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OYIBI-AMRAHIA AREA FEASIBILITY REPORT

FEASIBILITY STUDIES FOR RURAL PIPED WATER SUPPLY SCHEMES IN GREATER ACCRA REGION (2003)

FINAL REPORT PREPARED FOR

REGIONAL DIRECTOR

COMMUNITY WATER & SANITATION AGENCY

GREATER ACCRA REGION

P.O. BOX 884

ACHIMOTA, ACCRA[1]

MARCH 2003

[1] *UNIHYDRO ACCRA OFFICE : No.3 HOS/20,COMMUNITY 20, ACCRA ABATTOIR ROAD*

Water Supply Engineers

Pls for study & comments. Discuss with Water Supply Advisor & Consultants and move it to detailed design & tender. 824 GHAC03.19348

19/05

UNIHYDRO Limited
WATER INDUSTRY SERVICES, PRODUCTS & SUPPLIES

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Our ref:
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ATTENTION: Mr. Edem Asimah

15 May 2003

Regional Director
Community Water & Sanitation Agency
Greater Accra Region
P.O. Box 884, Achimota

Dear Sir:

Submission of Final Feasibility Reports
Feasibility Studies, Design, Tendering & Construction Supervision of Rural Piped Water Supply Schemes in Greater Accra Region

We refer to the contract agreement for feasibility studies in Oyibi-Kpone Seduase-Amrahia and Ashalaja proposed supply areas, and wish to submit our final report on feasibility studies for the following prime communities:

- Oyibi-Amrahia Supply Area
- Ashalaja Supply Area

Thanks for your usual co-operation.

For and on behalf of Unihydro Limited

Samuel Asare
Project Engineer

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1 INTRODUCTION

1.1 Project Background

The Greater Accra Region Community Water and Sanitation Programme is implementing the construction of water supply and sanitation facilities in the Ga, Tema, Dangme East and Dangme West Districts under joint funding by the Government of Ghana and the Government of Denmark (Danida).

During the Year 2002 Rural Water Supply Component Drilling Programme several high yielding boreholes were constructed in some communities in Ga district and Tema Municipality. Inorder to collect borehole discharge data for preliminary decision making regarding the promotion of rural piped water supply schemes based on mechanized or production boreholes the drilling contractor was tasked to undertake long duration pumping tests of five selected high yielding boreholes.

The Community Water and Sanitation Programme, now wishes to determine the optimum usage of the five selected high yielding boreholes, with the view to utilizing them as sources for small rural piped water supply schemes in clusters of communities located around these boreholes. The five main target communities are as follows:

- Kweiman Area - Ga District (with 1 borehole)
- Habitat Area - Ga District (with 2 boreholes)
- Ashalaja Area - Ga District (with 1 borehole)
- Oyibi Area - Tema District (with 1 borehole)
- Kpone Seduase - Tema District (with 1 borehole)

The proposed beneficiary communities are mainly rural farming communities with very low level of infra-structural development and standard of living of its inhabitants.

The Community Water and Sanitation Programme, Greater Accra Region, therefore engaged Unihydro Limited to undertake feasibility studies, design and construction supervision of the proposed project.

1.2 Scope of Feasibility Study Phase

The scope of studies to be carried out as part of the feasibility study phase is as follows:

(i) Field visits to the communities to carry out extended pumping tests on the proposed high-yielding boreholes. During this exercise, the perception of the people on the water quality should be assessed and the GPS co-ordinates of the boreholes and the communities should also be recorded.

(ii) Carry out detailed interpretation of the results from the extended pumping test with recommendations on the sustainable production or safe yield levels.

- Proximity to a production borehole with potential for rural piped supplies
- General indication of interest in having improved water supplies
- Social relations between the surrounding communities

For instance, Adamorobe is close to Kpone Seduase but was not considered since there is serious land litigation between the people of Kpone Seduase and Adamorobe. Also Adamorobe falls within the Eastern region. Goten is also closer to Kpone Seduase than Amrahia but was not considered because it has a successful borehole fitted with handpump with yield enough for its population.

All the communities near Old Saasabi like Bawaleshie and its cluster communities are also connected to the Dodowa Water supply system and hence were not considered for this project.

3 SOCIO-ECONOMIC SURVEY

3.1 METHODOLOGY FOR SOCIO-ECONOMIC STUDY

The study applied social and economic methodologies. The socio-economic study was executed through the application of multi-dimensional community participatory techniques, which are itemized below:

- Community fora and meetings.
- Household sample survey: Three percent of the total population was randomly sampled and interviewed.
- Specific field investigation.
- Guided transient walk.
- Survey questionnaires on community profiles.
- Direct visual observations
- Household interviews and institutional surveys.

The study thus used multi-dimensional approach to collect data. The interviewers administered the questionnaires.

The target groups selected for the detailed interview were people in the various economic groups. The interview conducted on their economic activities determined their ability and willingness to pay for improved potable water supplies.

The household interview was administered on randomly selected people - three percent of the total population in each community. The interview method makes available precise and detailed information, which supplements what had been provided in the community profile questionnaires. This is because private and personal information that could not be provided on survey questionnaires could be acquired through in-depth interviews.

3.1.1 Data Collection

In collecting data, the investigators and other assistants who were well trained and had prior knowledge in research, administered the survey questionnaires. The interviews were conducted in the local language Ga.

The questionnaire used by the GARCWSP for collecting community information and socio-economic data was reviewed and detailed interview guides added.

Community meetings were held and the people briefed about the study. During these meetings, the survey questionnaires were administered and community information. Socio-economic information collected:

Present at the meetings were the following:

- Chiefs, women's leaders and their elders.
- WATSAN Committee Members
- Unit Committee members.
- Assemblymen.
- Community Workers (Teachers, nurses, caretakers and retired public servants).
- Opinion leaders.

The following information was collected during household interviews:

- Economic Activities.
- Income Level.
- Expenditure.
- Ability and Willingness to pay for water.
- Perception and Acceptability of borehole water for mechanization into pipe system.

To complement data collection efforts of the multi-disciplinary survey team, the technical and the socio-economic studies were undertaken concurrently within a period of three weeks.

All completed questionnaires were coded and edited the day after the interviews for omissions, inconsistencies and mistakes to be corrected. The data was later computerised and tables and statistical functions (where necessary) obtained for analysis by the investigators. All data collection activities were carried out concurrently so as to ensure comprehensive and well-integrated information on the communities.

3.2 SOCIO-ECONOMIC ASSESSMENT

3.2.1 Location

The selected communities for this study are located in Tema district. The communities are located at 0.5km to 6.5km from the main Dodowa road. Oyibi is the nearest (0.5km) whilst Adigon is the furthest (6.5km). Some however are located along the main road and these include the Good News College/Seminary, Valley View University, Malejor and the Amrahia communities. The communities are all concentrated except Adigon, which is a settler and animal rearing community with houses widely dispersed from each other.

These communities are basically rural and homogeneous, made up mainly of people of Ga descent. However, members of Adigon are settlers from Ada while Oyibi also has quarters with residents who hale from different tribes other than Ga. The main languages spoken are Ga, and Twi, though members of some of the communities speak Ada and Ewe well.

3.2.2 Socio-Economic Aspects

(a) Community Leadership

The table below represents the names of the various political leaders as identified by the community representatives.

Table 1: Community Leaders

Community	Chief	Linguist	Women's Leader
Oyibi	Nii Bokettey Bottey	Stephen A. Boquaye	Naa Bottey Otiyie (queen)
Old Saasabi	Nii Ashittey Amarh	Henry Tettey Adjettey	Victoria Amarh (leader)
Kpone Seduase	Nii Nuettey Akpoo I	James Tettey	Akpo Yomo
Adigon	Nii Okoh Mensah	John Mantey	Naa Awo (leader)
Good News College/ Seminary	-	-	-
Valley View Univ.	-	-	-
Malejor	Nii Atta Boye	-	-
Amrahia	Nii Okoh	-	-

3.2.3 Demographic Characteristics

(a) Population Distribution

The sex distribution in the communities are presented in Table 2 below:

Table 2: Sex Distribution in the Communities

Particulars	Oyibi	Old Saasabi	Adigon	Kpone Seduase	Good News Co/Seminary	Valley View University	Malejor	Amrahia	Total
Male (M)	1176	227	56	227	41	662	70	558	3017
Female (F)	1224	236	59	236	19	298	80	572	2724
Total	**2400**	**463**	115	**463**	**60**	**960**	**150**	**1,130**	5741

Reference 2002 Census Population Distribution Rates.

The female population is higher than the male in all the six communities. The male to female ratio is approximately 49:51 of the total population. Based on the household interviews the average number of persons per household ranges between 4 -5. The trend differed in the two institutions where male populations are just about double that of females.

(b) Settlement Types

The communities are classified into three categories of settlement types based on the Community Water and Sanitation Agency (CWSA) guidelines and an institutional category as follows:

- Rural: Population of 75-2000
- Peri-Urban: Population of 2001-5000
- Urban: Population of 5000 and above
- Institutions

Table 3: Population and Settlement Types

Community	Population	Settlement Type
Oyibi	2400	Peri-Urban
Old Saasabi	463	Rural
Kpone Seduase	463	Rural
Good News Co/Seminary	60	Institution
Valley View University	920	Institution
Malejor	150	Rural
Amrahia	1.130	Rural
Adigon	115	Rural

About 75% of the communities are rural with poor infrastructure base while only one. Oyibi can be described as peri-urban based on the Community Water and Sanitation Guidelines.

3.2.4 Community Infrastructure

Based on the survey carried out. the following facilities were identified in the various communities.

