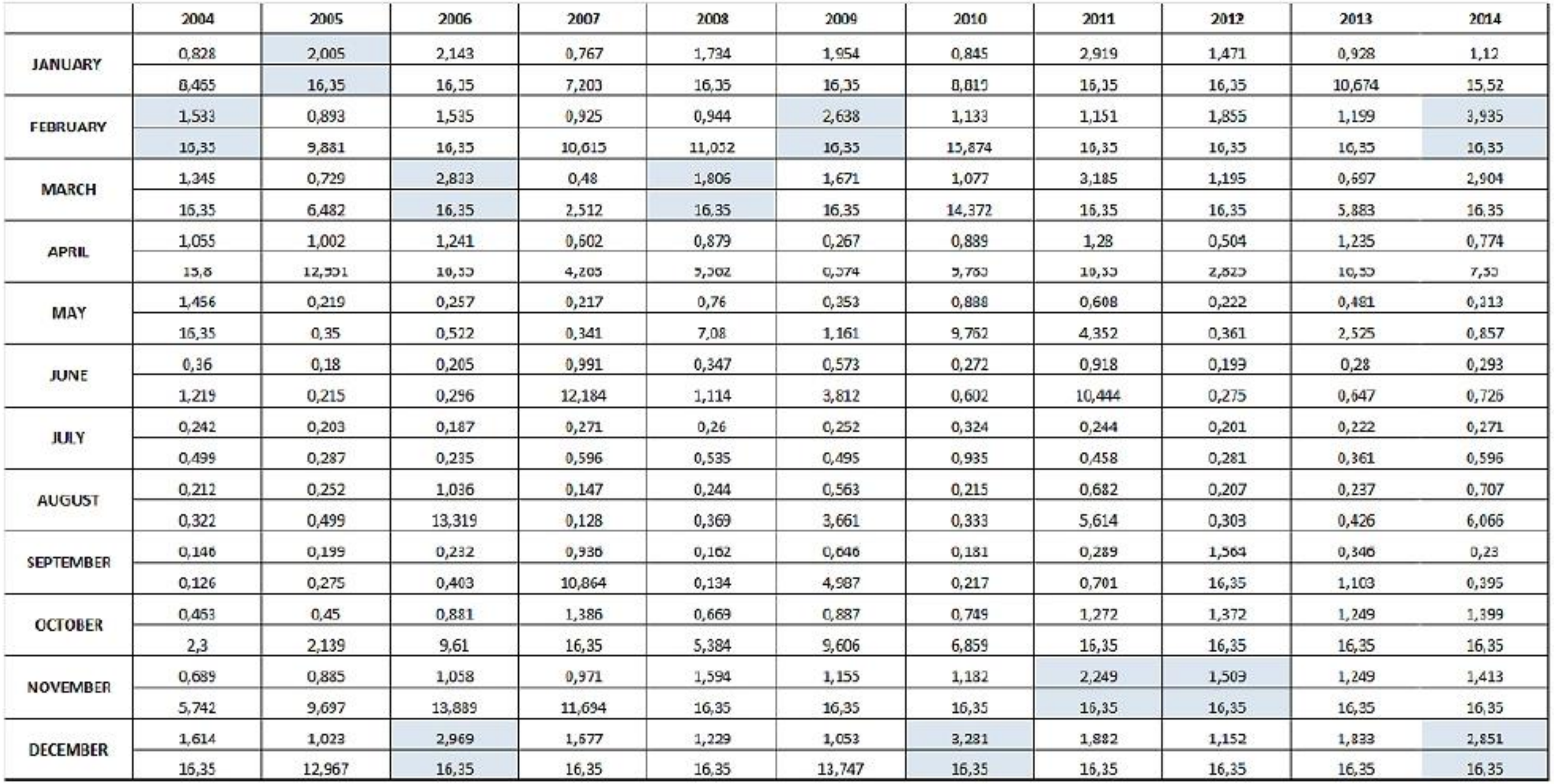
DAILY FLOW RATE (M3/S) READINGS AND CALCULATIONS FROM DWA METER AT DERDEPOORT OVER A 12 MONTH PERIOD

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	0,479	2,512	0,477	0,886	0,625	0,574	0,536	0,472	0,346	0,242	0,266	0,777
2	0,765	3,69		0,881	0,626	0,584	0,505	0,46	0,327	0,255	0,379	0,455
3	0,642	6,769		2,014	0,614	0,539	0,498	0,462	0,306	0,242	0,444	0,403
4	0,398	1,276		0,887	0,625	0,491	0,487	0,459	0,297	0,31	0,368	0,357
5	0,305	0,705		0,854	0,608	0,494	0,481	0,462	0,315	0,268	0,286	0,322
6	0,292	1,175	3,108	0,847	0,605	0,509	0,482	0,457	0,332	0,272	0,239	0,309
7	0,292	1,937	5,433	0,32	0,637	0,512	0,523	0,45	0,319	0,317	0,228	1,406
8	0,462	0,811	4,22	0,803	0,647	0,548	0,526	0,445	0,324	0,27	0,276	0,773
9	0,32	8,491	1,927	0,789	0,629	0,585	0,512	0,445	0,32	0,234	0,489	2,263
10	0,307	1,697	13,642	0,777	0,577	0,56	0,515	0,448	0,316	0,234	0,299	0,731
11	0,261	1,014	10,66	0,758	0,572	0,56	0,509	0,456	0,335	0,237	4,848	0,854
12	0,237	0,749	9,897	0,751	0,581	0,588	0,48	0,469	0,287	0,205	0,771	2,087
13	0,831	0,634	5,117	0,747	0,553	0,582	0,497	0,455	0,285	0,206	0,602	0,752
14	0,586	0,561	2,845	0,791	0,559	0,561	0,508	0,433	0,331	0,197	0,441	1,231
15	0,399	0,511	2,148	0,793	0,582	0,582	0,541	0,429	0,301	0,214	3,812	2,32
16	0,541	0,474	1,767	1,153	0,603	0,601	0,531	1,181	0,27	0,223	1,013	2,604
17	0,289	0,429	3,247	0,793	0,608	0,577	0,559	1,491	0,297	0,211	0,832	0,836
18	0,235	0,396	1,838	0,769	0,579	0,555	0,538		0,249	0,19	0,822	1,95
19	0,226	0,413	2,562	0,772	0,714	0,539	0,525		0,24	0,189	0,478	3,439
20	0,333	0,367	1,361	0,76	0,639	0,513	0,527		0,24	0,197	0,402	2,578
21	0,426	2,434	1,234	0,733	0,635	0,506	0,504	0,414	0,234	0,18	0,364	1,105
22	0,243	1,523	1,182	0,697	0,64	0,522	0,516	0,376	0,246	0,175	0,555	0,94
23	0,217	1,865	1,13	0,71	0,603	0,536	0,549	0,374	0,266	0,173	1,333	3,932
24	0,22	1,041	1,091	0,735	0,628	0,519	0,559	0,337	0,24	0,189	0,713	2,735
25	1,677	1,417	1,047	0,678	0,62	0,509	0,557	0,329	0,233	1,763	0,405	1,078
26	2,249	0,658	0,975	0,634	0,618	0,508	0,534	0,323	0,229	3,625	0,347	0,739
27	0,434	0,523	1,035	0,652	0,599	0,51	0,479	0,32	0,252	0,529	5,414	5,868
28	0,331	0,478	1,039	0,664	0,584	0,483	0,474	0,369	0,217	0,397	0,775	9,846
29	0,299		0,892	0,648	0,583	0,519	0,478	0,361	0,227	0,328	0,55	2,007
30	0,263		1,306	0,628	0,57	0,617	0,486	0,349	0,24	0,3	1,072	1,213
31	1,372		1,169		0,58		0,484	0,371		0,297		1,341
Average Flow Rate per day (m^3/second)	**1,719**	**1,58**	**2,656**	**0,785**	**0,601**	**0,543**	**0,513**	**0,476**	**0,28**	**0,402**	**0,955**	**1,84**
Average Volume per day (m^3)	148549,47	136512	229495,01	67824	51926,4	46828,8	44314,83	41126,4	24105,6	34732,8	82512	158976
Average volume per month (m^3)	4605033,6	3822336	7114348,8	2034720	1609718,4	1404864	1373760	1274918,4	723168	1076716,8	2475360	4928256
Average volume per year (m^3)	32443200										Minimum flow rate	Maximum flow rate

Table 2.7.1 – Daily Flow Rates at Derdepoort (Author, 2015)

FLOOD VOLUME (M3/S) READINGS FOR DERDEPOORT OVER THE LAST TEN YEARS

Year – October to October (Lowest and Highest Readings in that Month)



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
JANUARY	0,828	2,005	2,143	0,767	1,734	1,954	0,845	2,919	1,471	0,928	1,12
	8,465	16,35	16,35	7,203	16,35	16,35	8,815	16,35	16,35	10,674	15,52
FEBRUARY	1,533	0,893	1,535	0,925	0,944	2,638	1,133	1,151	1,855	1,199	3,935
	16,35	9,881	16,35	10,615	11,052	16,35	15,874	16,35	16,35	16,35	16,35
MARCH	1,345	0,729	2,833	0,48	1,806	1,671	1,077	3,185	1,195	0,697	2,904
	16,35	6,482	16,35	2,512	16,35	16,35	14,372	16,35	16,35	5,883	16,35
APRIL	1,055	1,002	1,241	0,602	0,879	0,267	0,889	1,28	0,504	1,235	0,774
	15,8	12,551	16,35	4,265	5,562	0,574	5,765	16,35	2,625	16,35	7,55
MAY	1,456	0,219	0,257	0,217	0,76	0,353	0,888	0,608	0,222	0,481	0,313
	16,35	0,35	0,522	0,341	7,08	1,161	9,762	4,352	0,361	2,525	0,857
JUNE	0,36	0,18	0,205	0,991	0,347	0,573	0,272	0,918	0,199	0,28	0,293
	1,219	0,215	0,296	12,184	1,114	3,812	0,602	10,444	0,275	0,647	0,726
JULY	0,242	0,203	0,187	0,271	0,26	0,252	0,324	0,244	0,201	0,222	0,271
	0,499	0,287	0,235	0,596	0,535	0,495	0,935	0,458	0,281	0,361	0,596
AUGUST	0,212	0,252	1,036	0,147	0,244	0,563	0,215	0,682	0,207	0,237	0,707
	0,322	0,499	13,319	0,128	0,369	3,661	0,333	5,614	0,303	0,426	6,066
SEPTEMBER	0,146	0,199	0,232	0,936	0,162	0,646	0,181	0,289	1,564	0,346	0,23
	0,126	0,275	0,403	10,864	0,134	4,987	0,217	0,701	16,35	1,103	0,395
OCTOBER	0,463	0,45	0,881	1,386	0,669	0,887	0,749	1,272	1,372	1,249	1,399
	2,3	2,139	9,61	16,35	5,384	9,606	6,859	16,35	16,35	16,35	16,35
NOVEMBER	0,689	0,885	1,058	0,971	1,594	1,155	1,182	2,249	1,509	1,249	1,413
	5,742	9,697	13,889	11,694	16,35	16,35	16,35	16,35	16,35	16,35	16,35
DECEMBER	1,614	1,023	2,969	1,677	1,229	1,053	3,281	1,882	1,152	1,833	2,851
	16,35	12,967	16,35	16,35	16,35	13,747	16,35	16,35	16,35	16,35	16,35

Table 2.7.2 – Monthly Flood Volumes at Derdepoort (Author, 2015)

The peak floods have been highlighted in each year to gain an understanding of the trends in flooding as well as the values for further calculations. The designs of the water systems will need to cater for flood management and these values will provide maximum water rates and volumes.

QUARRY CATCHMENT AND CALCULATION

All stormwater which lands on the site is either directed towards the Moreleta Spruit, Rietspruit or into the quarry. The quarry catchment is removed from all calculations regarding the river systems as no water which falls on the quarry site ends up in the river systems. The quarry catchment is focused on the collection of storm water, harvesting and directing the storm water on site into the purification system.

The storm water management system within the quarry and industrial area will be responsible for draining the site of all runoff from hard surfaces including the purification and storage of the water for use and incorporation into the social and economic elements proposed in the design intervention.

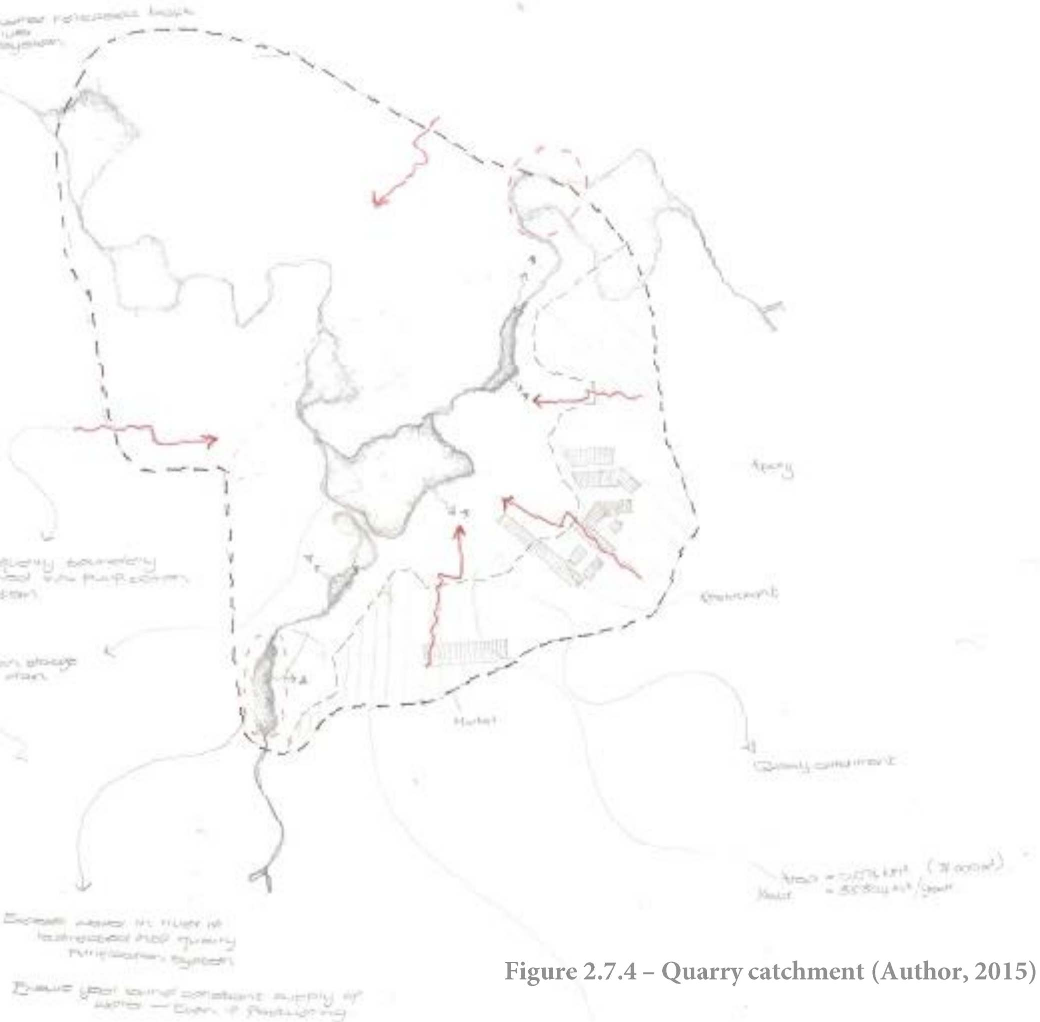


Figure 2.7.4 – Quarry catchment (Author, 2015)