Table 4: Community Facilities

Community	Hlth Inst.	Sch	Water	Makt	Rd	Post Office	Elec-tricity	Church	Police Station
Ovibi	Nil	Yes	Yes	Nil	Yes	Nil	Yes	Yes	Nil
Old Saasabi	Nil	Nil	Yes	Nil	Yes	Nil	Nil	Yes	Nil
Kpone Seduase	Nil	Yes	Yes	Nil	Yes	Nil	Nil	Yes	Nil
Good News Co	Nil	Yes	Yes	Nil	Yes	Nil	Yes	Yes	Nil
Valley View	Nil	Yes	Yes	Nil	Yes	Nil	Yes	Yes	Nil
Malejor	Nil	Nil	Yes	Nil	Yes	Nil	Nil	Yes	Nil
Amrahia	Nil	Yes	Yes	Nil	Yes	Nil	Yes	Yes	Nil
Adigon	Nil	Yes	Yes	Nil	Yes	Nil	Nil	Nil	Nil

There are no communal latrines in Adigon. Malejor and Amrahia hence the people defecate in the surrounding bushes. however there are few private/household latrines in the Malejor and Amrahia communities. Old Saasabi and Kpone Seduase have public latrines while Ovibi has both public and private household latrines. The two institutions: Good News and Valley View University. in addition to Malejor and Amrahia communities are located on the main Dodowa road while the rest are also accessible by feeder roads.

The main sources of water supply are Boreholes. streams. ponds. dams. tanker services and occasionally rain harvest. All the boreholes drilled at Adigon were dry hence the people depend solely on dams. which they share with animals. Ovibi and Old Saasabi and Kpone Seduase have high yielding borehole. And these sources serve as the main source of water to the people. The two institutions. Malejor and Amrahia communities depend on tanker services for drinking water supply.

None of the communities has a health post or a police station: they mostly depend on the facilities at Dodowa and Adenta.

Oyibi. Amrahia and the two institutions are connected to the national grid while Adigon has not erected poles. Meanwhile Old Saasabi. Kpone Seduase and Malejor have erected poles but the installation of the physical infrastructure for the power supply is on-going.

Oyibi. Kpone Seduase. Malejor. Amrahia and Adigon have schools while Old Saasabi depends on the educational facilities at Oyibi. Below is the breakdown of educational facilities available in the four communities and the available population data at the time of the survey.

Table 5: Community Schools and their Populations

Community	Population	JSS	Prim	Kindergarten	College/Univ
Oyibi	80 250 100	Yes	Yes	Yes	-
Kpone Seduase	-	Yes	Yes	Yes	-
Good News College	50	Nil	Nil	Nil	Yes
Valley View Univ.	920	Nil	Nil	Nil	Yes
Malejor	15	Nil	Nil	Yes	-
Amrahia	-	Yes	Yes	Yes	-
Adigon	53 18	Nil	Yes	Yes	-

(a) Type of Houses

The houses in these communities are a combination of mud with thatch roofs and cement blocks with aluminium sheet roofs. Most of the houses at Adigon are made from mud which may be due to the fact that they are settlers while Oyibi. Kpone Seduase. Old Saasabi. and Malejor have a combination of the two types of houses. In addition Oyibi has a quarters built by a private developer. which is situated about 600m away from the main community. Part of Amrahia and the quarters at Oyibi have modern structured houses built with cement and roofed with tiles or iron sheet.

(b) Space Availability for New Projects

There is enough space within the communities for the construction of both individual household and communal water supply and sanitation facilities without any problems.

The chiefs and elders in all the communities have agreed to make land available for the purposes of putting up reservoirs and standpipes.

However, the Community Water and Sanitation Agency should obtain permission from the Ghana High Way Authority so as to enable the contractor cut across roads when the need arises.

3.2.5 Economic Activities

The predominant occupation for both men and women are trading and farming. Women do trading, dressmaking and also provide services such as hair dressing as supplementary occupations. Some buy the farm products from the men for sale at Dodowa and Madina markets. Some men also serve as consultants for land sales, masons/foremen at building sites, carpenters and drivers as supplementary activities.

Out of the six communities under study, four (Oyibi, Kpone Seduase, Adigon and Old Saasabi) have been selected for detailed surveys on the economic activities available and studies on the ability and willingness of the community people to pay for water. Malejor, Amrahia and the two institutions currently depend on tanker services at a very high cost, hence one can comfortably presume that they will be willing and can afford to pay for water. However, the people's acceptability of the borehole source for mechanization into pipe system was carried out on all the communities in the coverage area. The following are findings made on the detailed household survey.

Table 6: Occupational Distribution

Occupation	Oyibi		Old Saasabi		Adigon		Kpone Seduase	
	No	%	No	%	No	%	No	%
Farming	5	6.9	7	46.7	3	30	2	14.3
Trading	16	22.2	3	20.0	1	10	4	29
Civ/Pub Servants	10	13.9	0	0.0	1	10	0	0
Farming/trading	14	19.4	5	33.3	2	20	3	21.4
Beautician/Farming	5	6.9	0	0.0	0	0	1	7.14
Labourer/land dealer	3	4.2	0	0	0	0	0	0
Artisan Farming	18	25	0	0	3	30	4	29
Trading Artisan	2	2	0	0	0	0	0	0
Unemployed.	0	0	0	0	0	0	0	0
TOTAL	72	100	15	100	10	100	14	100

It must be stressed here that almost every member of these communities do some farming except those in full time white colour jobs. The results of the survey indicate that most of the respondents engage in subsistence farming as their secondary occupation.

There are also skilled labourers such as artisans. carpenters. masons. auto mechanics and drivers etc who will be very useful for this project.

3.2.6 Local Organization and Fund Raising Activities

(a) Local organization

There are well-organized groups in the communities that can be used for community mobilization and dissemination of information. These groups include unit committees. church groups. occupational associations. resident associations (as in case of Oyibi Quarters). school committees and PTA (where applicable).

Out of the four communities. only Old Saasabi has a youth association resident in Tema. which contributes to development projects through cash donations. However. there are also some individuals in the four communities who contribute cash and building materials towards development projects. Meanwhile in the communities where there are no resident groups outside. members undertake all developmental projects mainly through the contributions of residents in the communities.

(b) Fund Raising Activity

(i) Fund Raising & Communal Labour

The communities have the requisite organizational capacity to undertake development projects. Funds are raised through community work. levies and proceeds from Traditional Council Loyalties (at Oyibi where the levy system does not work). Some individuals who hail from the communities also contribute funds towards local developmental projects.

Communal labour is usually organized on Sundays and Tuesdays for Oyibi. Fridays in Adigon and Kpone Seduase. and Saturdays only for Old Saasabi to provide essential services needed in the communities.

Most of the community members are active and have acquired some experience in community development projects such as the construction of schools. water projects and are contributing toward grid electricity connection. They are therefore willing to participate in the project.

(ii) WATSAN Committees

There are WATSAN Committees in all the communities. These committees are very active and much concerned about their water problems. Members are very enthusiastic and have expressed their interest and acceptance of the mechanization of the high yielding boreholes into pipe system.

3.2.7 Willingness and Ability to Pay

3.2.7.1 Indicators of willingness to pay

The willingness and the ability of people to pay for water was determined by the following factors:

- Income and expenditure levels
- Respondents view on the need to contribute financially to project
- Respondents view on the benefits of scheme

(a) Income and Expenditure levels

The main economic activities in these communities are farming (which also include rearing of animals in Adigon) and trading. The bulk of the income for farmers is realised in the harvesting period. which is usually on annual basis. Animal rearing community like Adigon also stores its wealth in herds of cattle and sheep. This situation will greatly affect their contribution towards the water scheme. Thus. their water demand during the time between growing new crops and harvesting could reduce.

However, most traders though also farm and harvest annually, also buy from others to sell. And since there is no particular one period for harvesting all crops, they are likely to maintain their volume of sales though it may fluctuate occasionally. The trend of the income and expenditure levels of the communities is presented below. This implies that traders may not have any problem in relation to the regularity of inflow of income and hence their ability to pay for water. Therefore their demand for water is not likely to reduce.

The income and the expenditure analysis are based on the **median income level analysis** and its distribution in the communities is as follows:

Table 7: Income and Expenditure Distributions

Community	Median Income/month (¢)	Median Expenditure/month (¢)
Oyibi	825.000	565.000
Old Saasabi	420.000	330.000
Kpone Seduase	519.000	355.000
Adigon	450.000	385.000

The median household monthly income for Old Saasabi and Adigon are ¢420.000 and ¢450.000. Kpone Seduase ¢519.000 while that of Oyibi is ¢825.000, which is about twice that of its cluster communities. The differences between the values of income at Oyibi and the other communities may be due to the fact that most of the people at Oyibi earn fix incomes and could easily determine it, which was not possible in the farming communities. Oyibi is the busiest and the center of activity in the area hence its high-income level is not a surprise. The occupations, which serves as the source of the peoples income have been compiled and presented in Annex 1.

The expenditure levels however vary with income: the higher the income, the higher the expenditure levels. The range is between ¢565.000- ¢330.000. The low level of expenditure compared to income could be due to the fact that household income is mainly spent on the accompaniments which are not too costly. Others like dough and vegetables are taken from the farm on which little is spent. The next item of expenditure identified. which is school fees is low at Adigon. Old Saasabi. Kpone Seduase and Oyibi main community. However the story is different in the Oyibi Quarters where some people send their children to schools outside the town and pay higher school fees. Some however have their children in tertiary institutions and pay high fees. (Refer to Annex 1 for detailed breakdown of their expenditure).

From the studies conducted. it was realized that. with the exception of Adigon. which still depends on dams. three other communities depend on boreholes for potable water supply in the area. The borehole water is sold at Oyibi and Kpone Seduase for ¢100 per 18-liter bucket. There are always queues at the borehole sites since the water sources (thus one working borehole in each community) are not enough for the population. The Oyibi quarters is connected to the Ghana Water Company main line from Kpong. However. the water does not flow regularly and has stopped flowing for the past 6 months. Residents buy water from Dodowa and occasionally depend on the borehole at Oyibi.

Old Saasabi residents fetch the borehole water free of charge hence at Old Saasabi and Adigon records could not be taken on the expenditure on water. In Adigon the inability to take record of expenditure on water is due to the fact that most of the community members depend on unwholesome water from a dam on which they pay no money.

The people have therefore indicated that water is a high felt need and will be willing to pay for it. Based on the studies. an average of 6.3% of their income will be spent on water which is encouraging (refer to table 8).

The percentages of income the people are willing to pay on water in the various communities are presented in Table 8 below.