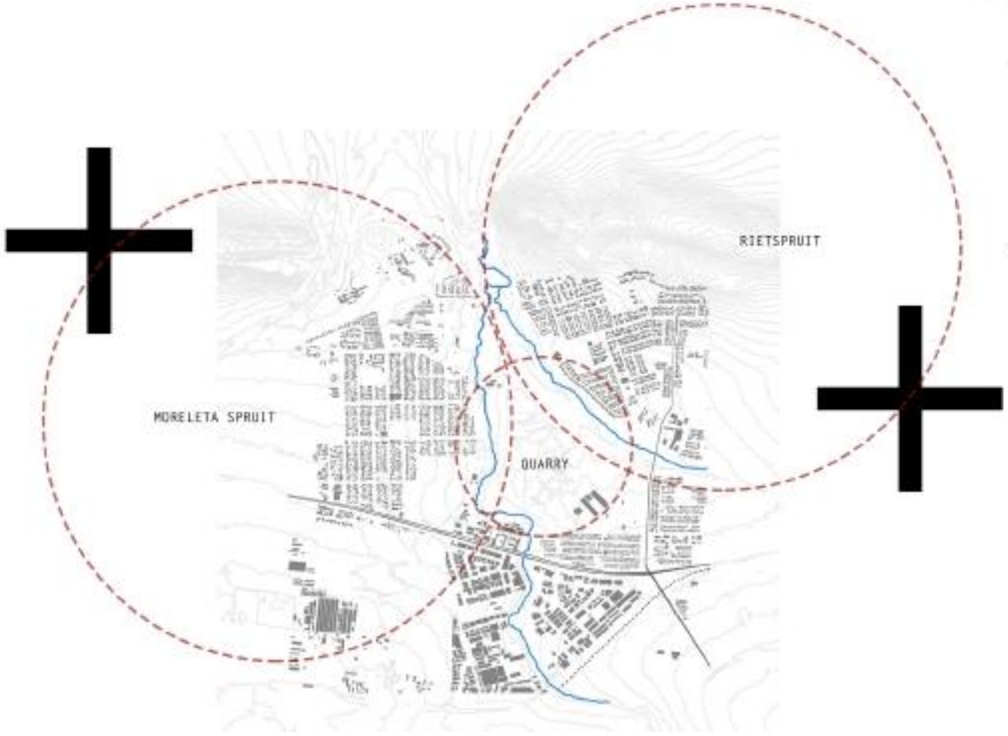
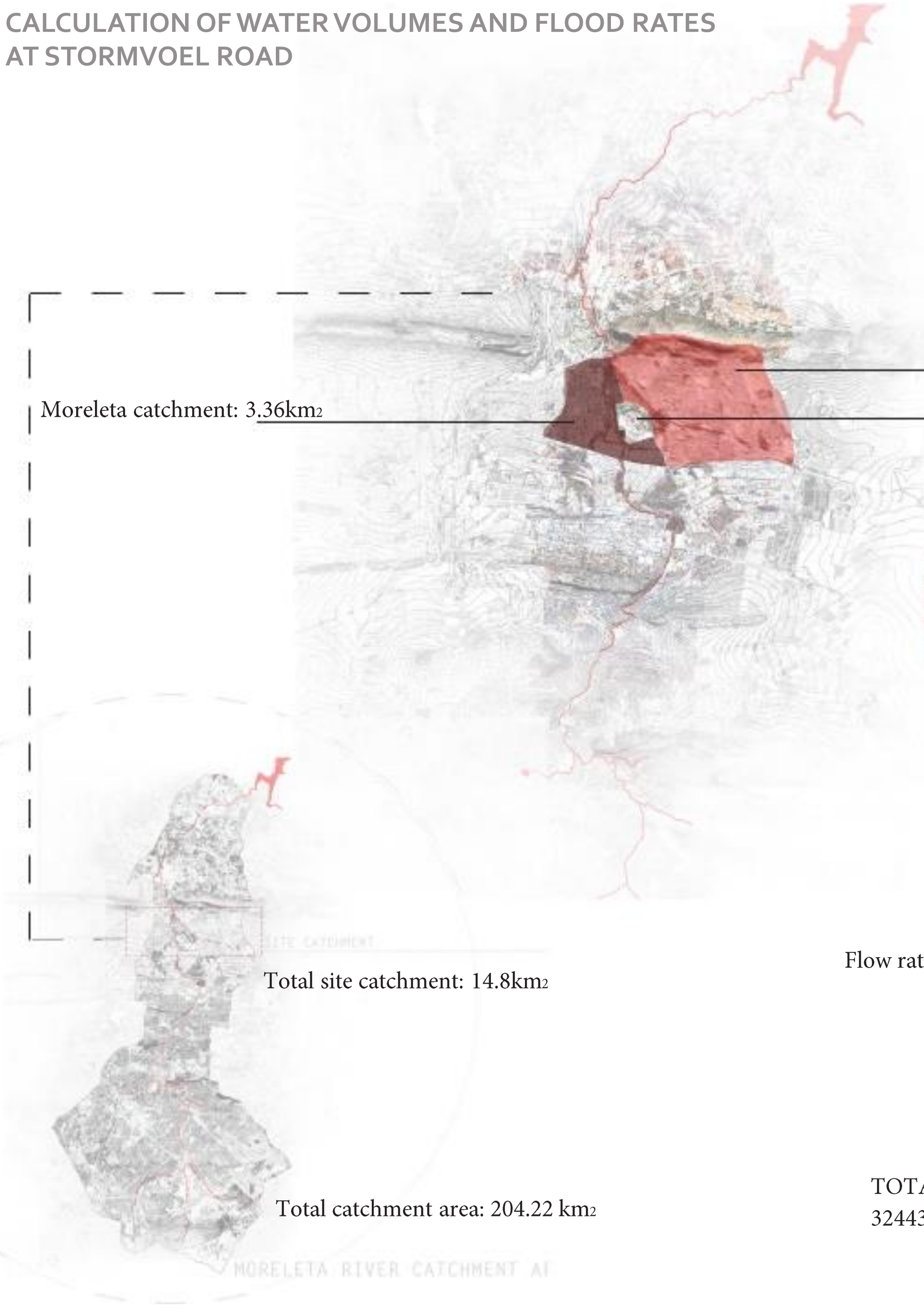


Figure 2.7.5 – Division of various catchments for the site (Author, 2015)

CALCULATION OF WATER VOLUMES AND FLOOD RATES AT STORMVOEL ROAD

The quarry catchment is a closed catchment area as no water from the quarry enters into the river system. The quarry water calculations will be calculated at a later stage and contribute to the water systems as a calculation of a Storm water runoff value for that catchment area.

The Moreleta Spruit and Rietspruit catchments are calculated as 7% of the total river catchment area. The total water volumes from the Derdepoort water meter will need to be reduced by 7% in order to determine the total water volumes in both the Rietspruit and Moreleta Spruit when entering the site.



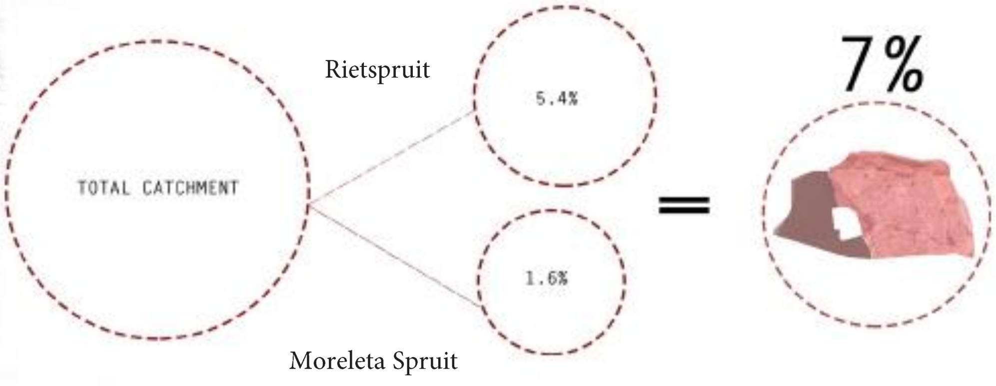
Rietspruit catchment: 11.34km^2

Moreleta catchment: 3.36km$_2$

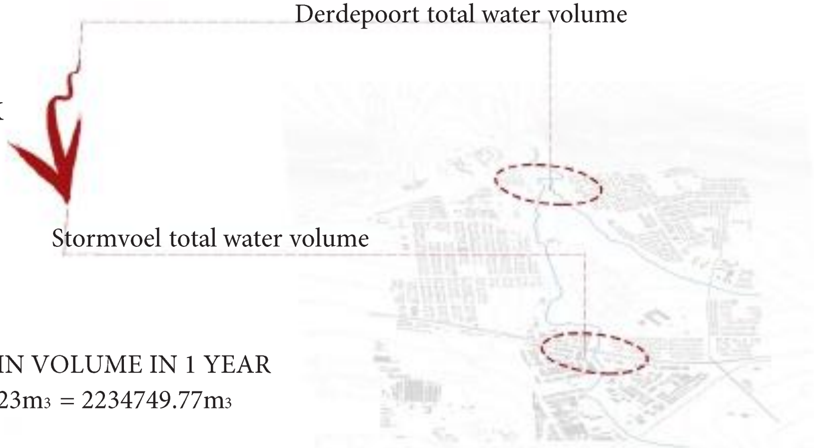
Quarry catchment: 0.7km^2

Total site catchment: 14.8km$_2$

Total catchment area: 204.22 km$_2$



Flow rater per day - 7% = X



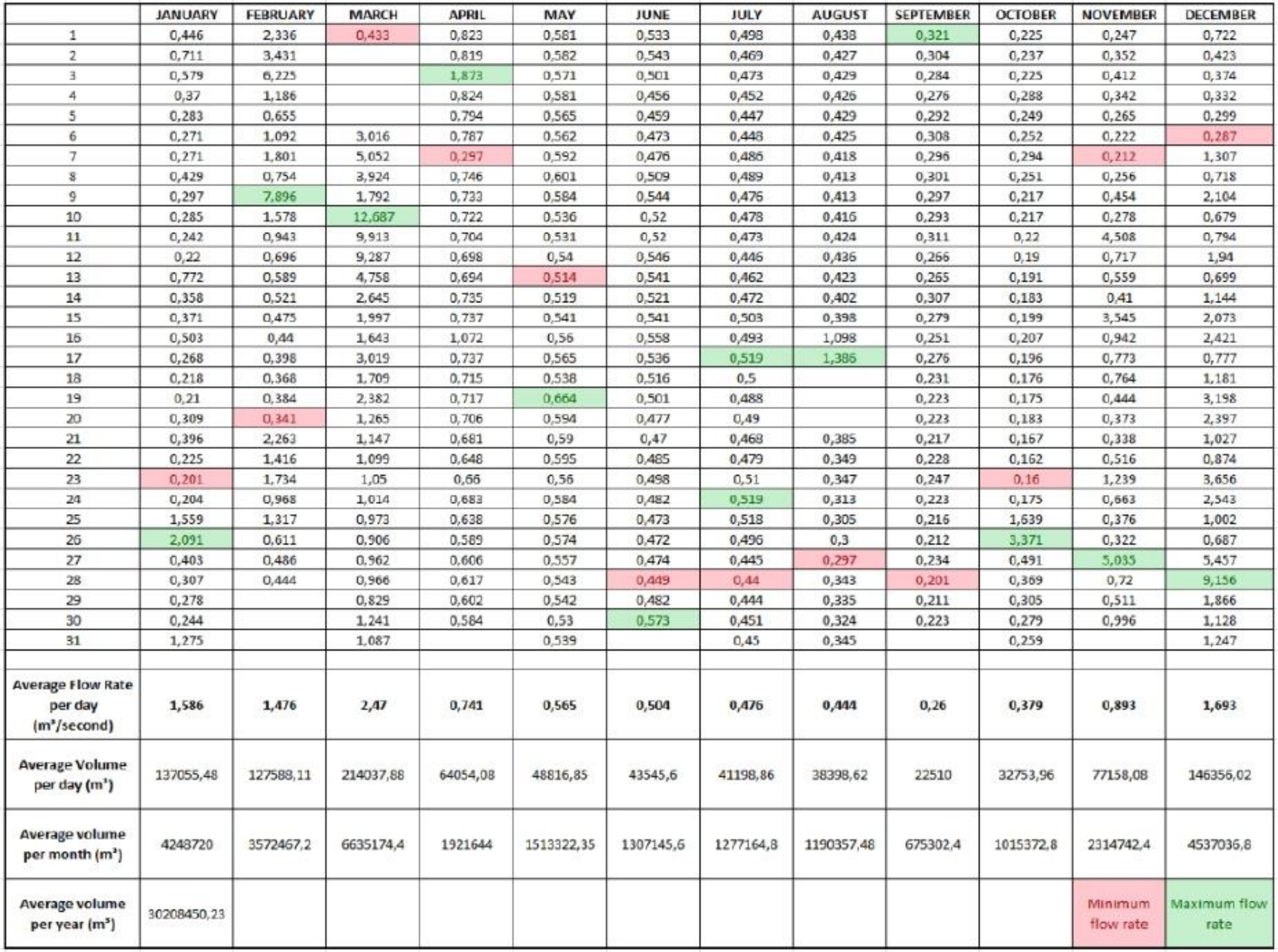
Derdepoort total water volume

Stormvoel total water volume

TOTAL DIFFERENCE IN VOLUME IN 1 YEAR
32443200m$_3$ - 30208450.23m$_3$ = 2234749.77m$_3$

Figure 2.7.6 – Catchment area calculations (Author, 2015)