Table 8: Distribution of Percentage of Income to be spent on Water

Community	% Average income to be spent on Water
Oyibi	5
Old Saasabi	6
Kpone Seduase	6.5
Adigon	7.5
Average	**6.3**

(b) View on Why Contribute Financially towards Project

A large proportion of the respondents, about 42% in the household interviews indicate that there is a need to contribute financially towards the proposed project for maintenance purposes. There was also a very popular statement as " ke noko fitee esane asa": meaning when part of the system is broken down, it would have to be repaired. Consequently, about 53% indicated that money must be contributed toward repair and procurements of spare parts.

In addition, about 5% also identified the fact that the initial capital for water projects are huge and the government alone cannot afford it, so there is a need for community members to contribute in cash towards the initial investment. There is therefore the need to pay some money for water consumed. It is therefore obvious that the people appreciate the scheme and are willing to contribute towards the success of the project.

(c) Benefits of scheme

Among the benefits mentioned by the beneficiaries are as follows: good health, save of time and reduction in energy input. About 39% of the respondents stated good health. Others, 14% stated that the new system would help save the long hours used in search of water for other productive ventures. In the view of the second group, it will help reduce the burden of walking long distances to fetch water for domestic upkeep, regarded as women's responsibility. The third group 55% stated reduction in energy required in the high prices they pay for tanker services and the long distances the people have to travel to fetch water. the women and children especially use long hours of their day in meeting their water requirements. In addition to the need expressed above. the project is technically feasible and the communities are willing and have the capacity to pay for the provision of potable water.

The communities' concerns also stem from the fact that. they believe it is only when they are healthy. that they can work towards the development of their families and the communities as a whole.

It can therefore be concluded that. the people of the communities in the Oyibi/Amrahia Rural Water Supply area see the provision of potable water as one of their highly felt needs and are also willing to contribute both human and material resources towards the achievement of this goal. This situation justifies the communities to be beneficiaries of the GAR-CWS Rural Water Supply Programme.

The implication is that provision of potable water to the communities will reduce the high incidence of water related diseases. loss of time for productive agricultural and school hours used in fetching water and bring about improved community health and increased productivity. The communities are therefore eager to contribute towards the provision of potable water. This. they said will save them the time and money spent in the treatment of water related diseases.

4 TECHNICAL FEASIBILITY

4.1 EXISTING WATER SUPPLY SITUATION

Prior to the point source water supply intervention under the Danida funded programme there was no safe and regular water supply facility in the Oyibi Supply area. The main sources of water are:

- Oyibi – 1 abandoned borehole(salinity problem), standpipe with occasional water flow(last water flow was 6 months ago), and the new borehole constructed as part of the Danida funded programme
- Old Saasabi – 1 seasonal pond which is very turbid and the new borehole constructed under the Danida funded programme
- Adigon – 1 dam which is very turbid and also shared with livestock.

4.2 Sustainable Yield Estimate for Oyibi Borehole & Old Saasabi Boreholes

4.2.1 Theoretical background

The sustainable yields of the Borehole No. BH1 has been estimated using the approach outlined in the CWSA "Guidelines for Mechanised Boreholes" developed by the Volta Region Community Water Supply Programme. The spreadsheet as used in this analysis has been modified by the Greater Accra Region CWSA Small Town Hydrogeology Team. Considerations such as seasonal water level decline, sensitivity to storativity values and well efficiency have been included in the analysis.

The method uses the Modified Nonequilibrium Equation (Cooper & Jakob, 1946) to estimate the maximum sustainable yield that each well can be pumped in order to develop a pumping water level that does not exceed the maximum allowable drawdown in the well after 300 days of pumping. It is assumed that recharge occurs during the remaining 65 days of the hydrological year.

The maximum sustainable yield at different intermittent pumping rates is estimated by applying the Modified Nonequilibrium Equation to two imaginary wells that simulate the effect of different pumping cycles.

The method is highly theoretical, and suffers from a number of weaknesses including:

- The well efficiency can be only roughly estimated from the step pumping test: calculations based on theoretical drawdown compared to actual drawdown require storativity and effective well radius estimates that can lead to large errors.

- In order to estimate the maximum allowable drawdown it is necessary to know the maximum allowable pumping level as well as the seasonal water level decline. The latter requires detailed groundwater monitoring data of the area, which is not easily available.

- The effective well radius of a pumping well can exceed the actual well radius and is difficult to quantify. Even small changes to this distance can have big impacts on the maximum sustainable yield. The effective well radius was assumed to be equal to the drilled radius of the borehole.

- The storativity can only be determined from pumping tests with observation well data, which were not available in this analysis. Reported minimum and maximum values of 0.005 and 0.05 respectively have been used to evaluate different scenarios.

The values of respective sustainable yields are rough estimates. Every borehole should be monitored in shorter recurrences (e.g. on a monthly basis) in the first few years of scheme operation to verify the accuracy and/or reliability of the determined values. In the event that future monitoring reveals over or under-estimation of the values appropriate adjustments should be done accordingly. Against a backdrop of realistically variable parameters like effective well radii (especially in fracture aquifers), relatively conservative values of sustainable yields have been chosen.

In arriving at the final choice of sustainable yields for different boreholes, caution has been taken not to exceed constant test discharge rates. Well efficiencies decrease with increase in discharge rates, and it is possible to encounter massive drawdowns, which were hitherto unknown. In the event of dewatering of fracture or water ingress zones, sharp water level decline may result and reflect a less productive groundwater regime.

In the evaluation of constant discharge pumping tests, late data has been given higher credence, as this is more reliable for interpolation to determine future aquifer responses. Sight should not be lost of that fact that the key reason for long term pumping test is to determine probable occurrences of barrier or recharge boundaries that reflect different groundwater regimes which could be lost on short term tests and give rise to erroneous predictions. Basing evaluation of constant discharge pumping tests on mid-term data may yield erroneous well efficiencies as well as sustainable yields.

4.2.2 Efficiency & Sustainable Yield Status of the Boreholes

Well efficiency estimates from the step test as compared to a ratio of calculated to measured drawdown show significant disparity (70%, 20% and 18% respectively). The low efficiency values have been used to determine sustainable yields(this would give the most conservative estimate).

Efficiencies compare favourably and consequently show similar sustainable yields.

Table 11. 1 Summary of Step Pumping Test Results

Step	Parameter	Oyibi BH1	Old Saasabi BH1	Kpone Seduase BH1
1	Discharge (m^3/d)	216.0	158.4	172.8
	Drawdown (m)	19.3	3.6	7.5
	Well Losses (%)	24.08	47.35	42.86
2	Discharge (m^3/d)	259.2	201.6	216
	Drawdown (m)	24.3	5.4	10.4
	Well Losses (%)	27.57	53.37	48.39
3	Discharge (m^3/d)	288	259.2	316.8
	Drawdown (m)	27.8	8.10	18.6
	Well Losses (%)	29.72	59.54	57.89
4	Discharge (m^3/d)	316.8	316.8	
	Drawdown (m)	31.5	11.2	
	Well Losses (%)	31.75	64.27	
Estimated Transmissivity (m^2/d). Logan (1964)		18.0	18.0	49.2
Efficiency for constant discharges		0.70	0.70	

Table 11.2 Summary of Input Data for Sustainable Yield Calculations

Parameter Description	Oyibi	Old Saasabi	Kpone Seduase
Borehole ID	BH1	BH1	BH1
Depth(m)	71	45	54
Well Diameter (inch)	8.5	6.5	8.5
Discharge Rate(l/min)	200	220	180
SWL(m)	20.31	13.4	5.32
Duration of Pumping(min)	4320	2880	2880
Drawdown at end of test	29.83	29.79	15.26
Drawdown per log cycle	0.8186	0.4158	0.5241
Maximum pumping water level(m)	54	29.0	37
Transmissivity(m2 day)	64.39	139.42	90.5
Pumping setting(m)	60	33	44

Table 11.3 Summary of Sustainable Borehole Yield Estimates

Parameter	Oyibi BH 1		Old Saasabi BH 1		Kpone Seduase BH 1	
	m^3/h	m^3/d	m^3/h	M^3/d	m^3/h	M^3/d
Estimated Sustainable Yield at continuous 24 hours pumping per day	9.4	225.6	12.4	297.6	14.9	357.6
Estimated Sustainable Yield at intermittent 12 hours pumping per day	10.8	129.6	12.5	150.0	10.0	120.0
Constant discharge rate	12	288	13.2	316.8	10.8	230

4.3 WATER QUALITY ASSESSMENT

4.3.1 Results of Laboratory Analyses

This assessment of water quality results is based upon the new production boreholes at Oyibi, Old Saasabi and Kpone Seduase. All the physico-chemical results for all the water sample are presented in Annex 3.

(a) Physical parameters

The borehole sources showed pH values of 5.7-6.9. The Old Saasabi borehole source has a pH value which falls within the acceptable guideline range whereas the Oyibi and Kpone Seduase boreholes show a lower pH. The conductivity values were also 1850µS/cm for the Oyibi BH1, 1006µS/cm for the Old Saasabi BH1 and 609µS/cm for Kpone Seduase BH1.

The boreholes also showed low turbidity values well below the guideline value. The apparent colour, total suspended solids and total dissolved solids values were lower than the WHO (1993) recommended guideline values and therefore very acceptable.

(b) Chemical parameters

The chemical quality of the borehole source is generally acceptable for potable purposes. The chloride concentrations of the borehole sources are Oyibi BH1(240mg/l), Old Saasabi BH1(98.6mg/l) and Kpone Seduase(99.3mg/l): the chloride value for the Oyibi BH1 is close to the guideline limit of 250mg/l indicating a potential for increasing salinity with long-term pumping. On the other hand, the chloride level in the other boreholes is very promising.

© Nutrients

The nitrate levels of 9.8mg/l(Oyibi BH1), 0.02mg/l(Old Saasabi BH1) and 0.01(Kpone Seduase BH1) far below the WHO (1993) recommended guideline limit of 50 mg/l for drinking water.

(d) Trace metals

The iron and manganese levels in the boreholes was were well below the respective guideline values.

(e) Remarks

The physical and chemical quality of the borehole sources is generally acceptable for potable purposes. However the Oyibi borehole showed a potential for increasing salinity and may not be very suitable as a mechanized borehole to serve the supply area. The Old Saasabi and Kpone Seduase boreholes showed quality parameters that were very promising and can be considered for use as mechanized boreholes to serve the supply area.

(b) View on the Cost, Time and Energy used in Drawing Water

On cost. time and energy required to draw the available water. members took into consideration the expenses incurred to get potable water. number of hours spend in queues waiting for their turn. the long distance they have to travel to get water and the energy to be exerted in fetching. Below is the collation on their views.

Table 12.2: Views on Cost, Time and Energy used in Drawing Water

Sources Available	Oyibi		Old Saasabi		Adigon		Kpone Seduase		Malejor		Amrahia	
	No	Energy/Time Spent	No	Status	No	Status	No	Status	No	Status	No	Status
Pond Dugouts	3	Outside the Comm Carry water from long distances	2	Outside the Comm Carry water from long distances	-	-	1	Outside the Comm/ Carry water from relatively long distances	-	-	-	-
Dam	-	-	-	-	1	Outside the Comm Carry water from long distances		-	1	Outside the Comm/ Carry water from long distances	1	Outside the Comm Carry water from long distances
Tanker Service	-	-	-	-	-	-		-	1	Very expensive Wait sometimes for days for water	1	Very expensive Wait sometimes for days for water
Pipe	1	Located in houses (quarters) but now drive long distance to Dodowa to fetch water	-	-	-	-		-	-	-	-	-
Borehole	1	Within Community difficult to pump-energy intensive waste time in long queue	2	Within Community difficult to pump-energy intensive	2	All Not in use	2	Only one working- Within Community / difficult to pump-energy intensive/ waste time in long queue	-	-	-	-

4.3.3 Acceptability of Borehole Sources for Mechanization

(a) Community Stand Point

In the survey carried out on the acceptability of the community people on mechanization of borehole water into a pipe system to serve them, the people made the following decisions:

Based on the views presented above, all the WATSAN committees and about 98% of members selected in the three communities have perceived the borehole water as the most reliable and free from germs compared to the others currently available. They also indicated that since the borehole is the most reliable and purest source of water but requires a lot of energy to draw, they would be very grateful if the programme could go ahead and mechanize it. This they stressed would make the safe water easily accessible to the young and especially elderly in the communities who cannot go through the strenuous process of pumping.

However, 2% (mostly from Oyibi) of all those sampled complained about the salty nature of their borehole water and suggested that the water for the pipe system be drawn from another source or from the Volta Lake to enable them also enjoy the pleasant taste those in the cities enjoy.

(b) Water Quality Stand Point

From the stand point of water quality results the borehole source has been assessed to be suitable for potable use by the communities. All the major quality parameters showed values that were below the WHO guideline values except the chloride and conductivity values for the Oyibi BH1: the Oyibi borehole may be prone to salt water encroachment during long term pumping as part of a piped water supply scheme. The Kpone Seduase and Old Saasabi boreholes show very promising water quality results and can therefore be considered as the main sources for the proposed water supply scheme.

4.4 WATER NEED ASSESSMENTS: OYIBI -AMRAHIA AREA

Oyibi-Amrahia supply constitutes communities around two productive boreholes located at Kpone Seduase and Old Saasabi proposed for mechanisation. The assessments of the water need of the communities are based on per capita consumption of 20lpd and the existing water system facility in the communities. The communities within the acceptable radius of the two borehole sources forming the Oyibi-Amrahia water supply scheme is presented below;

- Old Saasabi
- Oyibi/Oyibi Estate
- Kpone Seduase
- Good News Seminary
- Valley View University
- Malejor
- Amrahia

The location of the communities is presented in figure 1 below.

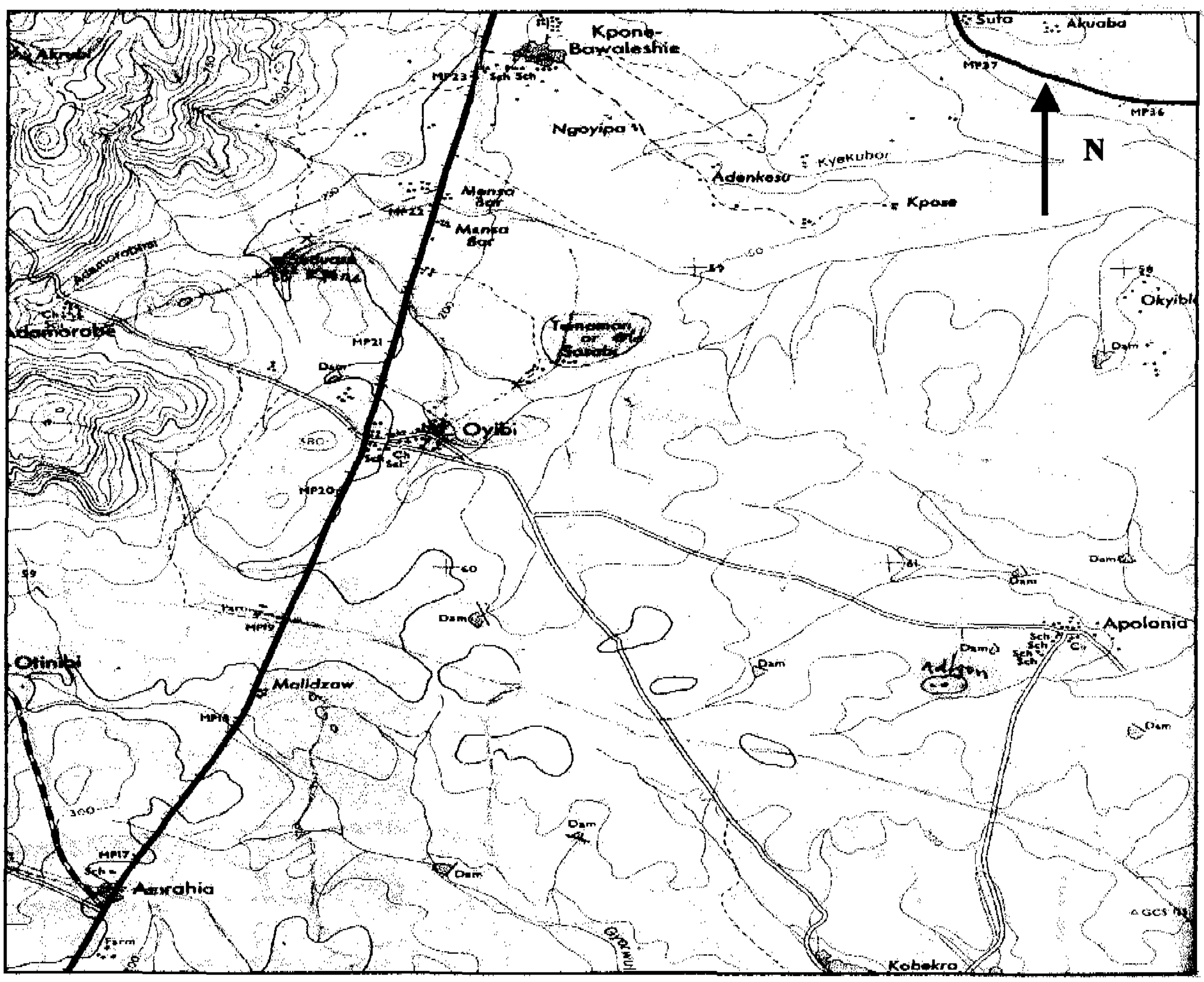


Figure 1: Location Map of Proposed Communities for Borehole Mechanisation

The selected communities for this study are all located in Tema district. Kpone Seduase community is 1.5 km from the main Accra Dodowa road. Oyibi, Good News Seminary, Valley View University, Malejor and Amrahia are all located about (0.5km) along the Accra-Dodowa road.

Adigon, which is the furthest (6.5km), is a settler and animal-rearing community with houses widely dispersed from each other and is relatively closer to Appolonia. The distance from Adigon to Appolonia is estimated to be 500m. Appolonia is connected to GWCL pipeline and therefore the possibility of connecting Adigon to Appolonia water distribution network will be more cost effective than the Oyibi-Amrahia proposed mechanisation provided the human factors and technical factors indicate success.

Mensah Bar and Kpone Bawleshie are connected to GWCL pipeline from Dodowa with adequate public standpipes located within the communities. Adombre is located in the Eastern Region and therefore does not form part of this scope.

4.4.1 Population Forecast.

The population estimation of the study area was carried out during the feasibility study stage. The breakdown of the projected 10-year forecast is presented as **Table 13.1**. The average growth rate of 2.8 % was adopted for the supply area.

This stem from the fact that the average inter-censal annual growth rates recorded over the periods for the communities in the region ranges from 1.1% to 11.5% (refer to Unihydro baseline studies, 1999 and Keseve Extension Water supply Design Report, 2003)

Over the same period the Greater Accra Region recorded an average annual growth rate of **4.4%.** The average annual growth rates of the supply area over the two census periods and that of the average Regional growth rate therefore vary significantly. This has been reported to be largely due to the very high growth rates recorded by the fishing communities and urban migration.

To provide a more realistic population forecast over the design period therefore, a most likely annual growth rate of **2.8%** estimated as the mean of the community's average annual growth rate over the period from 1970 to 2000 and that recorded for the Region, have been adopted for the supply area. The recorded population of each of the communities in year 2000 has therefore been projected.