DAILY FLOW RATE (M^3/S) READINGS AND CALCULATIONS FOR MORELETA SPRUIT ENTERING SITE



	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	0,446	2,336	0,433	0,823	0,581	0,533	0,498	0,438	0,321	0,225	0,247	0,722
2	0,711	3,431		0,819	0,582	0,543	0,469	0,427	0,304	0,237	0,352	0,423
3	0,579	6,225		1,873	0,571	0,501	0,473	0,429	0,284	0,225	0,412	0,374
4	0,37	1,186		0,824	0,581	0,456	0,452	0,426	0,276	0,288	0,342	0,332
5	0,283	0.655		0,794	0,565	0,459	0,447	0,429	0,292	0,249	0,265	0,299
6	0,271	1,092	3,016	0,787	0,562	0,473	0,448	0,425	0,308	0,252	0,222	0,287
7	0,271	1,801	5,052	0,297	0,592	0,476	0,486	0,418	0,296	0,294	0,212	1,307
8	0,429	0,754	3,924	0,746	0,601	0,509	0,489	0,413	0,301	0,251	0,256	0,718
9	0,297	7,896	1,792	0,733	0,584	0,544	0,476	0,413	0,297	0,217	0,454	2,104
10	0,285	1,578	12,687	0,722	0,536	0,52	0,478	0,416	0,293	0,217	0,278	0,679
11	0,242	0,943	9,913	0,704	0,531	0,52	0,473	0,424	0,311	0,22	4,508	0,794
12	0,22	0,696	9,287	0,698	0,54	0,546	0,446	0,436	0,266	0,19	0,717	1,94
13	0,772	0,589	4,758	0,694	0,514	0,541	0,462	0,423	0,265	0,191	0,559	0,699
14	0,358	0,521	2,645	0,735	0,519	0,521	0,472	0,402	0,307	0,183	0,41	1,144
15	0,371	0,475	1,997	0,737	0,541	0,541	0,503	0,398	0,279	0,199	3,545	2,073
16	0,503	0,44	1,643	1,072	0,56	0,558	0,493	1,098	0,251	0,207	0,942	2,421
17	0,268	0,398	3,019	0,737	0,565	0,536	0,519	1,386	0,276	0,196	0,773	0,777
18	0,218	0,368	1,709	0,715	0,538	0,516	0,5		0,231	0,176	0,764	1,181
19	0,21	0,384	2,382	0,717	0,664	0,501	0,488		0,223	0,175	0,444	3,198
20	0,309	0,341	1,265	0,706	0,594	0,477	0,49		0,223	0,183	0,373	2,397
21	0,396	2,263	1,147	0,681	0,59	0,47	0,468	0,385	0,217	0,167	0,338	1,027
22	0,225	1,416	1,099	0,648	0,595	0,485	0,479	0,349	0,228	0,162	0,516	0,874
23	0,201	1,734	1,05	0,66	0,56	0,498	0,51	0,347	0,247	0,16	1,239	3,656
24	0,204	0,968	1,014	0,683	0,584	0,482	0,519	0,313	0,223	0,175	0,663	2,543
25	1,559	1,317	0,973	0,638	0,576	0,473	0,518	0,305	0,216	1,639	0,376	1,002
26	2,091	0,611	0.906	0,589	0,574	0,472	0,496	0,3	0,212	3,371	0,322	0,687
27	0,403	0,486	0.962	0,606	0,557	0,474	0,445	0,297	0,234	0,491	5,035	5,457
28	0,307	0,444	0,966	0,617	0,543	0,449	0,44	0,343	0,201	0,369	0,72	9,156
29	0,278		0,829	0,602	0,542	0,482	0,444	0,335	0,211	0,305	0,511	1,866
30	0,244		1,241	0,584	0,53	0,573	0,451	0,324	0,223	0,279	0,996	1,128
31	1,275		1,087		0,539		0,45	0,345		0,259		1,247
Average Flow Rate per day (m^3/second)	**1,586**	**1,476**	**2,47**	**0,741**	**0,565**	**0,504**	**0,476**	**0,444**	**0,26**	**0,379**	**0,893**	**1,693**
Average Volume per day (m^3)	137055,48	127588,11	214037,88	64054,08	48816,85	43545,6	41198,86	38398,62	22510	32753,96	77158,08	146356,02
Average volume per month (m^3)	4248720	3572467,2	6635174,4	1921644	1513322,35	1307145,6	1277164,8	1190357,48	675302,4	1015372,8	2314742,4	4537036,8
Average volume per year (m^3)	30208450,23										Minimum flow rate	Maximum flow rate

Table 2.7.3 – Daily Flow Rates for Moreleta Spruit (Author, 2015)

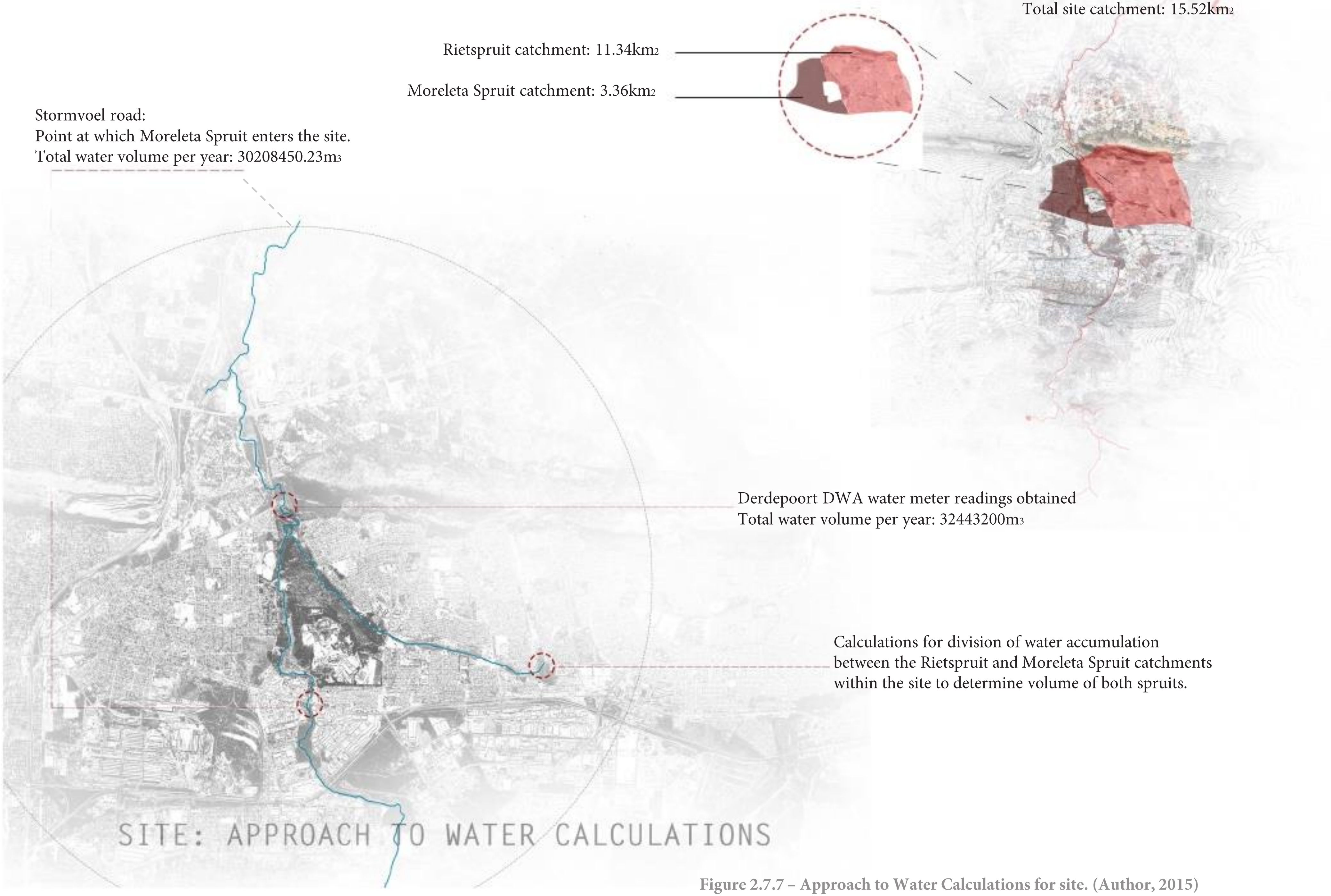
FLOOD VOLUME (M3/S) READINGS FOR MORELETA SPRUIT OVER THE LAST TEN YEARS

Year – October to October (Lowest and Highest Readings in that Month)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
JANUARY	0,77	1,864	1,992	0,713	1,612	1,817	0,785	2,714	1,368	0,863	1,041
	7,872	16,35	16,35	6,698	16,35	16,35	8,201	16,35	16,35	9,926	14,433
FEBRUARY	1,425	0,83	1,427	0,86	0,677	2,453	1,053	1,07	1,726	1,115	3,659
	16,35	9,189	16,35	9,871	10,278	16,35	14,762	16,35	16,35	16,35	16,35
MARCH	1,25	0,677	2,634	0,446	1,679	1,554	1,001	2,962	1,111	0,648	2,7
	16,35	6,028	16,35	2,336	16,35	16,35	13,365	16,35	16,35	5,471	16,35
APRIL	0,981	0,931	1,154	0,559	0,817	0,248	0,826	1,19	0,468	1,148	0,719
	12,834	12,044	16,35	3,964	8,892	0,533	9,1	16,35	2,627	16,35	6,835
MAY	1,354	0,203	0,239	0,201	0,706	0,328	0,825	0,565	0,206	0,447	0,291
	16,35	0,325	0,485	0,317	6,584	1,079	9,078	4,047	0,335	2,348	0,737
JUNE	0,334	0,167	0,19	0,921	0,322	0,532	0,252	0,853	0,185	0,26	0,272
	1,13367	0,199	0,275	11,331	1,036	3,545	0,559	9,712	0,255	0,601	0,675
JULY	0,225	0,188	0,173	0,252	0,241	0,234	0,301	0,226	0,186	0,206	0,252
	0,464	0,266	0,218	0,554	0,497	0,46	0,869	0,425	0,261	0,335	0,554
AUGUST	0,197	0,234	0,963	0,136	0,226	0,523	0,199	0,634	0,192	0,22	0,657
	0,299	0,464	12,386	0,119	0,343	3,404	0,309	5,221	0,281	0,396	5,641
SEPTEMBER	0,135	0,185	0,215	0,87	0,15	0,6	0,168	0,268	1,454	0,321	0,213
	0,117	0,255	0,374	10,103	0,124	4,637	0,201	0,651	16,35	1,1025	0,367
OCTOBER	0,43	0,418	0,819	1,288	0,622	0,824	0,696	1,182	1,275	1,161	1,301
	2,139	1,989	8,937	16,35	5,007	8,933	6,378	16,35	16,35	16,35	16,35
NOVEMBER	0,64	0,823	0,983	0,906	1,482	1,074	1,099	2,091	1,403	1,161	1,314
	5,34	9,018	12,916	10,875	16,35	16,35	16,35	16,35	16,35	16,35	16,35
DECEMBER	1,501	0,951	2,761	1,559	1,142	0,979	3,051	1,75	1,071	1,704	2,651
	16,35	12,059	16,35	16,35	16,35	12,784	16,35	16,35	16,35	16,35	16,35

Table 2.7.4 – Monthly Flood Volumes at Moreleta Spruit (Author, 2015)

SITE SPECIFIC APPROACH TO WATER CALCULATIONS



Total site catchment: 15.52km^2

Rietspruit catchment: 11.34km^2

Moreleta Spruit catchment: 3.36km^2

Stormvoel road:
Point at which Moreleta Spruit enters the site.
Total water volume per year: 30208450.23m^3

Derdepoort DWA water meter readings obtained
Total water volume per year: 32443200m^3

Calculations for division of water accumulation between the Rietspruit and Moreleta Spruit catchments within the site to determine volume of both spruits.

Figure 2.7.7 – Approach to Water Calculations for site. (Author, 2015)

DIVISION OF ACCUMULATED WATER BETWEEN RIETSPRUIT AND MORELETA SPRUIT

:

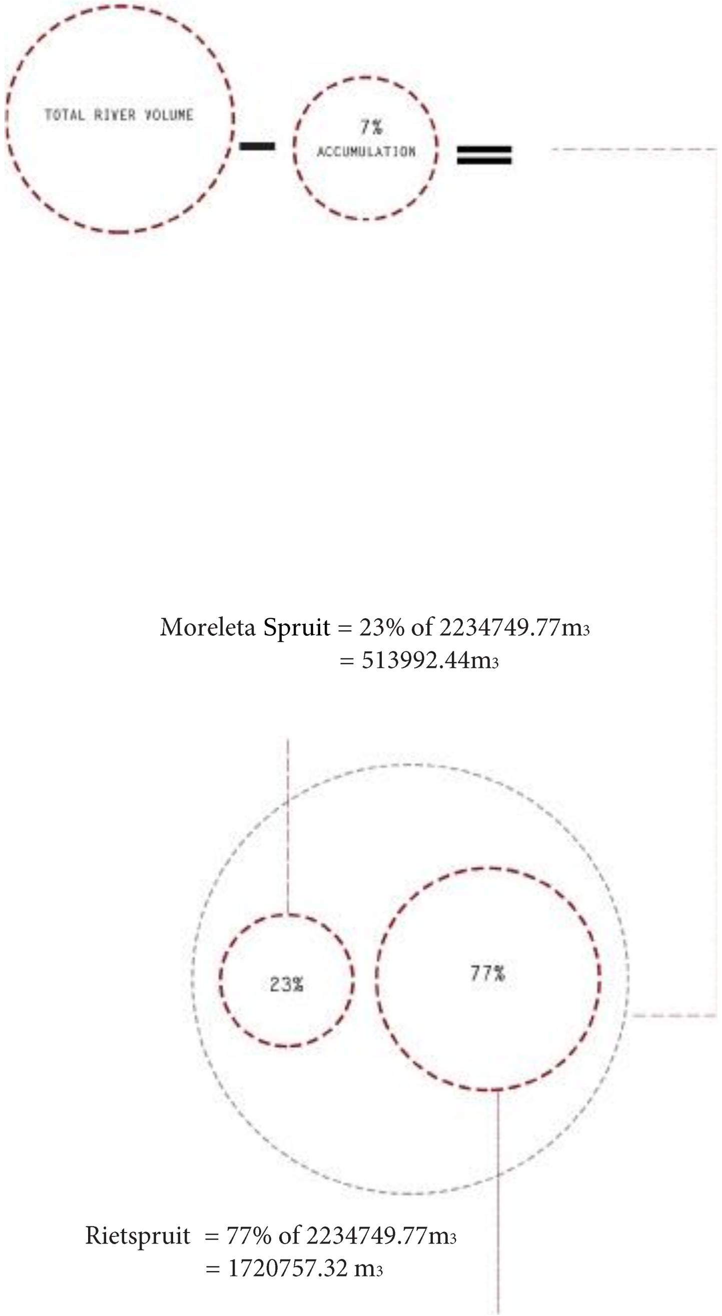
The catchment of the site will be divided between the two river systems, the percentage of each rivers accumulation throughout the year will depend on the percentage of each catchment within the larger catchment of the overall site.

Rietspruit has a larger catchment area, all water in the river system is accumulated from this catchment. The Rietspruit will have a volume of 1720757.32m$_3$ per year.

The Moreleta Spruit has a volume of 30208450.23m$_3$ flowing into the site and through catchment runoff Accumulates 513992.44m$_3$ during the year, the total volume of water leaving the site will be 30722442.67m$_3$.

The total volumes from each river system:
- Moreleta Spruit 30722442.67m$_2$
- Rietspruit 1720757.32m$_2$

Which adds up to an accumulative volume of 32443200m$_2$ which is equal to the volume of water obtained from the DWA water meter at Derdepoort.