The population forecasts have been carried out for 5year time horizons, ie for years 2002, 2007, and 2012 results is presented in **Table 13.1** below;

Table 13.1 Population Forecast for Oyibi –Amrahia Area

SUPPLY AREA	Community	Present Population 2002	Avg. Growth Rate	Regional Growth Rate %	Population Forecast		
					2002 P_0	2007 P_5	2012 P_{10}
Oyibi Area	Old Saasabi	463	2.8	4.4	463	532	610
	Oyibi/Estate	2400	2.8	4.4	2400	2755	3163
	Kpone Seduase	463	2.8	4.4	463	532	610
Amrahia Area	Good News Seminary	60	2.8	4.4	60	69	79
	Valley View University	960	2.8	4.4	960	1102	1265
	Malejor	150	2.8	4.4	150	172	198
	Amrahia	1130	2.8	4.4	1130	1297	1489
	TOTAL				**5,626**	**6459**	**7415**

4.4.2 Water Demand Computation

The water demand is calculated as,

Water Demand (Q) = $P_o(1+b)^n * q * (1+L_L)$ ....(1)

Where;

P_o = Present population

b = Population growth rate = 2.8%

n = design period = 10 years

q = a per capita water demand = 20lpd

L_L = Provision for physical losses (due to leakage) = 20%

Present Water Demand

For the present situation, $n = 0$

Present Water Demand $\mathbf{Q_p = P_o * q* (1+ L_L)}$..............................(2)

$Q_p = P_o * 20* (1+20\%)$.

$Q_p = P_o * 20* (1.2)$

$\mathbf{Q_p = 24\ P_o}$

Projected Water Demand

$Q_T = P_o (1+b)^n * q* (1+L_L)$.............................. **(3)**

$Q_T = P_o (1+0.028)^{10} * 20* (1+0.2)$.

$Q_T = P_o * (1.3) *20*1.2$

$Q_T = 31.63\ P_o \equiv$ say $\mathbf{(32\ P_o)}$

This describes CWSA criteria for design of water supply systems in small communities that is a community whose population is less than 5000 people. It also presents the basic service maximum distance of **500m** and one standpipe serving **600 people**.

4.4.3 Existing Facilities in Supply Area

The existing facilities in the supply area were recorded during the feasibility studies. The summary is presented as **Table 13.2** below.

Table 13.2 Existing Facilities:- Institutions and Water Sources

No	Description	Calculation	Old Saasabi	Oyibi and Estate	Kpone Seduase	Good News Seminary	Valley View Univ.	Malejor	Amrahia
1	No. of Institution in supply area	Schools	Nil	3 but on one compound	1	Nil	Nil	Nil	2 but on one compound
		Health Centre	Nil	Nil	Nil	Nil	Nil	Nil	Nil
2	Water Source	Boreholes	1 fitted with Hand Pump-(proposed for mechanisation)	1 bh but salty	1 HP broken down 1 proposed for mechanisation	Nil	Nil	1 BH turn salty	Nil
		Dam	Nil	Nil	Nil	Nil	Nil	Dam	Nil
		Ponds	Dries up/turbid	Dries up/ Turbid	Yes	Nil	Nil	Nil	Nil
		Pipe	Stopped flowing for 6 months	Nil	Nil	Tanker services	Tanker Services	Tanker Services	Tanker services

4.4.4 Computation of Water Demand

The computation of the water need of the beneficiary communities is based on the following service levels and criteria;

1. per capita (present population) consumption = 24 litres /person/day
2. per capita (Projected population) consumption = 32 litres /person/day
3. Maximum No. of users (present population) per borehole = 300
4. Maximum walking distance to a water point = 500m
5. Design life for the water supply (n) = 10 years
6. Population growth rate = 2.8%
7. Number of Water Users per standpipe = 600

The water need is calculated as follows;

1. Daily Present Water Demand (DPWD) , Q_p = 24 P_o
2. Daily Total Water Demand (DTWD) , Q_T = 32 P_o
3. **Daily Residual Water Demand (DRWD) , Q_R = (P_o - Ps) *32 lpd**

Where P_s is the population served by existing boreholes fitted with hand pumps

Disadvantages

- Boreholes fitted with hand pumps are expensive to construct and operate
- The India MK 2 pump can only be repaired by a hand pump mechanic who would have to be paid for his or her service.
- If the hand pump fails no water can be drawn from the borehole until it is repaired .
- Water from boreholes may contain minerals, which may give an unacceptable taste.

Maintenance requirement

Two caretakers preferably a male and a female for each borehole will have to be chosen from among the community to carry out the following routine inspection and Maintenance.

1. Make sure drainage is adequate with no stagnant water around the borehole.
2. To repair/plaster the cement apron or drain when cracks or other damages occurs.
3. Keep the surrounding area free of overgrown vegetation.
4. Check pumps regularly for wear or failure of pump parts, particular when the flow of water decreases or stops.
5. **Nira AF-85 pump**; Replace worn out parts and keep bolts tight.
   India MK 2 pump; Keep pump chain well greased and all nuts and bolts tight.
   Most of the repairs can only be carried out by hand pump mechanic.

To prevent misuse of the pump, particularly by children;
Keep record of repairs and report problems and breakdowns to the WATSAN Committee and collect user fees, (if the community decides to do this)

4.4.7.2 Subsidy Threshold for Boreholes Fitted with Hand Pumps

The subsidy Threshold is the lifetime cost of the borehole /handpump option of water supply which would be required to provide a basic service level in the community.

The purpose of the Subsidy Threshold calculation is to determine the amount of subsidy that a community can receive under the CWSA Rural Water Supply Programme. The Program guideline is as follows:

- The community shall contribute 5% of the approved project cost if it is not more than the calculated Subsidy Threshold.
- If the project cost is more than the Subsidy Threshold the community will pay 5% of the cost equivalent to the subsidy threshold and 50% of the excess cost above the Subsidy Threshold.

4.4.7.3 Cost Estimation for Boreholes installed with Handpump Option

The estimate for the cost of borehole construction is presented as Table 13.5 below;

Table 13.5 Cost Estimation for Boreholes

Assumptions	
Basic Service Level	1 Borehole fitted with Hand Pump for 300 Users
O&M Cost Estimate	10 Years Projection
Average Borehole Depth	45 Meters
Success Rate	67 Percent (%)
Unsuccessful Rate	33 Percent (%)
Construction Cost for Successful Borehole	$100.00
Construction Cost for Unsuccessful Borehole	$75.00
CONSTRUCTION COST OF A NEW BOREHOLE	**AMOUNT ($)**
Construction of 45m Depth (45*100)	4,500.00
Construction of a Platform including Material Transport	950.00
Installation of Ghana Modified India Mark 2 Pump	2,500.00
Allowance for abandoned Borehole (45*75*0.33/0.67)	1,665.00
Maintenance for 10 years @ $160.00/year	1,600.00
TOTAL (THRESHOLD per BOREHOLE)	**11,215.00**

- **Above assumptions are based on regional average depth of Boreholes and success rates.**
- **However districts specific conditions could be taken into consideration.**

Table 13.6 Subsidy Threshold Calculation

Cost Item	**Calculation**	**Value**
Present Population	P_p	5626
Ten years design population	P_{10}	7415
Max. Users per Hand pump	300	300
No. of Hand pumps to be provided	$((P_{10}) / 300)) = \frac{7415}{300}$	24.7 (25)
Additional HP for Institutions	A	3
Existing Borehole with Hand pump	E	3
Total Hand pump to be provided	$(P_{10}) / 300 + (A-E)$	**25**
Standard cost of new Borehole with Hand pump	C	$11,215
Standard cost of rehabilitation of Borehole	D	$3,000
Subsidy Threshold	({[(P10 / 300) + (A-E)] x C)} + [D x E]	**$289,375** **¢2,488,625,000**

US $ = ¢ 8600 (May. 2003)

The estimated subsidy threshold based on sufficient water points (boreholes with hand pumps) for the supply area is **US$289,375**

In order to meet the 10-year projected demand supply deficit of **84%** it would be necessary to construct additional **25 boreholes** installed with hand pumps. It will be difficult to obtain sufficient sites for the drilling of all these boreholes. In addition, due to the concentration of boreholes the risk of pollution from latrines and toilets will increase greatly.

<u>Costs of Boreholes with Handpump</u>

1. **Capital Cost**

Construction Cost of 25 Boreholes with Hand pumps at $ 11,215 = **$ 280,375**

2. **Annual Maintenance Cost** for 25 Boreholes with Handpump at $160 = $ 4,000

4.4.7.4 Financing of Project- Boreholes fitted with Hand pumps

The cost of construction of the water supply shall be subsidized to 95% by Programme funding, while the beneficiary communities will pay 5%. The cost sharing is as follows:

Community Contribution(5%)	**$14,019**
Project Subsidy (95%)	$ 266,356
TOTAL CAPITAL COST($)	**$280,375**

The community contribution was analyzed on pro-rata according to the beneficiary population The results is presented in Table 13.7 below.

Table 13.7: Sharing of Community Contribution towards Boreholes with Handpump construction

Community	**Present Population (P_o)**	**COMMUNITY CONTRIBUTION**	
		US$	**GH(¢)**
OLD SASAABI	463	1,154	9,921,767
OYIBI	2,400	5,980	51,430,323
KPONE SEDUASE	463	1,154	9,921,767
GOOD NEWS SEMINARY	60	150	1,285,758
VALLEY VIEW	960	2,392	20,572,129
MALEJOR	150	374	3,214,395
AMRAHIA	1,130	2,816	24,215,111
Total	**5,741**	**14,019**	**120,561,250**

The project subsidy will not be provided unless the community has paid their 5% contribution before tendering and draw up a Facility Management Plan showing how they will organise and pay this maintenance. The project would like to discuss this plan with the community before constructions start.

4.4.8.1 Technology Option B: Piped System based on Mechanized Boreholes

The second option for the proposed water supply scheme is a piped scheme with standpipes based on mechanized boreholes. This option is considered most feasible for water supply to the Oyibi-Amrahia area. The supply scheme option consists of a transmission network fed by the two mechanized boreholes, service reservoirs serving the various communities and distribution networks in the various communities terminating at public standpipes.

Considering the physical setting of the project area and after preliminary study the fill and draw supply mode using dedicated transmission mains was found to have significant technical and cost advantages over the use of a floating supply mode. The design of the scheme was therefore based on the fill and draw mode with dedicated transmission mains.

4.4.8.2 Hydraulic Analysis.

Details of hydraulic analysis carried out to establish the feasibility of the design is presented as **(Annex 2).**

The analysis was carried out with the aid of the Micro Computer Programs for improved Planning and Design of water Supply Systems with the main objectives of determining the:

- Appropriate pipe sizes of transmission and distribution mains to carry the estimated flows.
- Required hydraulic characteristics of the borehole submersible pumps
- Adequacy of the available head at the selected tank site to provide good residual heads at the service points in the communities.
- The available head at the selected tapping points and its adequacy for feeding the tanks.

The analysis was carried out with the;

- Estimated Water demand for Year 2012.
- The peak daily water demand = 1.5x Average water demand
- Maximum hourly draw-off condition in the network (Peak Factor of 2.4-4.8)
- Minimum water level in the tank.

The following parameters were adopted:

1.	System	=	Pumped System
2.	Estimated Avg. demand	=	as per each community in the supply area
3.	Min. water level in tank	=	10m above ground level
4.	Ground levels at facility sites	=	As per elevation at the site(m)
5.	Peak factors	=	2.4 -4.8
6.	Hazen Williams C for uPVC. pipes	=	130

4.4.8.3 Service Reservoir

Estimation of service storage required for effective operation of the system was carried out with the following objectives:

(a) Ensuring equalization of pressures in the distribution network.

(b) Stabilization of heads on the pumps.

(c) Providing emergency reserve against interruptions.

(d) Compensating for fluctuations in water consumption during the day.

The size and pattern of variation of water consumption during the day and the duration of pumping are the key parameters required for the estimation of the capacity of the tank.

Service reservoirs sized according to the population of the communities and mode of distribution will be the supply of water to the local standpipes by gravity. These reservoirs are sized to provide half- day storage (50% of daily demand) in accordance with CWSA criteria. Standard reservoir sizes are selected. The reservoirs are sited above and as close as possible to the community and to be operated on the basis of "fill and draw". The volumes of reservoir proposed for the various communities are presented in Table 13.9 below;

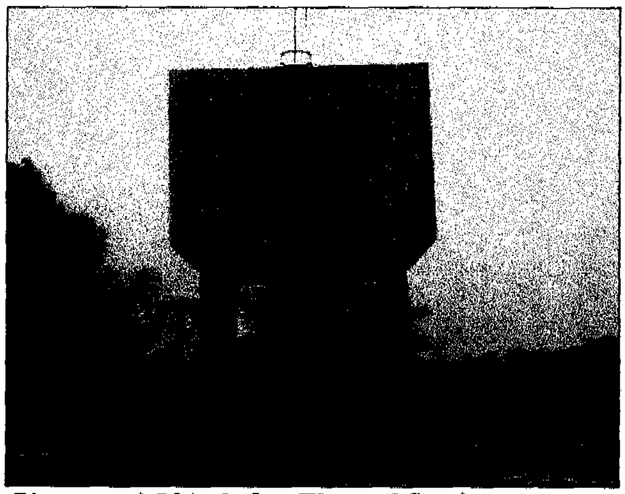
Storage in the form of polytanks on concrete supports is proposed for capacities up to 10m3 and reinforced concrete tanks for capacities above 10m3.

Table 13.9 Computation of Service Reservoir

No.	Description	Calculation	Old Saasabi	Oyibi/ Estate	Kpone Seduase	Good News Seminary	Valley View Univ	Malejor	Amrahia
P_o	Present population, P_o)		463	2400	463	60	960	150	1130
N_b	No of existing Bh. Fitted with handpumps,N_b		1	Nil	1	Nil	Nil	Nil	Nil
P_s	Population served by existing borehole (P_s)	N_b* 300	300 But BH will be used for mech.	0	300	0	0	0	0
P_D	Design population	(P_o - Ps)	463	2400	163	60	960	150	1130
V_D	Design Volume of Reservoir (m3)	$\frac{(P_D * 32 * 0.5)}{1000}$	7.41	38.4	2.60	0.96	15.36	2.4	18.08
	(Standard Design)		10	40	5	5	25	5	25
V_{Rec}	Recommended Volume of Reservoir (m3)		10	40	5	5	25	5	25

From the results, Old Saasabi, Kpone Seduase, Good News University, and Malejor requires a polytanks on concrete support whiles that of Oyibi/Estate, Valley View University and Amrahia storage will be in the form of reinforced concrete tanks.

A model of an elevated service reservoir is presented as picture 1 below



Picture 1: A Model of an Elevated Service Reservoir

4.4.8.4 Standpipes

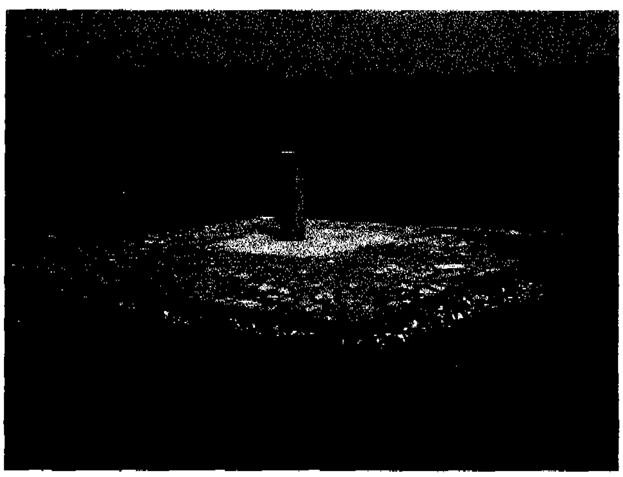
The number of public standpipes to be provided is calculated using the 10-year population so as to provide one standpipe for every **600 people** with additional standpipe for each school or clinic. The number of standpipes required is computed as follows:

$$\textbf{Number of standpipes} = \frac{(P_{10} - Ps)}{600}$$

Table 13.10 Computation of Standpipes

No.	Description	Calculation	Old Saasabi	Oyibi	Kpone Seduase	Good News Seminary	Valley View Univ	Malejor	Amrahia
P_O	Present population, (P_o)		463	2400	463	60	960	150	1130
P_{10}	Prejected population, (P_{10})	P_{10}	610	3163	10	91	1453	227	1710
N_s	No of persons served by a standpipe		600	600	600	600	600	600	600
N_b	No of existing Bh. Fitted with handpumps (N_b)		1	Nil	1	Nil	Nil	Nil	Nil
P_s	Population served by existing borehole (P_s)	N_b* 300	300 But BH will be used for mechanisation	0	300	0	0	0	0
SP_N	No. of Standpipes required (Round up)	$\frac{(P_{10} - Ps)}{600}$	1.06 2	5.3 6	0.51 1	0.1 1	2.42 3	0.38 1	2.85 3
SP_E	Extra standpipes for Institutions (Clinic, Schools etc)		Nil		1	Nil	Nil	Nil	1
SP_T	**Total No. of Standpipes**	20	2	7	2	1	3	1	4

A total of 20 public standpipes are recommended for Oyibi –Amrahia supply area. Since Oyibi estate is developing, it is recommended that provision for household connection is considered. The connections cost should be borne by the inhabitants and the pipelines metered with KENT meters. A model of proposed standpipe is presented as picture 2 below



Picture 2: A model of a public standpipe

The summary of the preliminary design parameters is presented in Table 13.11 below

Table 13.11: Summary of Preliminary Design Parameters

Supply Area	Community	Present Population	10 Year Demand (m^3/day)	Service Reservoir (m^3)	Standard Reservoir Size (m^3)	No. of Standpipes
OYIBI Area	**Old Saasabi**	463	14.8	7.41	10	2
	Oyibi	2400	76.8	38.4	40	7
	Oyibi Estate					
	Kpone Seduase	463	5.2	2.60	5	2
Amrahia Area	Good News Seminary	60	1.9	0.96	5	1
	Valley View University	960	30.7	15.36	25	3
	Malejor	150	4.8	2.4	5	1
	Amrahia	1130	36.16	18.08	25	4
TOTAL		**5626**	**170.4**			**20**

Due to non-availability of good sources of water, supply to the 7 communities has been planned as one big scheme. The proposed water supply will be based on borehole sources located at Old Saasabi and Kpone Seduase. The estimated number of standpipes is 20, which are made up of 17 standpipes for the communities and 3 standpipes for the various institutions.

Pipe routes and reservoir location should be carried out with the collaboration from Assemblymen/woman, Youth, Watsan and Opinion leaders in the community. The reservoir and standpipe locations are to be confirmed before tendering to avoid any land dispute.

4.5 CONCEPTUAL DESIGN

4.5.1 Piped System based on Mechanised Boreholes

Considering the population of the project area and their water demand, electrical pumped water supply is found to be the most feasible option for the community.

Due to non-availability of good sources of water, supply to the 7 proposed communities has to be planned as one big scheme. The layout of the water supply scheme is presented as **Figure 2**

The proposed water supply scheme involves the use of two submersible pumps to lift the water from the two productive borehole sources located at Old Saasabi and Kpone Seduase to feed seven (7) proposed elevated service reservoirs located at Kpone Seduase, Old Saasabi, Oyibi, Good News Seminary, Valley View University, Malejor and Amrahia supply areas.

The distribution to the communities will be by gravity system terminating at standpipes located in close proximity to the users within the community.

4.5.2 Cost Estimate for Pipe Scheme

A provisional cost analysis of the scheme was carried out. The three main areas considered were;

- Provisional Capital Investment Cost
- Operation and Maintenance cost
- The water Tariff as per bucket of 18 litres water.

4.5.2.1 Provisional Capital Investment Cost

The provisional Capital Investment Cost of the scheme is estimated on the major items of the scheme; ie pump installations, standpipes, delivery and distribution pipelines and service reservoirs. The estimate however includes excavation, backfill, testing and fitting.