TOTAL

DIFFERENC

IN
VOLUME:

2234749.77m

Moreleta Spruit = 23% of 2234749.77m$_3$
= 513992.44m$_3$

Rietspruit = 77% of 2234749.77m$_3$
= 1720757.32 m$_3$

Figure 2.7.8 – Water division between river systems (Author, 2015)

DAILY FLOW RATE (M3/S) READINGS AND CALCULATIONS FOR RIETSPRUIT TRIBUTARY

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	0.024	0.126	0.024	0,044	0,031	0,029	0,027	0.024	0.017	0.012	0.013	0,039
2	0,038	0.185		0,044	0,031	0,029	0,025	0.023	0.016	0.013	0,019	0,023
3	0,032	0,338		0,101	0,031	0,027	0,025	0,023	0,015	0,012	0,022	0,020
4	0,020	0,064		0,044	0,031	0,025	0,024	0,023	0,015	0,016	0,018	0,018
5	0,015	0,035		0,043	0,030	0,025	0,024	0,023	0,016	0,013	0,014	0,016
6	0,015	0,059	0,155	0,042	0,030	0,025	0,024	0,023	0,017	0,014	0,012	0,015
7	0,015	0,097	0,272	0,016	0,032	0,026	0,026	0,023	0,016	0,016	0,011	0,070
8	0,023	0,041	0,211	0,040	0,032	0,027	0,026	0,022	0,016	0,014	0,014	0,039
9	0,016	0,425	0,096	0,039	0,031	0,029	0,026	0,022	0,016	0,012	0,024	0,113
10	0,015	0,085	0,682	0,039	0,029	0,028	0,026	0,022	0,016	0,012	0,015	0,037
11	0,013	0,051	0,533	0,038	0,029	0,028	0,025	0,023	0,017	0,012	0,242	0,043
12	0,012	0,037	0,495	0,038	0,029	0,029	0,024	0,023	0,014	0,010	0,039	0,104
13	0,042	0,032	0,256	0,037	0,028	0,029	0,025	0,023	0,014	0,010	0,030	0,038
14	0,029	0,028	0,142	0,040	0,028	0,028	0,025	0,022	0,017	0,010	0,022	0,062
15	0,020	0,026	0,107	0,040	0,029	0,029	0,027	0,021	0,015	0,011	0,191	0,116
16	0,027	0,024	0,088	0,058	0,030	0,030	0,027	0,059	0,014	0,011	0,051	0,130
17	0,014	0,021	0,162	0,040	0,030	0,029	0,028	0,075	0,015	0,011	0,042	0,042
18	0,012	0,020	0,092	0,038	0,029	0,028	0,027		0,012	0,010	0,041	0,098
19	0,011	0,021	0,128	0,039	0,036	0,027	0,026		0,012	0,009	0,024	0,172
20	0,017	0,018	0,068	0,038	0,032	0,026	0,026		0,012	0,010	0,020	0,129
21	0,021	0,122	0,062	0,037	0,032	0,025	0,025	0,021	0,012	0,009	0,018	0,055
22	0,012	0,076	0,059	0,035	0,032	0,026	0,026	0,019	0,012	0,009	0,028	0,047
23	0,011	0,093	0,057	0,036	0,030	0,027	0,027	0,019	0,013	0,009	0,067	0,197
24	0,011	0,052	0,055	0,037	0,031	0,026	0,028	0,017	0,012	0,009	0,036	0,137
25	0,084	0,071	0,052	0,034	0,031	0,025	0,028	0,016	0,012	0,088	0,020	0,054
26	0,112	0,033	0,049	0,032	0,031	0,025	0,027	0,016	0,011	0,181	0,017	0,037
27	0,022	0,026	0,052	0,033	0,030	0,026	0,024	0,016	0,013	0,026	0,271	0,293
28	0,017	0,024	0,052	0,033	0,029	0,024	0,024	0,018	0,011	0,020	0,039	0,492
29	0,015		0,045	0,032	0,029	0,026	0,024	0,018	0,011	0,016	0,028	0,100
30	0,013		0,065	0,031	0,029	0,031	0,024	0,017	0,012	0,015	0,054	0,061
31	0,069		0,058		0,029		0,024	0,019		0,015		0,067
Average Flow Rate per day (m³/second)	**0,086**	**0,08**	**0,132**	**0,06**	**0,033**	**0,027**	**0,028**	**0,026**	**0,017**	**0,021**	**0,04**	**0,093**
Average Volume per day (m³)	7447,12	6912	11474,47	5184	2851,2	2332,8	2419,2	2246,4	1468,8	1814,4	3456	8035,2
Average volume per month (m³)	230860,72	214272	355708,8	160704	88387,2	72316,8	74995,2	69638,4	45532,8	56246,4	107136	249091,2
Average volume per year (m³)	1724889,52										🟥 Minimum flow rate	🟩 Maximum flow rate

Table 2.7.5 – Daily Flow Rates for Rietpruit Tributary (Author, 2015)

FLOOD VOLUME (M3/S) READINGS FOR STORM VOEL OVER THE LAST TEN YEARS

Year – October to October (Lowest and Highest Readings in that Month)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
JANUARY	0,041	0,100	0,107	0,038	0,087	0,098	0,042	0,146	0,074	0,046	0,056
	0,423	0,818	0,818	0,360	0,818	0,818	0,441	0,818	0,818	0,534	0,776
FEBRUARY	0,077	0,045	0,077	0,046	0,047	0,132	0,057	0,058	0,093	0,060	0,197
	0,818	0,494	0,818	0,531	0,553	0,818	0,794	0,818	0,818	0,818	0,818
MARCH	0,067	0,036	0,142	0,024	0,090	0,084	0,054	0,159	0,060	0,035	0,145
	0,818	0,324	0,818	0,126	0,818	0,818	0,719	0,818	0,818	0,294	0,818
APRIL	0,053	0,050	0,062	0,030	0,044	0,013	0,044	0,064	0,025	0,062	0,039
	0,690	0,648	0,818	0,213	0,478	0,029	0,489	0,818	0,141	0,818	0,368
MAY	0,073	0,011	0,013	0,011	0,038	0,018	0,044	0,030	0,011	0,024	0,016
	0,818	0,018	0,026	0,017	0,354	0,058	0,488	0,218	0,018	0,126	0,043
JUNE	0,018	0,009	0,010	0,050	0,017	0,029	0,014	0,046	0,010	0,014	0,015
	0,061	0,011	0,015	0,609	0,056	0,191	0,030	0,522	0,014	0,032	0,036
JULY	0,012	0,010	0,009	0,014	0,013	0,013	0,016	0,012	0,010	0,011	0,014
	0,025	0,014	0,012	0,030	0,027	0,025	0,047	0,023	0,014	0,018	0,030
AUGUST	0,011	0,013	0,052	0,007	0,012	0,028	0,011	0,034	0,010	0,012	0,035
	0,016	0,025	0,666	0,006	0,018	0,183	0,017	0,281	0,015	0,021	0,303
SEPTEMBER	0,007	0,010	0,012	0,047	0,008	0,032	0,009	0,014	0,078	0,017	0,012
	0,006	0,014	0,020	0,543	0,007	0,249	0,011	0,035	0,818	0,055	0,020
OCTOBER	0,023	0,023	0,044	0,069	0,033	0,044	0,037	0,064	0,069	0,062	0,070
	0,115	0,107	0,481	0,818	0,269	0,480	0,343	0,818	0,818	0,818	0,818
NOVEMBER	0,034	0,044	0,053	0,049	0,080	0,058	0,059	0,112	0,075	0,062	0,071
	0,287	0,485	0,694	0,585	0,818	0,818	0,818	0,818	0,818	0,818	0,818
DECEMBER	0,081	0,051	0,148	0,084	0,061	0,053	0,164	0,094	0,058	0,092	0,143
	0,818	0,648	0,818	0,818	0,818	0,687	0,818	0,818	0,818	0,818	0,818

Table 2.7.6 – Monthly Flood Volumes at Stormvoel (Author, 2015)

VOLUMES FOR USE IN FURTHER CALCULATIONS

Making use of the calculations previously explained, the same process was carried out for the last ten years worth of water data from the DWA Meter and Derdepoort.

This enabled the use of averages for each year and month for a more reliable and consistent set of data for the further calculations in the water scheme for the site.

The water calculations have determined the monthly average for each month over a period of the last ten years and from these averages the design will be able to ensure the functioning of the system at both the average maximum and average minimum flow rates and volumes. The system is designed to be in constant flow for the purification of water through the wetlands, additional calculations were done regarding the absolute minimum and maximum volumes and flow rates and have been designed to ensure the constant flow and functioning of the system even in extreme conditions. The absolute minimum value was determined through evaluation of all years and flow rates and the lowest recorded flow rate in the last ten years was used as the absolute minimum.

The absolute maximum value was determined by the analysis of the floods recorded in the last ten years and the highest value was used as this is the maximum volume of water that the system will need to handle.

ABSOLUTE MINIMUM: 0.16m3/s
ABSOLUTE MAXIMUM: 16,35m3/s

AVERAGE MONTHLY FLOW RATES (M^3/S) AND VOLUMES (M^3) 2004-2014

MONTH	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		MOTHLY AVERAGE
JANUARY	0,863	4,15	5,26	0,997	4,93	3,85	0,962	5,34	1,84	1,46	1,38		🟩 3,1032
FEBRUARY	2,27	0,994	5,13	0,659	1,19	4,02	1,63	1,36	1,48	1,31	3,85		2,3893
MARCH	3,74	0,682	2,32	0,282	4	2,3	1,32	4,03	1,41	1,01	7,11		2,8204
APRIL	1,15	1,3	1,2	0,292	0,967	0,593	3,79	2,11	0,79	1,94	2,07		1,62
MAY	0,684	0,423	0,687	0,215	1,02	0,648	1,86	1,42	0,593	0,866	1,63		1,0046
JUNE	0,398	0,349	0,515	0,91	0,607	0,872	0,966	1,26	0,574	0,831	1,41		0,8665
JULY	0,405	0,363	0,462	0,347	0,6	0,696	0,93	1,04	0,546	0,635	1,37		0,7394
AUGUST	0,345	0,314	0,949	0,265	0,49	0,759	0,695	1,04	0,5	0,56	1,16		0,7077
SEPTEMBER	0,214	0,192	0,382	0,511	0,3	0,461	0,402	0,676	2,21	0,489	0,728		🟥 0,6475
OCTOBER	0,305	0,347	0,407	3,03	0,537	1,06	0,544	1,69	2,33	1,75	1,09		1,309
NOVEMBER	0,364	1,61	1,07	0,732	3,3	2,43	1,04	2,06	1,72	1,95	2,49		2,1836
DECEMBER	2,18	1,52	1,8	2,34	1,54	2,33	3,2	2,99	3,09	3,77	4,95		2,671
MONTHLY AVERAGE (million m³)	1076500	1020333,3	1681833	881666,66	1623416,66	1668250	1444916,66	2084666,66	1423583,33	1380916,66	2436500	🟥 Average minimum	
TOTAL VOLUME PER YEAR (m³)	12918000	12244000	20182000	10580000	19481000	20019000	17339000	25016000	17083000	16571000	29238000	🟩 Average maximum	

Table 2.7.7 – Monthly Average Flowrates and Volumes (Author, 2015)

Overall Strategy

Figure 2.7.9– Overall Water Strategy(Author, 2015)

RIVER DIVERSION AND PURIFICATION STRATEGY

STRATEGY 3:

Diversion of portion of Rietspruit into quarry purification system using same principles as described in Strategy 1, but with the inclusion of bioswale for irrigation of agriculture and storm water management.

STRATEGY 1:

Diversion of portion of Moreleta Spruit into the quarry purification system.
Contour manipulation and dam creation for manipulation of water in to quarry.

STRATEGY 2:

Purification of water that is not diverted in to the purification system. In river purification strategy managing and purifying polluted runoff and stormwater outlets released in to river system.

Figure 2.7.10 – River Diversion and Purification Strategy (Author, 2015)

STORM WATER COLLECTION MANAGEMENT

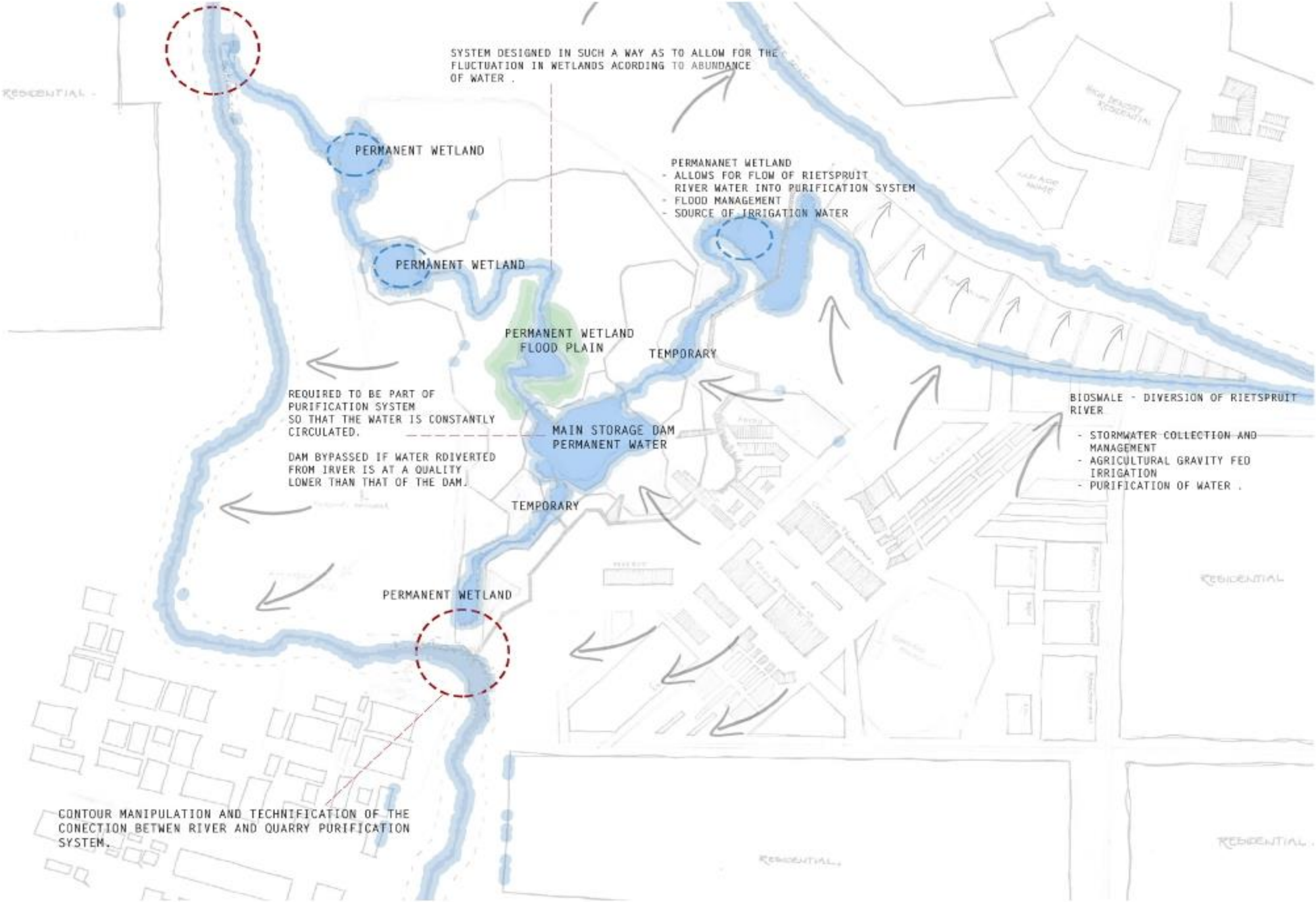


Figure 2.7.11 – Storm Water Collection (Author, 2015)

STRATEGY1

The diversion of the Moreleta Spruit requires intensive contour manipulation of the edge of the quarry to allow for direct water flow. The contour difference will require damming of the spruit to raise the water level allowing for free flow into the purification system.

Not all water will be diverted in order to preserve the spruit ecology. The spruit will be split upstream allowing half of the flow into the dam while the other half will be transported through a pipe beyond the dam directly into the river system downstream.