Table 14.1 Cost Estimate for Pipe Scheme

No.	Description	Unit	Quantity	Rate (USD)	Amount (USD)
1	GENERAL ITEM (10% of Civil Works)	No			**3,130.64**
2	DRILLING OF ADDITIONAL BOREHOLE	No.		-	-
3	**PUMP INSTALLATION**				
3.1	Supply and Installation of submersible				
3.2	Pump and accessories (3000+0.5*Q*H)	No.	1	10,712	10,711.50
3.3	Pump and accessories (3000+0.5*Q*H)	No.	1	7,200	7,200.00
3.4	Pump House	No.	2	2,000	4,000.00
3.5	Electricity Connection	Km	3	7,000	17,500.00
	Sub Total				**39,411.50**
4	**PIPELINES (DELIVERY)**				
4.1	Pipeline uPVC ≥ 75 mm Diameter	m	13,630	10	136,300.00
4.2	Pipeline uPVC ≤ 75 mm Diameter	m	500	8	4,000.00
4.3	Valve Fittings and Chamber	No	11	500	5,500.00
4.4	Pipework extras 5% of pipework (4.1+4.2))		707	8	5,652.00
	Sub Total				**151,452.00**
	Old Saasabi				
5	PIPELINES (DISTRIBUTION)				
5.1	Pipeline uPVC ≤ 75 mm Diameter	m	600	8	4,800.00
5.2	Valve Fittings and Chamber	No.	2	500	1,000.00
5.3	Pipework extras 5% of pipework (5.1)	m	30	8	240.00
5.4	High Level Tank (10m3)	m3	1	5,200	5,200.00
5.5	Standpipes	No	2	800	1,600.00
	Sub Total				**12,840.00**

No.	Description	Unit	Quantity	Rate (USD)	Amount (USD)
	Oyibi				
6	PIPELINES (DISTRIBUTION)				
6.1	Pipeline uPVC ≤ 75 mm Diameter	m	1,200	8	9,600.00
6.2	Valve Fittings and Chamber	No	8	500	4,000.00
6.3	Pipework extras 5% of pipework (6.1)	m	60	8	480.00
6.4	High Level Tank (40m3)	m3	1	11,100	11,100.00
6.5	Standpipes	No	7	800	5,600.00
	Sub Total				**30,780.00**
	Kpone Seduase				
7	PIPELINES (DISTRIBUTION)				
7.1	Pipeline uPVC ≤ 75 mm Diameter	m	600	8	4,800.00
7.2	Valve Fittings and Chamber	No	3	500	1,500.00
7.3	ipework extras 5% of pipework (7.1)	m	30	8	240.00
7.4	High Level Tank (5m3)	m3	1	5,200	5,200.00
7.5	Standpipes	No	2	800	1,600.00
	Sub Total				**13,340.00**
	Good News Seminary				
8	PIPELINES (DISTRIBUTION)				
8.1	Pipeline uPVC ≤ 75 mm Diameter	m	500	8	4,000.00
8.2	Valve Fittings and Chamber	No	2	500	1,000.00
8.3	Pipework extras 5% of pipework (8.1)	m	25	8	200.00
8.4	High Level Tank (5m3)	m3	1	5,200	5,200.00
8.5	Standpipes	No	1	800	800.00
	Sub Total				**11,200.00**

TABLE 14.2 CALCULATION OF ELECTRICITY TARIFF FOR 2 PUMPS

Item	Description	Unit	Quantity	Total units
1	Pumping hours a day	Hr	12	
2	Pump motor rated power	KW	6	
3	No. of Days per month	Day	30	
4	Units of electricity consumed		12*6*30	2,160
	Monthly Tariff charges	**Charge**	**Unit(KWH)**	**Amount(¢)**
5	First 300 units	800	300	240,000
6	Other additional units	980	1,860	1,822,800
7	Service Charge	1	5,000	5,000
	Sub Total			**2,067,800**
8	VAT	%	12.5	258,475
9	Gov't Levy and Street light	2,160	2.2	**4,752**
	TOTOL MONTHLY ELECTRICITY CHARGE			**2,331,027**
	Total Monthly Electricity Charge (2 PUMPS)			**4,662,054**
	Annual cost in GH Cedis(¢)			**55,944,648**
	Annual cost in USD Rate(1$= ¢8600)			**6,505**
	Monthly cost in USD Rate(1$= ¢8600)			**542.10**

The monthly electricity tariff is estimated as $542.10 (¢4,662,054)

4.5.3 Annual Operation and Maintenance Cost

To provide an assessment of the feasibility of the design, the estimated annual operation and maintenance costs of the facilities in the proposed scheme are presented as **Table 14.3** below.

The operation and maintenance at this stage is anticipated to cover the entire project area. The recovery of cost of O&M and management will be derived from water sales. The analysis of O&M is presented below;

Table 14.4 Cost Recovery Estimation

Description	Value	Amount ($)
Present water demand (m3/ day)	170.4	
O& M Cost of present demand 170.4m3 per day	(Monthly O&M in USD) { 30 days}	52.29
O & M cost of 1 m3 (55.55 No. size of 34 bucket)	{O&M cost per day} {present demand}	0.31
O& M Cost of 1 size 34 Bucket	(O&M cost of 1 m3) (55.55 No 34 bucket)	**0.0055**
(Current rate, 1$= ¢8600), May 2003	Equivalent in Ghanaian cedis	**¢48**

The Public utility and Regulatory Commission (PURC) tariff released on March 5th, 2003 cost a bucket of water from public standpipe as ¢64.

It may be recommended that the cost of one size ~~34-bucket~~ of 18 litres be fixed between ¢ 64 to ¢ 200 to cover the full operation and maintenance cost of the system. The prevailing cost of water in some of the communities is between ¢ 200.00 and ¢ 1,000.00. This decision is however the responsibility of the WATSAN Board and the people of the communities.

4.5.5 Financing of Project- Boreholes Mechanization

The cost of construction of the water supply shall be subsidized to 95% by Programme funding, while the beneficiary communities will pay 5%. The cost sharing is presented as Table 12 below:

Table 14.5: Provisional Investment Cost Sharing

Project Funding	Amount ($)	Amount (GH¢)
Community Contribution	15,653.18	134,617,305.00
Programme funding (95%)	297,410.33	2,557,728,795.00
TOTAL	**313,063.50**	**2,692,346,100.00**

Exchange rate 1$= ¢8600 May, 2003

The community contribution is shared among the present population based on a pro-rata. The sharing presented in **Table 14.6 below**.

The community contribution is to be paid before tendering commences

Table 14.6: Sharing of Community Contribution

Community	Present Population(Po)	Pro-rata	Comm. Contribution ($)	Comm. Contribution (GH ¢)
Old Saasabi	**463**	0.0823	1,288.20	11,078,530.43
Oyibi	**2400**	0.4266	6,677.50	57,426,507.64
Kpone Seduase	**463**	0.0823	1,288.20	11,078,530.43
Good News Seminary	**60**	0.0107	166.94	1,435,662.69
Valley View University	**960**	0.1706	2,671.00	22,970,603.06
Malejor	**150**	0.0267	417.34	3,589,156.73
Amrahia	**1130**	0.2009	3,143.99	27,038,314.02
Total	**5626**	**1.0000**	**15,653.18**	**134,617,305.00**

The construction cost of the scheme per head is calculated as follows;

Present population	5,626
Provisional Capital Investment Cost	**$313,063.50**
Per capita cost	$55.65

The cost per head is high considering CWSA guideline for per capita cost ($40). This is due to the long transmission network and the mechanization of 2 boreholes. This estimate may come down when the real quantities for the detailed design have been carried out.

4.5.6 The Summary of Cost of Technology Options

The cost of the proposed technology option for the supply of water requirement of Oyibi – Amrahia area is presented as Table 14.6 below;

4.5.7 MANAGEMENT OPTIONS

After facilitating the establishment of WSDBs we will proceed to organise management-training programmes for the members. Prior to the training programme, we will have to advice them on the type of management system to institute. The training will be dependent on the type of management system chosen.

4.5.7.1 The Possible Management Options

According to the existing institutional framework of Ghana, (Mainly the Local Government Act No. 462 (1993) and the more recent "Draft Small Towns Water and Sanitation Policy" territorial communities (DAs) own the assets. A Water and Sanitation Development Board (WSDB) can be created within each territorial community. The DA may delegate to the WSDB (among other bodies) the responsibility to provide water and sanitation services in a small town.

Different management models for the water service can be set up. Each WSDB, with the support of CWSA and DAs, if necessary must decide on the management model that seems best suited for the condition of the territorial community.

The three main options are:

- Community Management
- Delegation to a Private Entity
- Contractual Management (Relationship)

4.5.7.2 Community Management

In the community management model, the beneficiary community and the users are wholly responsible for managing the service, and can outsource certain tasks to private service providers with the exception of financial and commercial management.

The WSDB decides to implement a team consisting of users responsible for the operation and day-to-day management of the small-scale network. This structure is called the WATSAN. In this case, the WSDB assumes all the responsibilities, makes all the decisions, sets the price of the water and establishes the specifications and job profiles for the WATSAN. Note that in practice the relations between the various members are rarely specified in a written document.

The members of a WATSAN ensure the financial management and operation functions of the small-scale networks. The options within the WATSAN must be defined by the WSDB (secretary, accountant, village repairman, etc) and a job profile must be established on the basis of the role entrusted to them. The committee members are indemnified with salaries that are either fixed or proportional to the takings.

4.5.7.3 Delegation to a Private Entity

Recent Studies (for instance: PPIAF CWSA study on private sector participation in Small towns water supply, September, 2001) have outlined the interest of increasing private sector participation (PSP) in the management of water and sanitation services in small towns to ensure a good level of sustainability in the next year and also to raise more funds to invest in the improvement of services.

Hence the related issues for the project implementation are:

- To analyze the perception of the private management option by local actors (representatives in the District Assemblies, members of the WSDB, existing WATSAN teams, community leaders, etc.), because delegation must be a voluntary process;
- To help the local authorities and the WSDB to choose the best option and to define precisely which functions will be delegated to a private entity; in other words the objective is, when the principle of delegation is accepted, to propose the "aim's length";
- To identify the strengths and weakness of the institutional framework to increase the PSP for the management of water and sanitation services in small towns; and to prose in total agreement with CWSA, slight adaptations if necessary;
- To assist local authorities interested in the delegation option to identify potential operators, to choose the way of selecting them and to give any assistance (on legal, financial and technical issues) during the contract negotiation between the selected bidder and the WSDB;
- Capacity building of the WSDB to give them adapted tools to supervise the quality of services provided by the management operator and ensure the financial follow-up of the delegated contract in order to protect the interest of the final users;
- To elaborate specific proposal to address the pro-poor issue: innovative solutions will be proposed to WSDB in order to improve the access of the poorest to the water services (stand posts with low tariff, subsidised house connections, etc.).