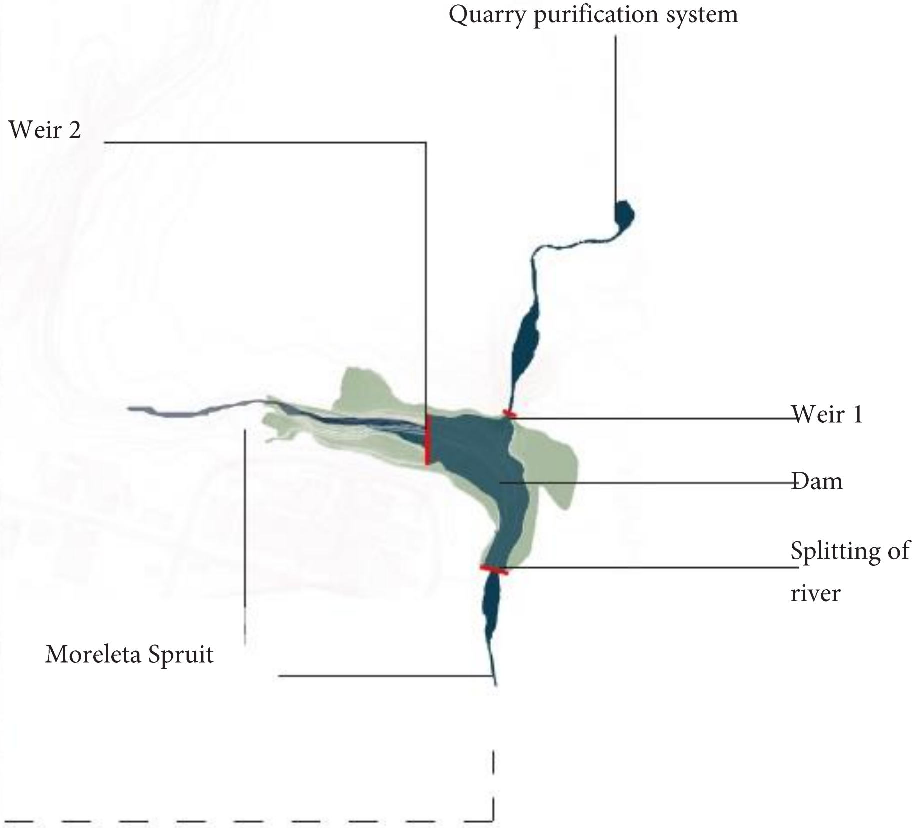
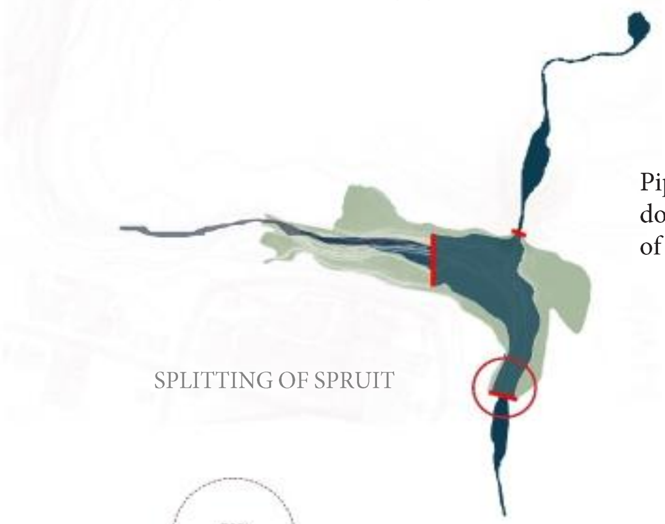
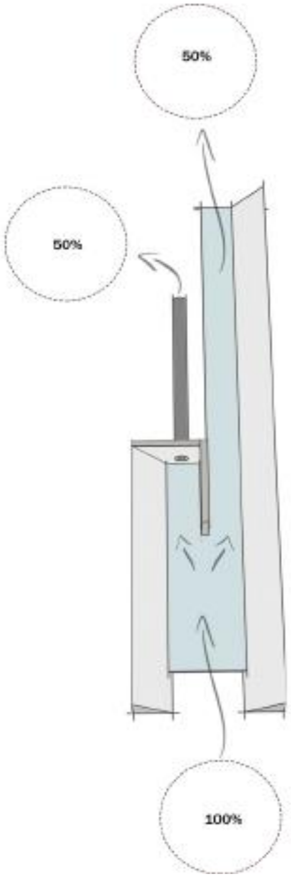


Figure 2.7.12 – Overall Water Strategy 1 and Contour Mapping (Author, 2015)

RIVER SYSTEM DIVERSION





The Moreleta Spruit will flow in the channel at 100% flow rate, the constructed divider will split the river in half, ensuring 50% of the water is released back into the natural system and 50% is diverted to the quarry purification system.

The pipe will be sized according to the average maximum flow rate, ensuring that it is able to handle 50% of the flow.

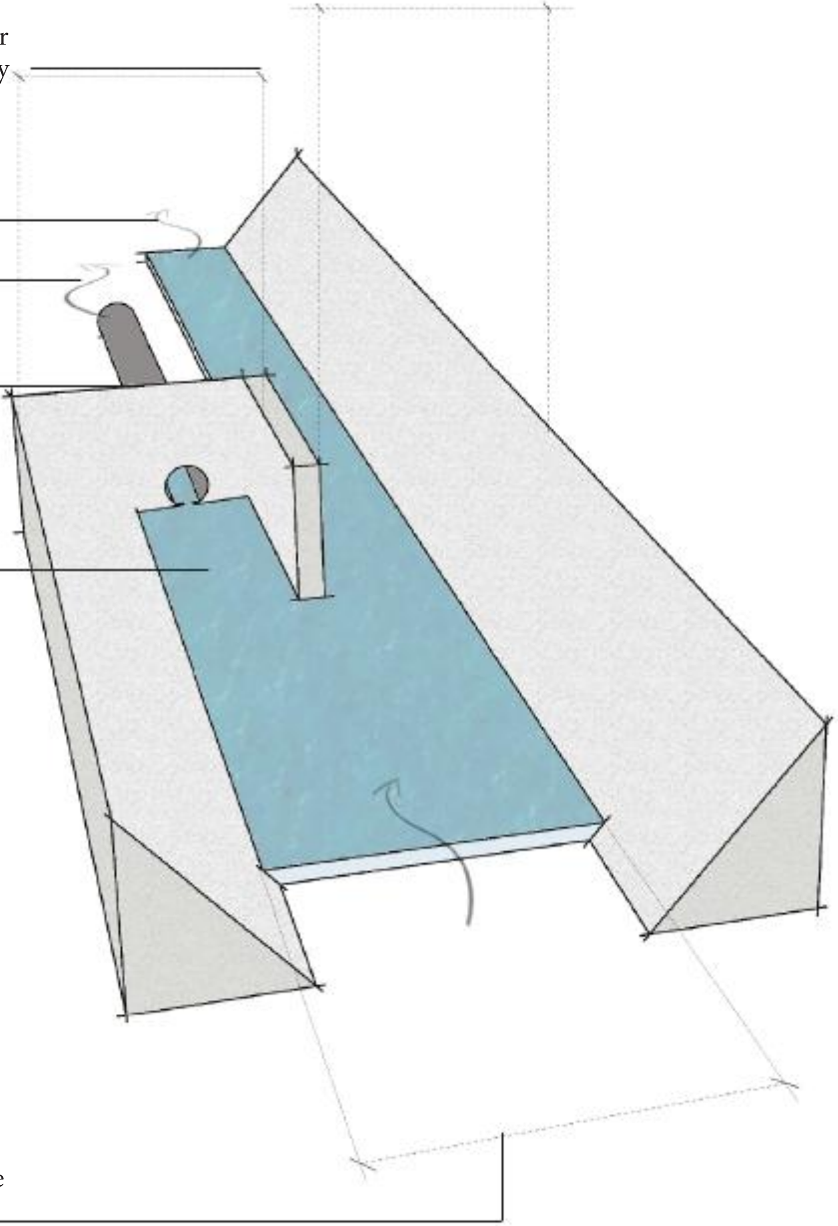


Figure 2.7.13 – River System Diversion Technification (Author, 2015)

WEIR 1 SIZING - QUARRY ENTRANCE

Level X was determined by the height to which the water needed to be raised in order to be able to flow into the quarry which was 2m.

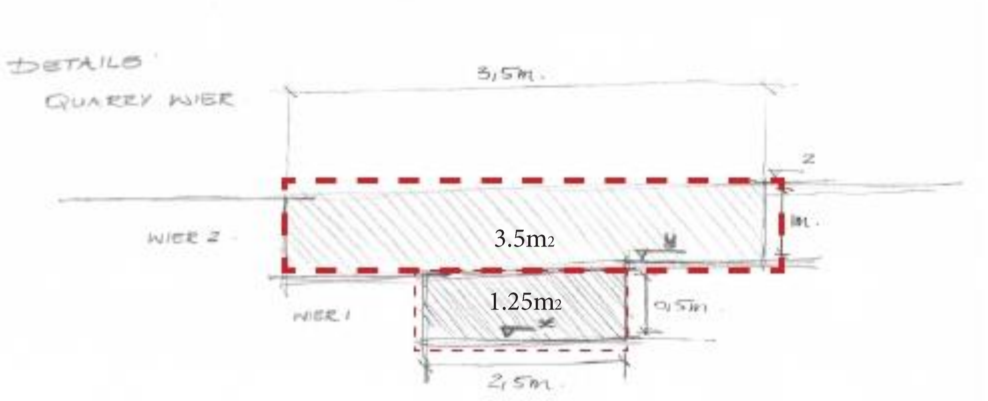
For the calculation of level Z, the cross sections of the wiers need to be able to accommodate 7.39m^3/s. Therefore;

The first allows for 1.55m^3/s, so the second part of the weir will need to allow through 5.84m^3/s.

The flow rate for Z was calculated as follows:

Flow rate: 16.35m^3/s/2 = 8.175m^3/s
8.175m^3/s - 1.55m^3/s = 6.625m^3/s
8.175m^3/s + 6.625m^3/s = 14.8m^3/s

Therefore 14.8m^3/s is entering the dam so between weir 1 and weir 2 each will allow for 7.39m^3/s



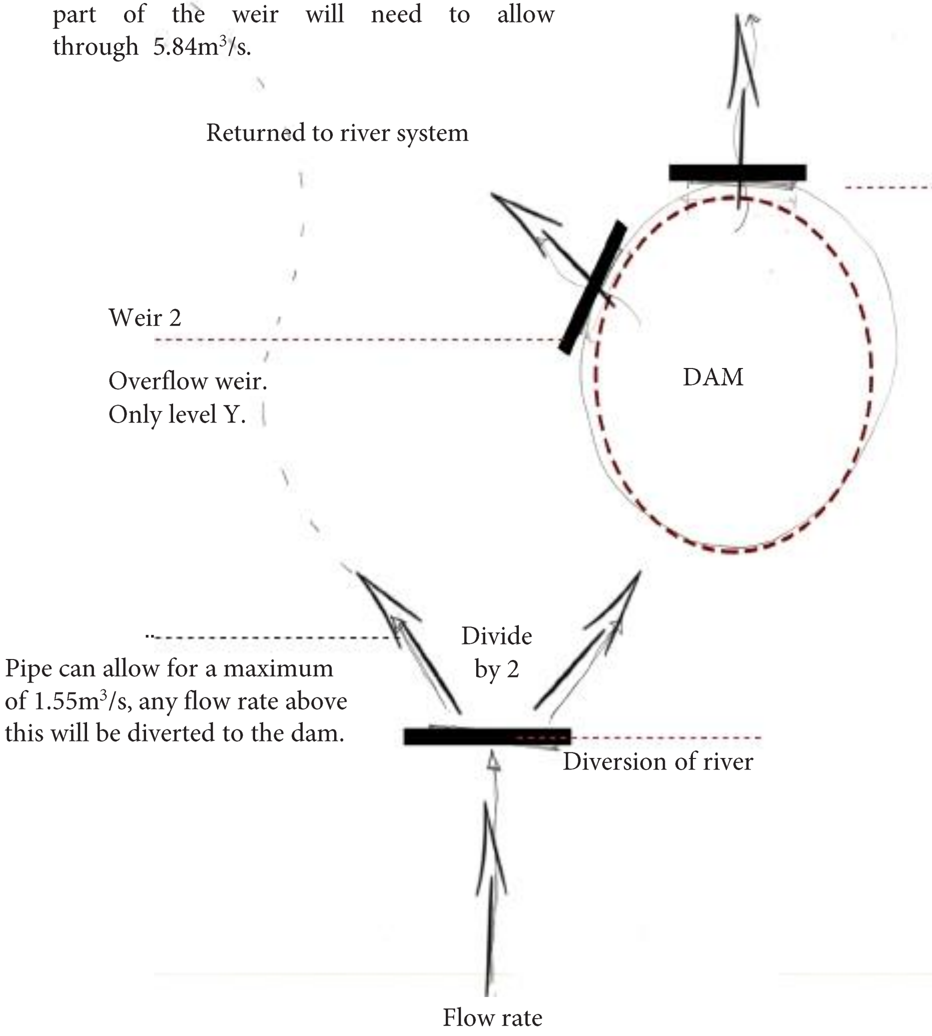
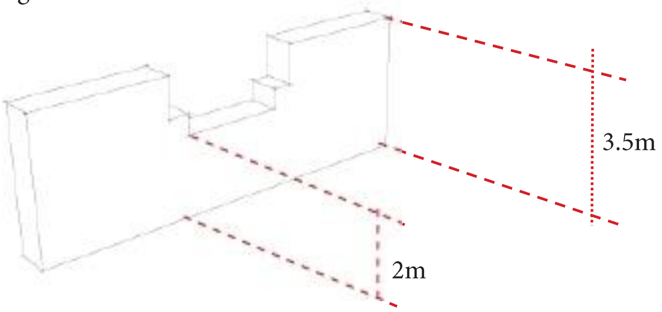


Figure 2.7.14 – Weir 1 Diversion and Flow Rates (Author, 2015)

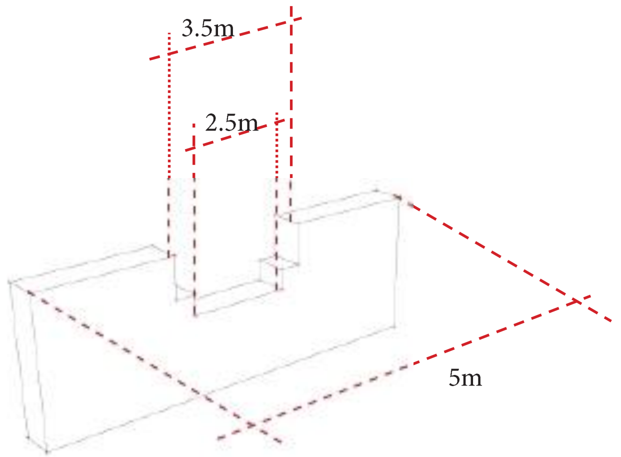
Level Y is determined by the average maximum: 3.10m^3/s

Calculation
Size: 2.5m x 0.5m = 1.25m^2
Flow rate = 1.55m^3/s
Velocity = 1.24m/s
Volume = 133 920m^3/day
= 4 151 520m^3/month



Level Z is determined by the absolute maximum: 16.35m^3/s

Calculation:
Size: 3.5m x 1m = 3.5m^2
Flow rate = 5.84m^3/s
Velocity = 1.66m/sm/s
Volume = 504 576m^3/day
FLOOD

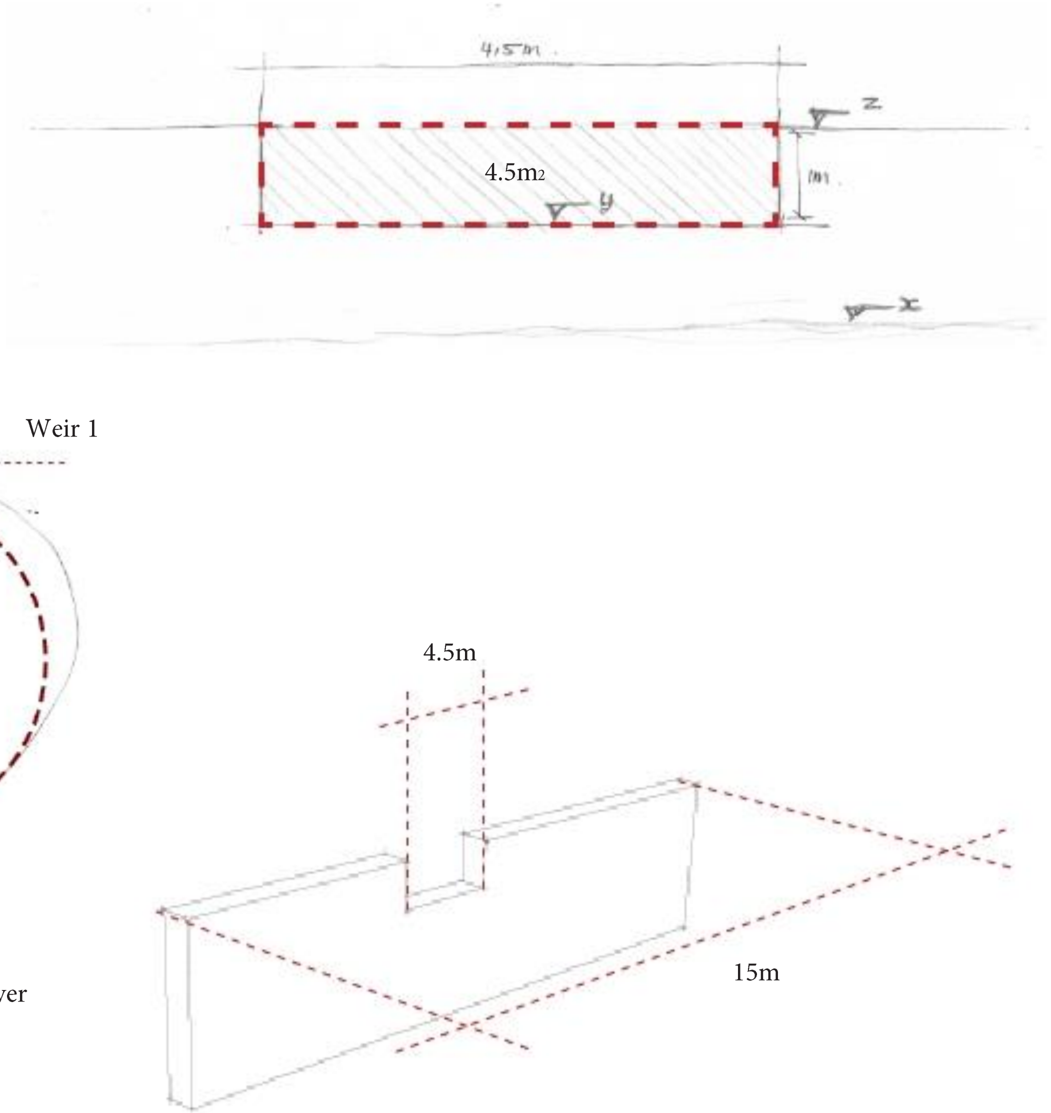


Drg2.7.6a – Weir 1 Sizing (Author, 2015)

WEIR 2 SIZING: RETURN TO RIVER

Weir 2 allows for the average maximum volume of water to be evenly distributed between the quarry purification system and the existing river system. This weir differs from Weir 1 as it has no X level, only a Y. This ensures that the river and the purification system receive approximately the same amount of water. The second weir is wider than the forst weir and will differ slightly in design and cross sectional area.

Level X: 2m
Level Y: 2.5m



Drg 2.7.7a – Weir 2 Sizing (Author, 2015)

Level Z is determined by the absolute maximum: 16.35m^3/s
Calculation:
Size: 4.5m x 1m = 4.5m^2
Flow rate = 7.39m^3/s
Velocity = 1.64m/s
Volume = 638 496m^3/day
FLOOD

Pipe can allow for a maximum of 1.55m^3/s, any flow rate above this will be diverted to the dam.

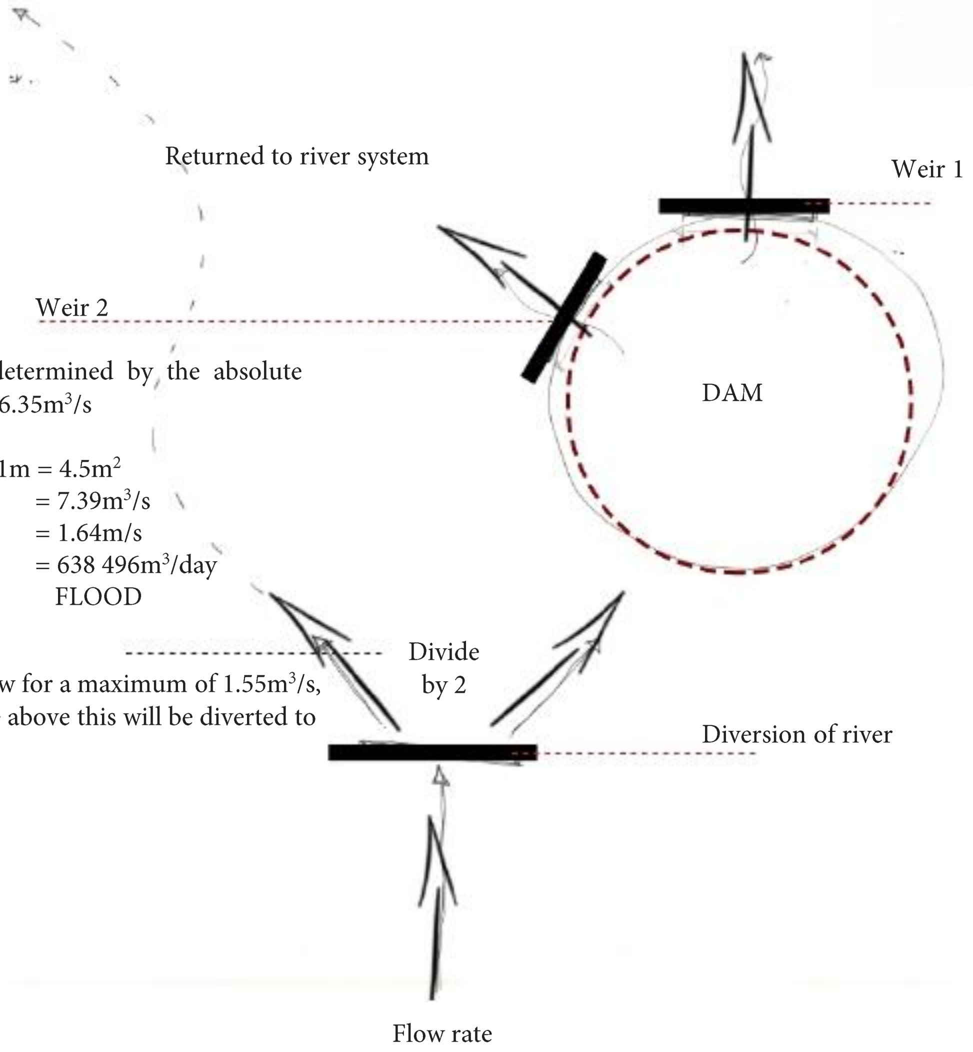


Figure 2.7.15 – Weir 2 Diversion and Flow Rates (Author, 2015)

WETLAND CHANNEL SIZING AND CALCULATION

The water flowing from the dam needs to be slowed down in order for the water to travel at the optimum speed through the wetland for maximum purification.

The ideal speed would be 0.1m/s. Each calculation will determine the cross sectional area of the river channel for that specific volume of water, the size will ensure that the volume of water entering the system is slowed down and assisted through the system at 0.1m/s.a.

Level a is the Absolute minimum flow rate that has been recorded, the design of the system ensures that the system will continuously flow even when minimal water is available. In terms of the wetland channel design, this value will determine the permanent water level within the system and permanent channel sizes. Plants that require permanent water will be planted in this zone.

Level b is the Average minimum flow rate that will pass through the system, this zone will be relatively permanent throughout the year and will be a zone of transitional planting for marginal plants

Level c will be determined by the Average maximum flow rate that passes through the system, if the volume of water at this level passes through the system at a speed of 0.1m/s, it ensures that smaller volumes of water will pass through at a slower rate, ideal for maximum purification. This is a transitional zone between aquatic and terrestrial environments and will consist of marginal plants.

Level d, is the Absolute maximum and is the floodplain area which will aid in flood management .

The large volumes of water which will be passing through the system in such an event will not be able to pass through at a rate ideal for purification, but will be able to prevent damage downstream.

The design interventions will need to take into consideration the floodplain areas.

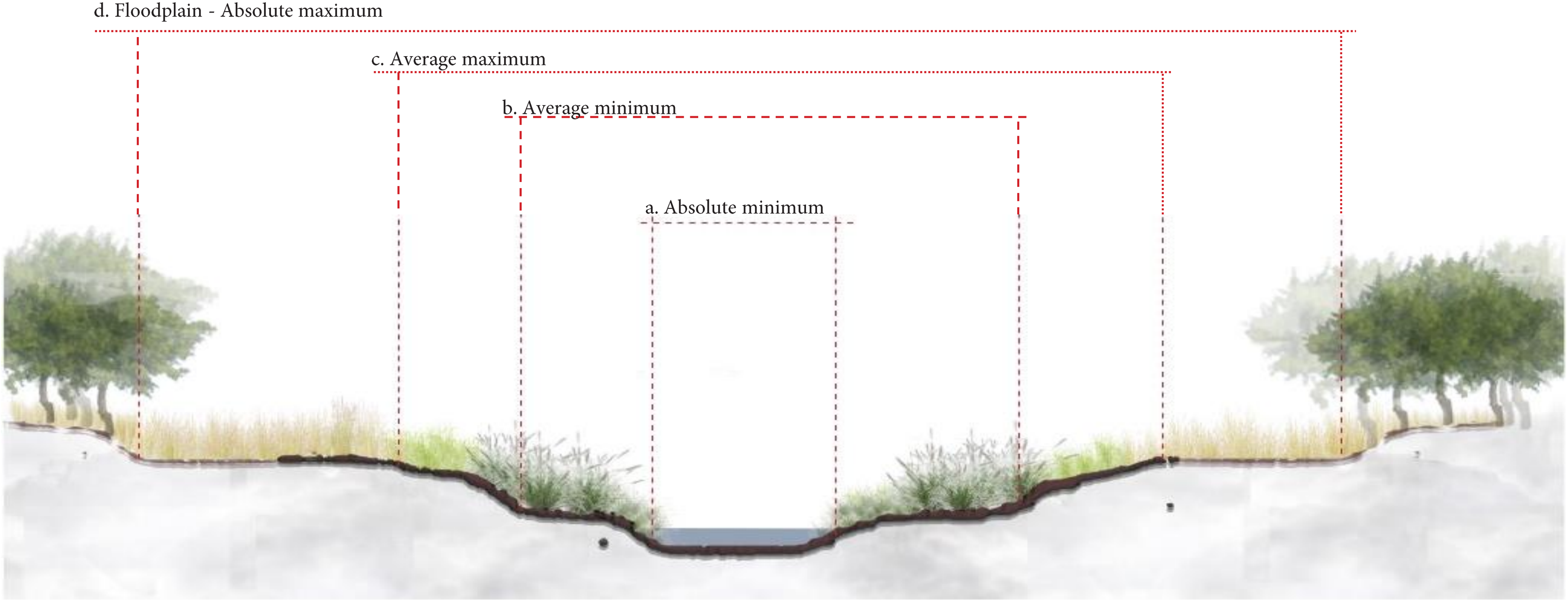


Figure 2.7.16 – Weir and Channel Sizing (Author, 2015)

CHANNEL A

Flow rate: $0.16m^3/s$
= $0.08m^3/s$ (division of river)
= $0.08m^3/s$ passing through site

Water enters system at $0.08m^3/s$
Required speed: $0.1m/s$

Area = $0.8m^2$

Volume = $0.08m^3/s \times 60 \times 60 \times 24$
= $6912m^3/day$
= $214\ 272m^3/month$

CHANNEL B

Flow rate: $0.65m^3/s$
= $0.32m^3/s$ (division of river)
= $0.32m^3/s$ passing through site

Water enters system at $0.32m^3/s$
Required speed: $0.1m/s$

Area = $3.25m^2$

Volume = $0.32m^3/s \times 60 \times 60 \times 24$
= $28\ 080m^3/day$
= $870\ 480m^3/month$

CHANNEL C

Flow rate: $3.10m^3/s$
= $1.55m^3/s$ (division of river)
= $1.55m^3/s$ passing through site

Water enters system at $1.55m^3/s$
Required speed: $0.1m/s$

Area = $15.5m^2$

Volume = $1.55m^3/s \times 60 \times 60 \times 24$
= $133\ 920m^3/day$
= $4\ 151\ 520m^3/month$

CHANNEL D

Flow rate: $16.35m^3/s$
= $8.17m^3/s - 1.55m^3/s$
= $6.625m^3/s$ (division of river)

$8.17m^3/s + 6.625m^3/s = 14.75m^3/s$

$14.75m^3/s / 2 = 7.39m^3/s$

$7.39m^3/s$ passing through site
Water enters system at $7.39m^3/s$
Required speed: $0.1m/s$

Area = $73.9m^2$ - too large, speed will not be 0.1m.s

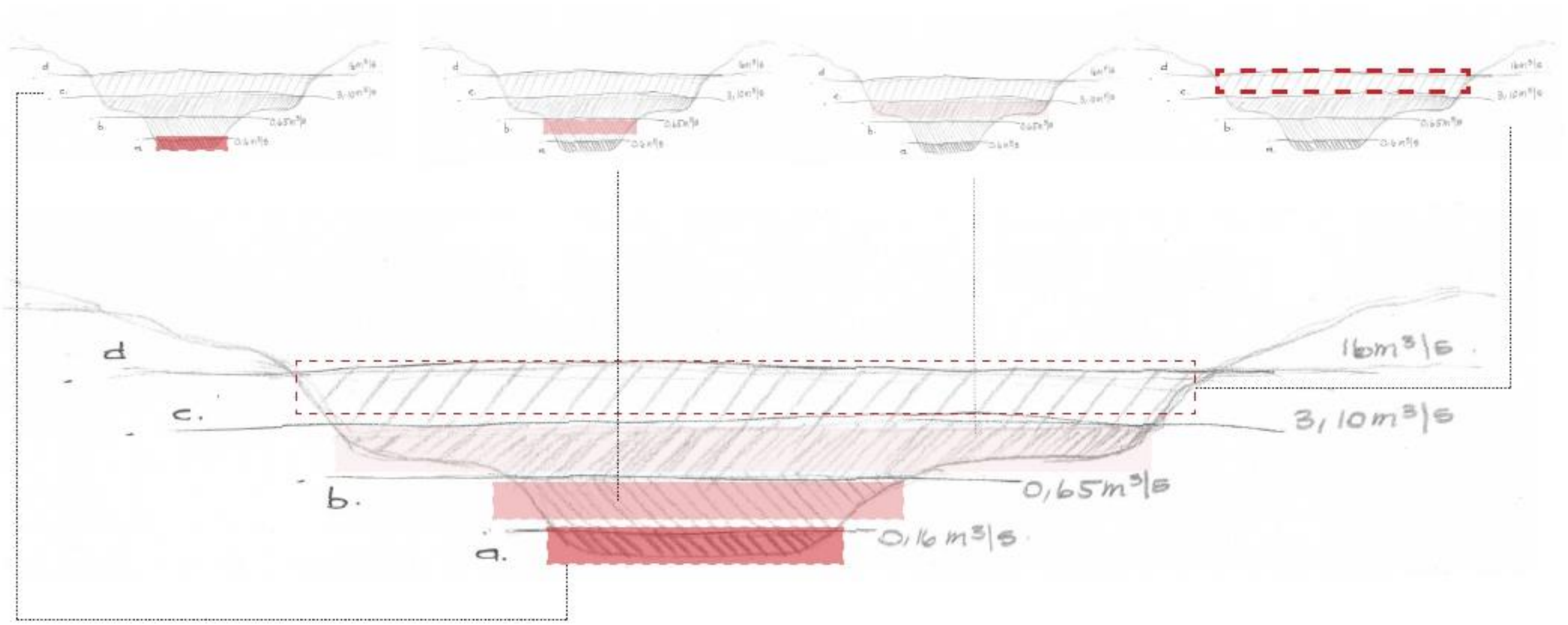
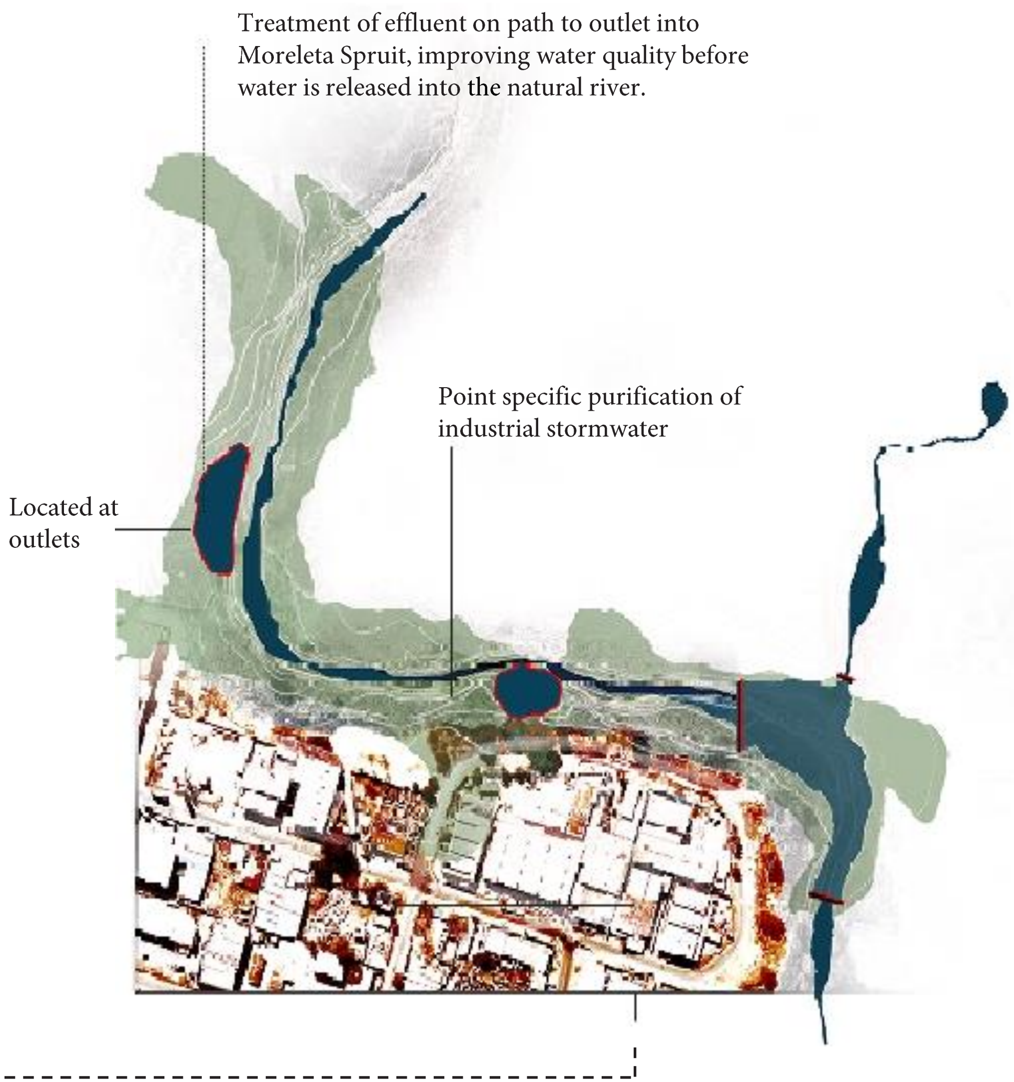


Figure 2.7.17 – Weir and Channel Sizing for Flow Rates (Author, 2015)

STRATEGY2

:

The water remaining in the Moreleta Spruit which is not diverted to the purification system needs to be treated as all storm water outlets from the urban runoff management system are located along the spruit. The highly polluted effluent requires treatment before joining the Moreleta Spruit. Pin point interventions are incorporated at the outlets, creating a treatment path for the water as it travels to the Moreleta Spruit.



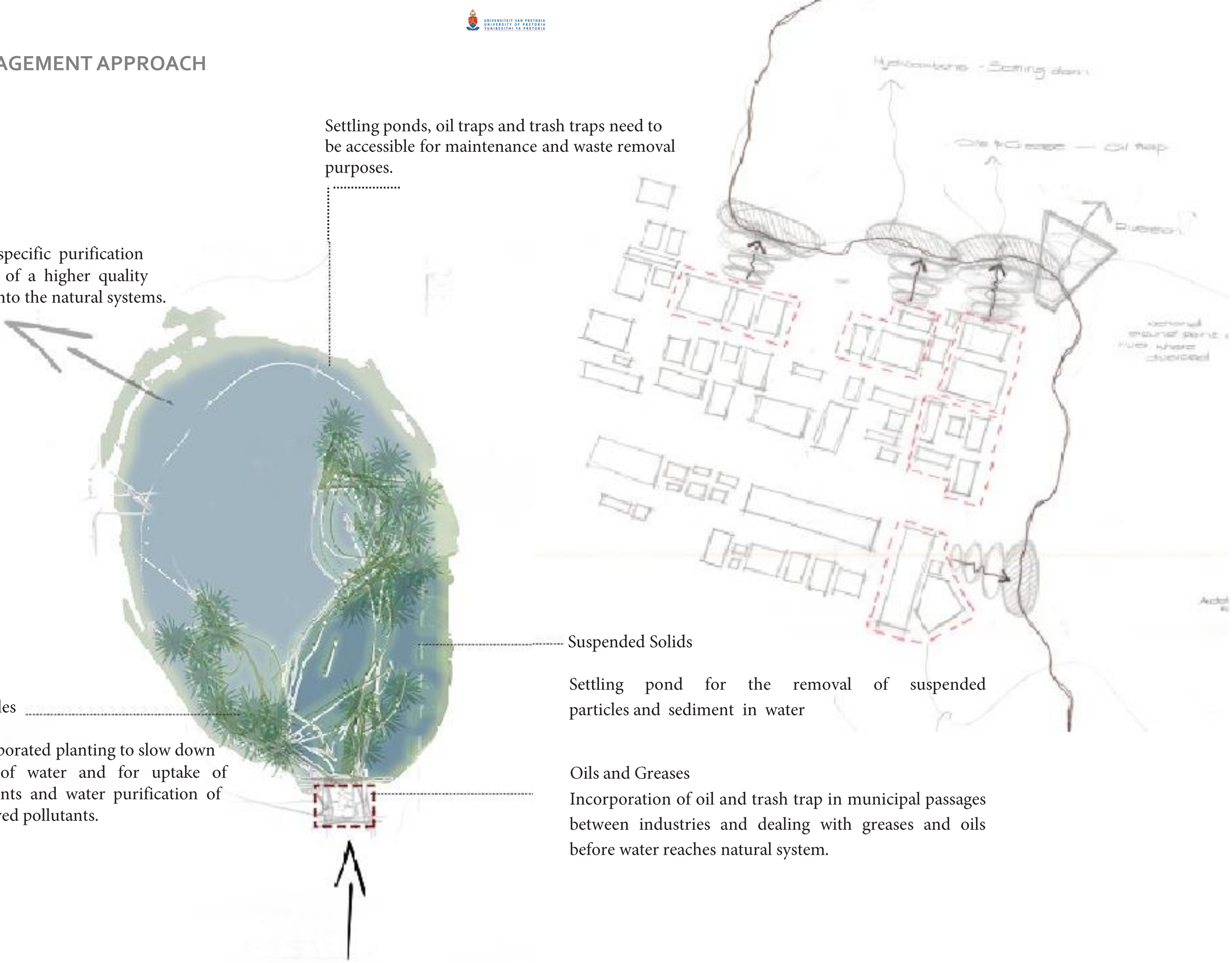
Treatment of effluent on path to outlet into Moreleta Spruit, improving water quality before water is released into the natural river.

Point specific purification of industrial stormwater

Located at outlets

Figure 2.7.18 – Strategy 2 (Author, 2015)

EFFLUENT MANAGEMENT APPROACH



Settling ponds, oil traps and trash traps need to be accessible for maintenance and waste removal purposes.

Through point specific purification strategies, water of a higher quality will be released into the natural systems.

Suspended Solids

Settling pond for the removal of suspended particles and sediment in water

Solubles

Incorporated planting to slow down flow of water and for uptake of nutrients and water purification of dissolved pollutants.

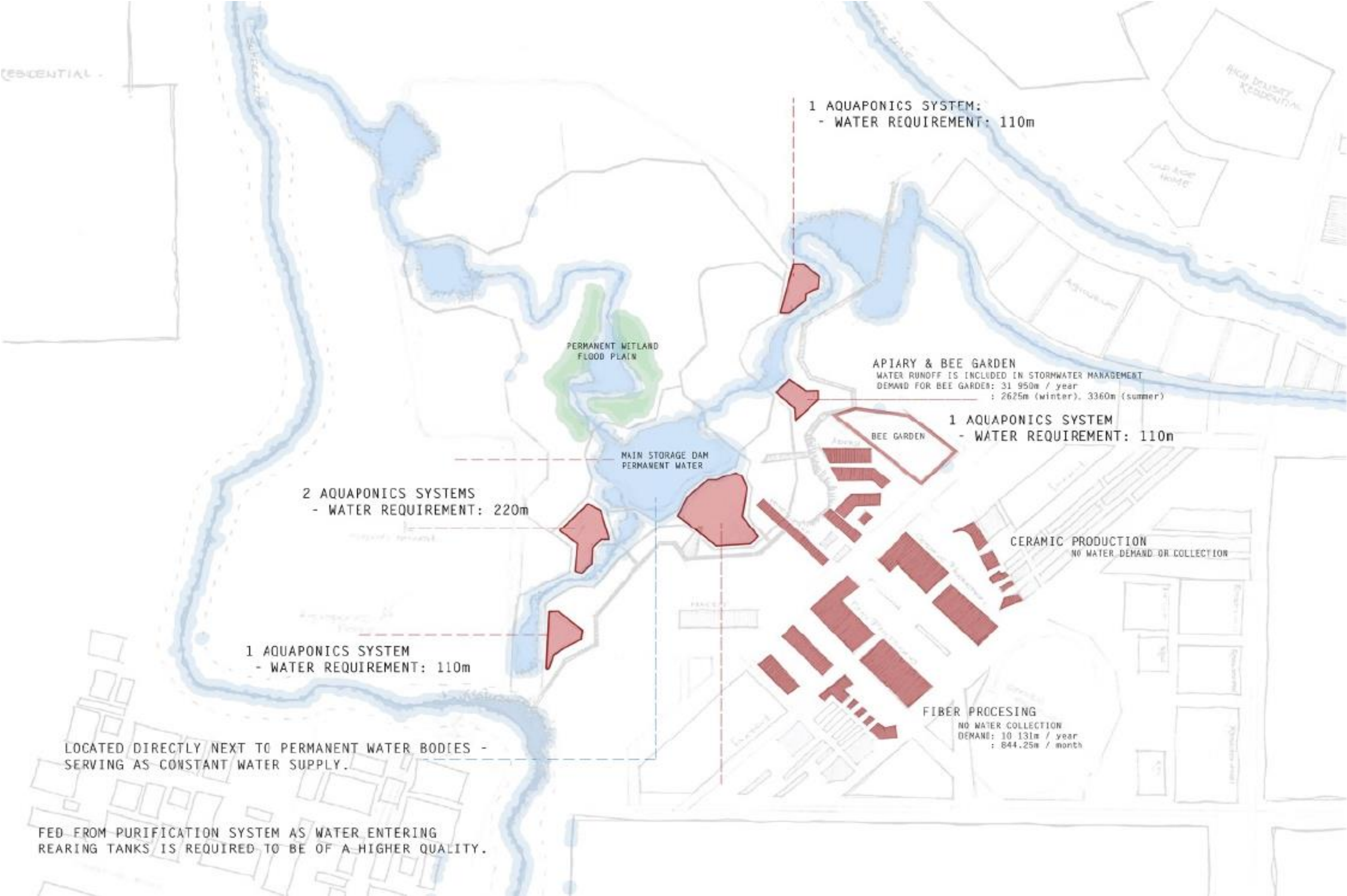
Oils and Greases

Incorporation of oil and trash trap in municipal passages between industries and dealing with greases and oils before water reaches natural system.

Effluent from industrial area.

Figure 2.7.19 – Effluent Handling (Author, 2015)

AQUAPONICS SYSTEM



1 AQUAPONICS SYSTEM:
- WATER REQUIREMENT: 110m

APIARY & BEE GARDEN
WATER RUNOFF IS INCLUDED IN STORMWATER MANAGEMENT
DEMAND FOR BEE GARDEN: 31 950m / year
: 2625m (winter), 3360m (summer)

1 AQUAPONICS SYSTEM
- WATER REQUIREMENT: 110m

2 AQUAPONICS SYSTEMS
- WATER REQUIREMENT: 220m

CERAMIC PRODUCTION
NO WATER DEMAND OR COLLECTION

1 AQUAPONICS SYSTEM
- WATER REQUIREMENT: 110m

FIBER PROCESING
NO WATER COLLECTION
DEMAND: 10 131m / year
: 844.25m / month

LOCATED DIRECTLY NEXT TO PERMANENT WATER BODIES - SERVING AS CONSTANT WATER SUPPLY.

FED FROM PURIFICATION SYSTEM AS WATER ENTERING REARING TANKS IS REQUIRED TO BE OF A HIGHER QUALITY.

Figure 2.7.20 – Aquaponics System Layout (Author, 2015)

SOCIAL AND ECONOMIC BENEFITS OF AQUAPONICS SYSTEM

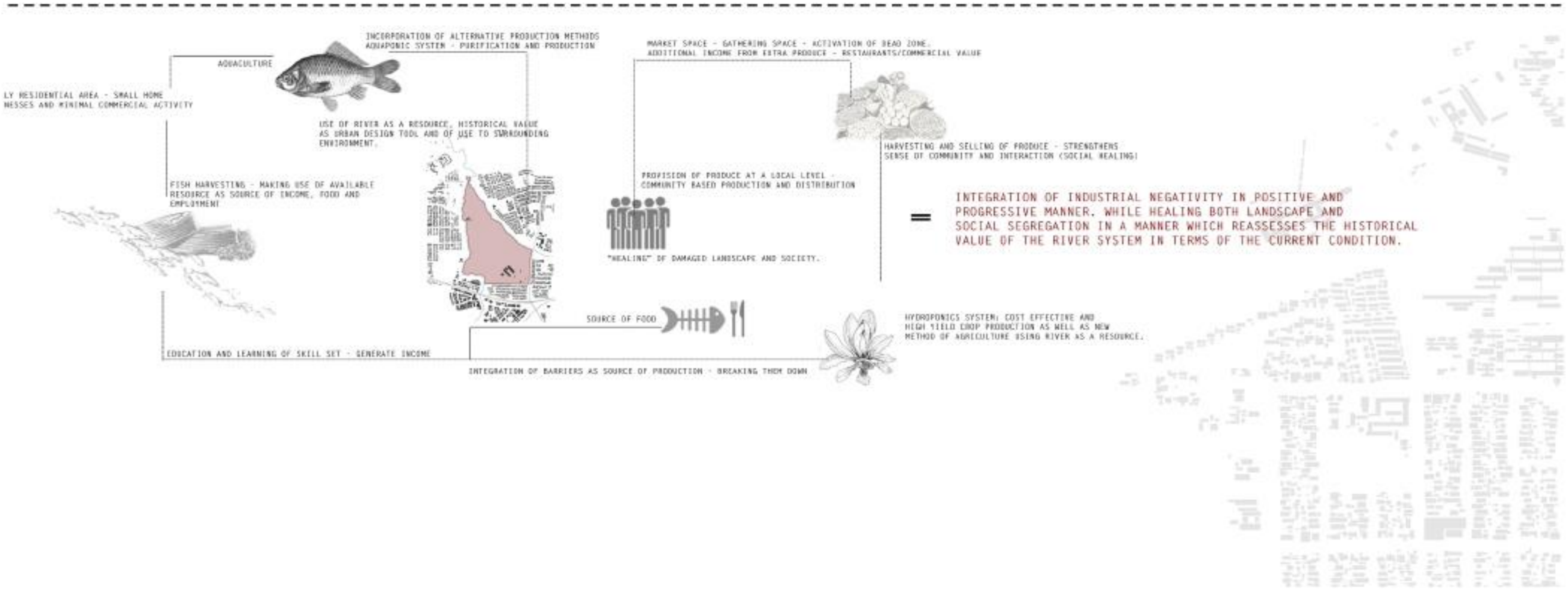
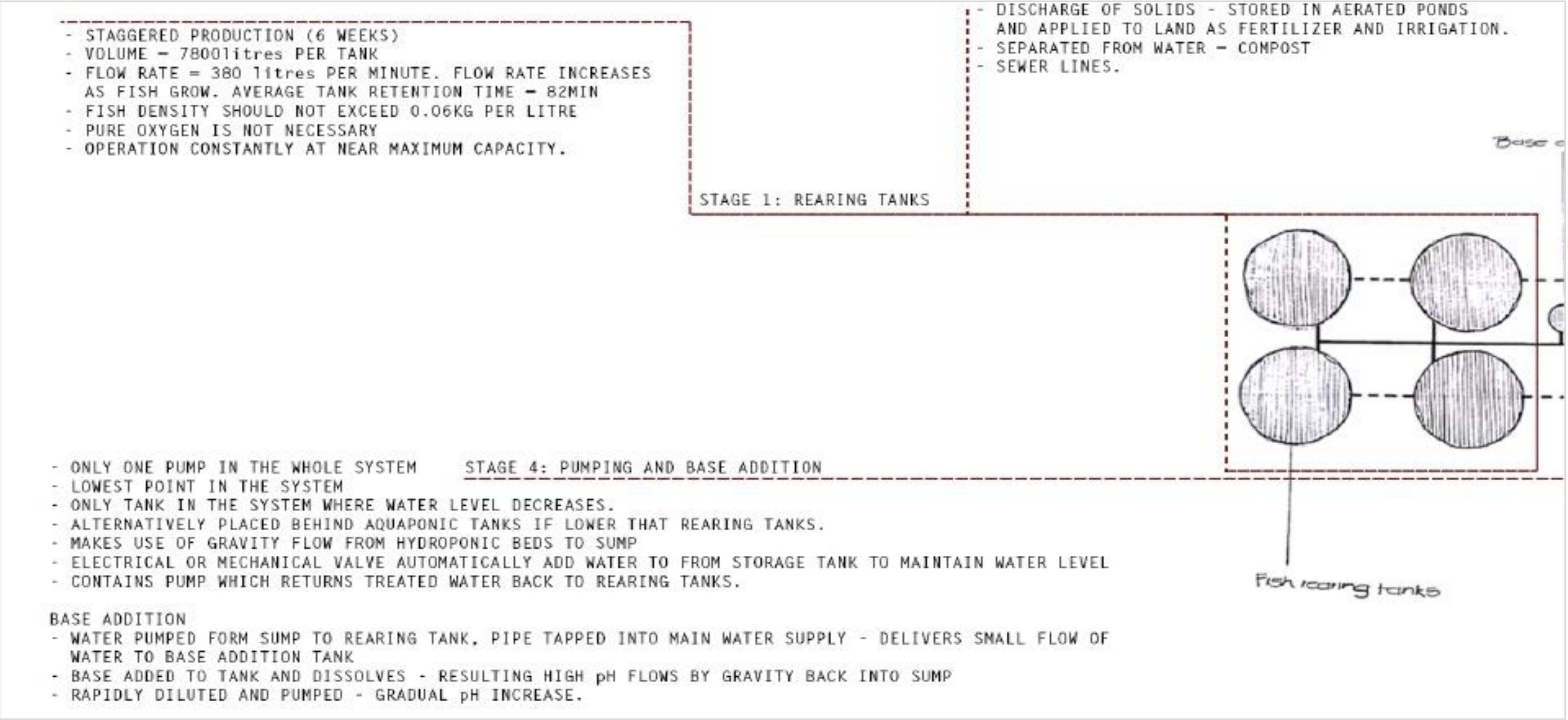


Figure 2.7.21– Aquaponics Systems Benefits (Author, 2015)

AQUAPONICS SYSTEM

The approach to the project was the purification of the Moreleta Spruit and using the river once again as a natural resource to rebuild the lost connection between man and the natural environment. The choice of site location to be in a wasted landscape, a post-industrial landscape brought in the economic element and the isolation of man from industrial systems and processes. The incorporation of aquaponics was able to form a link between man and the natural environment as well as the natural and industrial environments. The recirculating system will be able to use the water from the purification system in the quarry, providing produce for the surrounding community and potentially external purchasers as a means of income for the area. The integration of the social, ecological and economic aspects around the introduction of this system to the area is a catalyst for further and more sustainable production practices within the urban environment. The water from the purification that comes from the Moreleta Spruit is successfully being used as both a resource, feeding and providing for the urban environment, as well as an urban design tool through the generation of public space centered around the functioning and production activities of the river. The fish species chosen is the Tilapia, one of the most successfully cultured fish for aquaculture.

Tilapia occurs naturally in the river system but have sufficiently decreased in population as the quality of their natural environment was so drastically affected. There aquaponics system offers an opportunity to repopulate the river system if not all fish are harvested.



- STAGGERED PRODUCTION (6 WEEKS)
- VOLUME – 7800litres PER TANK
- FLOW RATE = 380 litres PER MINUTE. FLOW RATE INCREASES AS FISH GROW. AVERAGE TANK RETENTION TIME – 82MIN
- FISH DENSITY SHOULD NOT EXCEED 0.06KG PER LITRE
- PURE OXYGEN IS NOT NECESSARY
- OPERATION CONSTANTLY AT NEAR MAXIMUM CAPACITY.

- DISCHARGE OF SOLIDS - STORED IN AERATED PONDS AND APPLIED TO LAND AS FERTILIZER AND IRRIGATION.
- SEPARATED FROM WATER – COMPOST
- SEWER LINES.

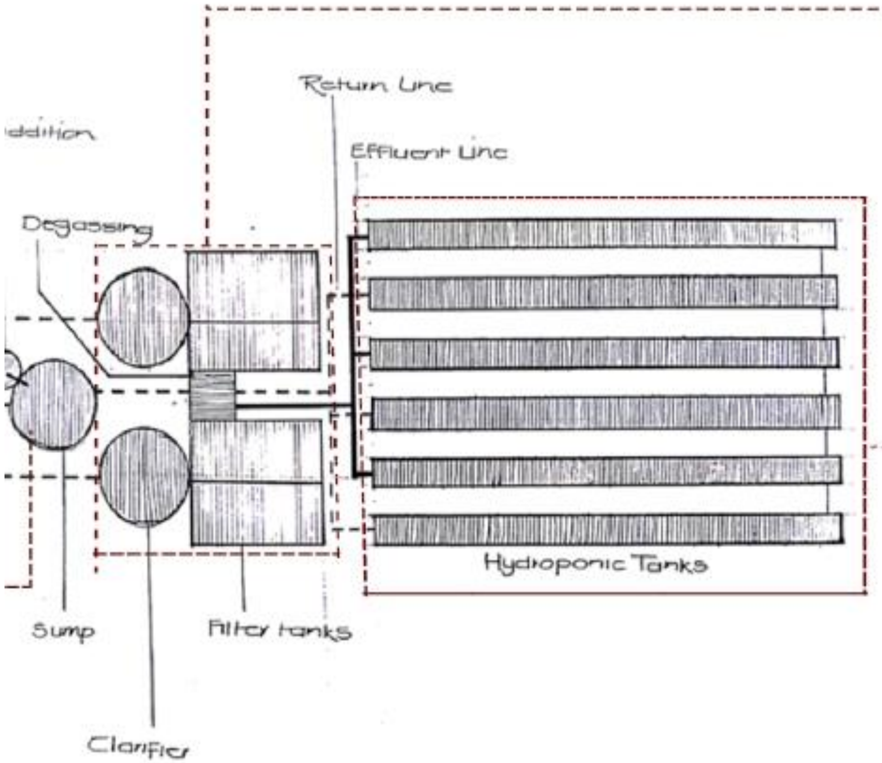
- ONLY ONE PUMP IN THE WHOLE SYSTEM
- LOWEST POINT IN THE SYSTEM
- ONLY TANK IN THE SYSTEM WHERE WATER LEVEL DECREASES.
- ALTERNATIVELY PLACED BEHIND AQUAPONIC TANKS IF LOWER THAT REARING TANKS.
- MAKES USE OF GRAVITY FLOW FROM HYDROPONIC BEDS TO SUMP
- ELECTRICAL OR MECHANICAL VALVE AUTOMATICALLY ADD WATER TO FROM STORAGE TANK TO MAINTAIN WATER LEVEL
- CONTAINS PUMP WHICH RETURNS TREATED WATER BACK TO REARING TANKS.

BASE ADDITION
- WATER PUMPED FORM SUMP TO REARING TANK. PIPE TAPPED INTO MAIN WATER SUPPLY - DELIVERS SMALL FLOW OF WATER TO BASE ADDITION TANK
- BASE ADDED TO TANK AND DISSOLVES - RESULTING HIGH pH FLOWS BY GRAVITY BACK INTO SUMP
- RAPIDLY DILUTED AND PUMPED - GRADUAL pH INCREASE.

Figure 2.7.22– Aquaponics Systems Explanation (Author, 2015)

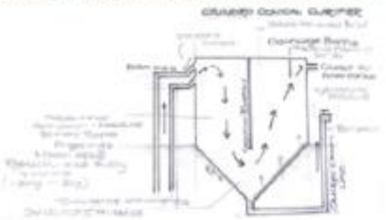
AQUAPONICS SYSTEM – CLARIFICATION AND FILTRATION

STAGE 2: CLARIFICATION AND FILTRATION



- CLARIFIER - REMOVES SETTLE-ABLE SOLIDS (50%)

- FILTER TANKS
  - REMOVE RESUSPENDED AND FINE SOLIDS (50%)
  - TWO FILER TANKS IN SERIES
  - MESH CLEANED ONCE/TWICE PER WEEK
  - BACTERIA PREVENT NUTRIENT UPTAKE IN PLANTS.
  - 185 GALLONS EACH



- DEGASSING
  - ACCUMULATION OF ORGANIC MATTER FORMS THICK SLUDGE AND DUE TO ANAEROBIC CONDITIONS – FORMATION OF GASSES
  - WATER IS SPLIT INTO THE IRRIGATION OF THREE HYDROPONIC BEDS.

STAGE 3: HYDROPONIC BEDS

- 3 SETS OF 2 RAFT HYDROPONIC TANKS
- MAXIMUM EXPOSURE OF ROOTS TO WATER
- DISRUPTION IN PUMPING DOES NOT AFFECT PLANTS WATER SUPPLY. (SAND, GRAVEL ETC.)
- EASILY MOVED SHEETS FOR HARVEST.
- SHEETS SHIELD WATER FROM DIRECT SUNLIGHT - MAINTAINING IDEAL WATER TEMPERATURE.

DETAILS:
- BEDS - 30.4m x 1.2m x 0.5m deep
- CHANNELS LINED WITH LOW DENSITY POLYETHYLENE LINERS (20mm)
- COVERED BY EXPANDED POLYSTYRENE SHEETS (RAFTS) - 2.4m x 1.2m x
- GROWTH OF LEAFY GREENS - TYPE OF GROWTH DEPENDS ON EFFLUENT IN

AQUAPONICS SYSTEM FLOW RATES AND DESIGN

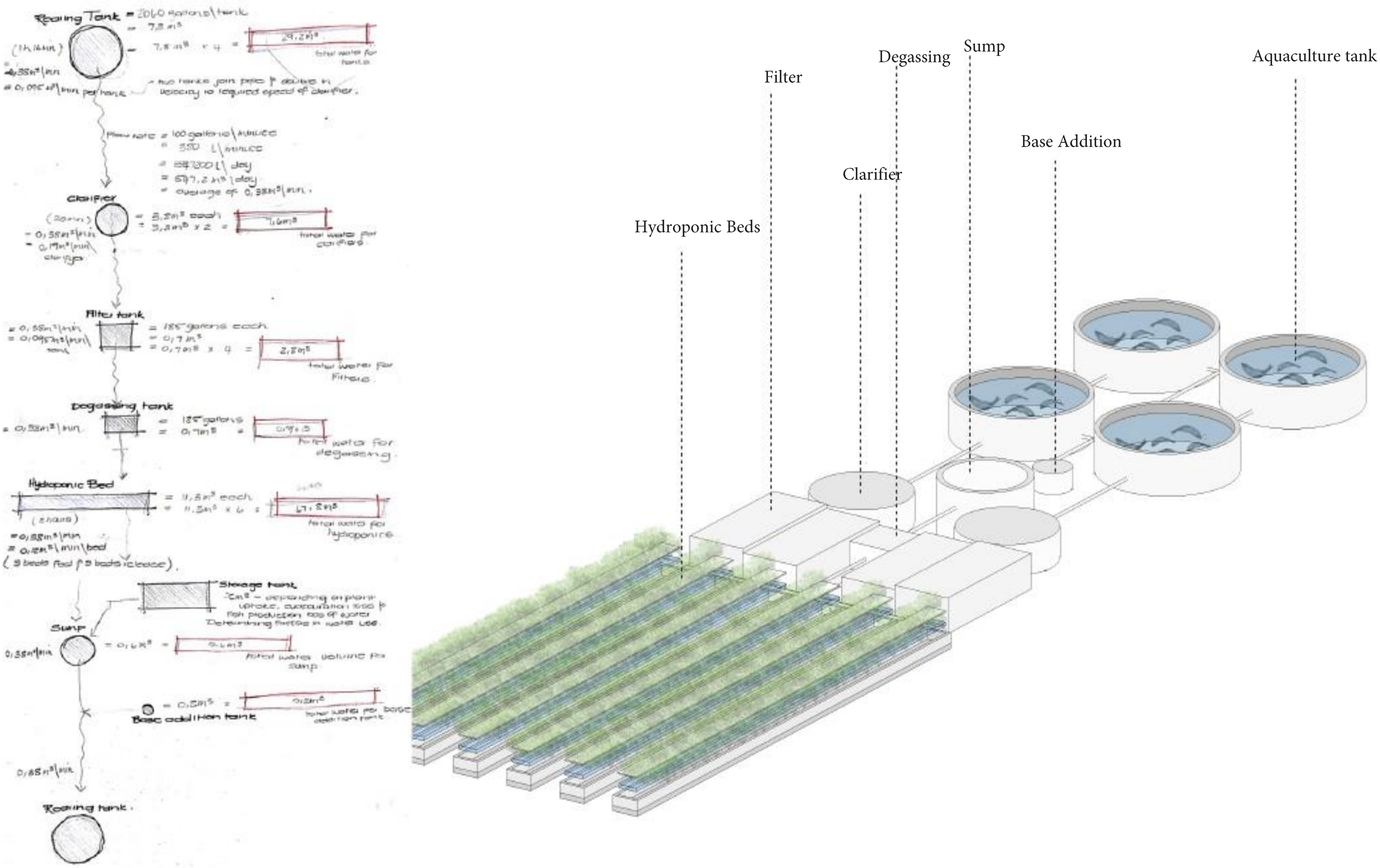


Figure 2.7.23– Aquaponics Systems Design and flow rates (Author, 2015)