4.5.7.4 Problems to be tackled in the Case of Community Management System.

Players should bear in mind the problems encountered in the operation of networks based on a community management system. In effect, although the analysis of the operating conditions of these small rural networks have sometimes given very promising results, it has more frequently highlighted a number of factors hindering efficient and durable management of the facilities, including in particular:

- Insufficient professional and rigorous financial and technical management.
- Confusion of the user's representation and service monitoring functions with the operating functions; the same bodies (WATSANs) or individuals often find themselves to be both the judges and the parties involved.
- The dilution of responsibilities and the low level of individual acceptance of responsibility by the members of existing committees.

In certain cases this has led to:

- The appropriation of the facilities by few people, under conditions with poor transparency that do not guarantee the long-term durability of the service.
- Poor coverage of costs and collection of debts.
- Misappropriation of funds, either directly (cash flow) or indirectly (over charging certain expenses);
- The postponing of decisions to incur expenses for maintenance or equipment renewal, or the making of non-appropriated investments.

Another factor that can penalize the management of the facilities is the isolation and weaknesses of the bank network. The bank network in places situated far from the large urban is particularly weak and it is difficult to protect the funds. In such cases the facility managers are obliged to make long and costly trips, whether to deposit funds or to get fuel or spare parts.

4.5.7.5 Advantages and Disadvantages of Private Management System

Given that the private management system is new, it is difficult to evaluate its advantages and disadvantages in the long term.

However, what is already coming to the fore in villages where this management system is implemented is the need to give good quality capacity building to the various players involved in management, that is to say the WSDB and the operator.

We also can take profit of other successful African experiences and of the lessons recently learnt in other countries, for example Mauritania (more than 200 schemes in small towns operating under a lease contract by a private operator) or Uganda (which is experimenting management contracts for a dozen of communities since 2001).

Another essential consideration is to ensure that all the players fully understand the specifications, and to negotiate amendments where necessary.

The animator will therefore stress the importance of having a vigorous structure with such a management system. They will explain the various advantages of this management system to the members of the WSDB.

4.5.7.6 Contractual Management

Under this management system the community (represented by WATSAN) and the District Assembly contracts the services of a private orgasnisation or an individual and then monitor the operations. This implies collaboration between a community management and that of a private entity. Below are the implications of a contractual relationship.

4.5.7.6.1 The Advantages Concerning the contractual Relations

The system complies with the framework authorized by the different texts concerning the water sector, the territorial communities and regulations of associations, and fits into the dynamic currents aiming at promoting centralization and rendering basic services to the communities.

More specifically, it establishes the role of the DWST /DA as the guarantor of the good management of the service. As it is not involved in the day-to-day management of the service, it can take the necessary step back and concentrate on supervision and questions of arbitration (and have the legitimacy to do so with respect to the two other proximity players).

In addition, it allows some of the advantages of community management to be kept, especially the participation of the users in the monitoring of the service, without involving them in "operational" functions for which they have difficulty in mobilizing the skills internally.
Moreover, being a professional in whose interest lies the good functioning of the small town

network, the operator will be encouraged to adapt the level of services to the solvent demand of the users. Lastly, this system aims at using the responsiveness to the demand of the users/customers specific to the private sector (especially when it is competitive) and the fact that it is in the operator's interest to ensure the long-term durability of his working resources.

4.5.7.7 Advantages Concerning the Sharing of Responsibilities.

- The specifications set the conditions for delegating management to a private sector, and define precisely the task and responsibilities of each party involved so as to limit the risk of conflicts.

- The specifications must be established and negotiated in detail for each District. They must be supplemented, amended, modified by the WSDB and RWST /DA so that they meet their interest and ensue smooth functioning of the service, while at the same time respecting satisfying the interest of the operator.

- The contract provides for extension and cancellation of clauses, and conditions for revising and negotiating the duties. In effect, in a context where with new facilities a few unknown still remain, particularly concerning solvent demand, it is preferable to have the possibility of reviewing the amounts of the duties or the sale price per cubic meter after a few months, in the interest of everyone involved.

- The proposed financial arrangement must maximize protection of the funds. As rules can always be skirted, it is recommended rather to emphasize the interest each party has in fulfilling its tasks correctly and to limit disputes, by instituting check procedures among other things.

- As concerns the operational aspect, by giving responsibility to a manager, the risk of misappropriations are limited as since the operator has virtually no interest in dodging this.

4.5.7.8 Advantages Concerning the Financial Management and Protection of the Funds

Regarding Finance, it is proposed that there be a renewal and extensions funds deposited on an account opened by the WSDB, from which money can only be withdrawn with the double signature of the manager.

The setting up of three separate parts in the price of water service will enable financial flow to be controlled. These may include;

I. A part for the functioning of the WSDB,
II. A part for the renewal and extensions fund.
III. A part for Auditing by an independent body.

4.5.7.9 Management Training

Based on the results of the analysis of the identified institutions (CWSA, DWST and the District Environmental Health Officers) and the recommendations in the pre-feasibility study on institutional development and capacity building, trainers should be contracted who intend must consult CWSA on the various activities to be undertaken.

The trainer(s) specifically should facilitate and coordinate with CWSA:

- The procurement of needed equipment for strengthening the institutions,
- Arrange for training course (relevant for institutional development) in identified institutions. Some of the training courses could be conducted at the following institutions: Institute of Local Government Studies; Ghana Institute of Management and Public Administration; Management Development and Productivity Institute; School of Hygiene (Accra), and MDPI (Accra).

  Placement of personnel in a particular training programme in a training institution would be based on the identified training needs and the capacity of the training institution to meet the demand.

4.5.8 Recommendation on Management Options

Three different categories have been identified as possible management options for the piped water system being constructed for the people in the Tema and Ga district of the greater Accra region. Based on the background information available and the community's' choice which were based on prior information on the advantages and disadvantages of each option, we recommend the following option for each community.

Name of Community	Community Choice of Management option	Recommended Option based on Background Information	Comments
Kpone Seduase	Community Management	Community Management (Bulk Supply to Community)	The WATSAN is very organized and currently manage & sell water from the borehole
Oyibi main Community	Has not made any choice due to indecision	Contractual Management (Private Person + Watsan Board +District Assembly)	The WATSAN committee Is inactive & community difficult when it come to organisation and fund raising. Have no experience in community sale of water.
Oyibi Estates	Has not made any choice due to indecision	Contractual Management (Private Person + Watsan Board +District Assembly)	No WATSAN-Already use to billing from private manager (GWCL)
Old Saasabi	Community Management	Community Management(Bulk Supply to Community)	WATSAN active and Capable, although does not currently sell water: well organized
Maledjor	Community Management	Community Management (Bulk Supply to Community)	Organised: currently WATSAN manages & sell tanker water
Amrahia	No choice due to indecision	Contractual Management (Private Person + Watsan Board +District Assembly)	No WATSAN-community very difficult to organise. Currently people sell tanker water privately
Good News College	Institutional Management	Bulk supply to Institution	The institution: will be responsible for repairs
Valley View Univ.	Institutional Management	Bulk supply to Institution	The institution: will be responsible for repairs

Gross Revenue generated should be shared in the proportion 70:20:10 to the following entities;

- 70% to Private Person for Operation and Maintenance
- 20% to Water Boards for administration expenses
- 10% to District Assembly for Major repairs and expansion

5 FINDINGS AND RECOMMENDATIONS

From the feasibility studies carried out and the analysis of all data collected the following findings were made:

5.1 Socio-economic Feasibility

The 5 communities and 2 institutions forming the proposed supply area have a combined population of **5,626.** The highest population centre is Oyibi with a total population of 2000.

Based on the household survey, the average age in the area ranges between 33 and 38 years. The male to female population ratio is approximately 49:51 in all the communities.

The main occupations in the project area are farming and petty trading.

The median monthly household income for the communities ranges from ¢420,000 to ¢519,000 whilst expenditure levels ranges from ¢330,000 to ¢385,000. The main items of expenditure are food and school fees.

5.2 Technical Feasibility

The main source of potable in the area is the two new production boreholes (Kpone Sedause BH1 and Old Saasabi BH1) constructed as part of the Danida funded programme. The boreholes have been temporarily equipped with hand pumps and are being used by the communities.

The Oyibi BH1 has relatively high conductivity and chloride level, and may be prone to salt water encroachment when subjected to long term pumping as in a water supply.

The Kpone Seduase and Old Saasabi boreholes have been identified as the most promising water sources for the proposed rural piped water scheme in the area.

The actual water supply coverage in the supply area is about 16%, leaving a large deficit of 84%. The total water demand (daily average) in the area is estimated as 170.4m^3 /day. The peak daily demand is also estimated to be 255.6m^3 /day and this can be safely supplied from the Kpone Seduase and Old Saasabi boreholes which have a combined safe yield of 270m^3 /day for a 12 hour pumping schedule.

The estimated subsidy threshold based on sufficient water points (boreholes with hand pumps) for the supply area is US$289,375.

A feasible piped water scheme can be constructed at a total capital cost of US$313,063.50; this cost is only a provisional estimate and may be reduced after detailed design.

The system would comprise 2 mechanized boreholes feeding water to 7 service reservoirs and 20 public standpipes.

Annual operation and maintenance cost were estimated to be US21,673.67.

The per capita cost of the scheme would be US$55.65; the high per capita cost can be attributable to the long delivery pipe length from Kpone Seduase to Amrahia.

5.3 Recommendations

The socio-economic survey and water needs assessment confirm that there is a good potential for developing a piped water supplies for the Oyibi-Amrahia supply area.

However, the proposed production boreholes are adequate to serve 5 communities and 2 institutions based on the safe yield analysis.

It is therefore recommended that a new piped water supply system be constructed for the supply area. The proposed piped system involve the mechanization of two production boreholes located at Old Saasabi and Kpone Seduase to supply water to the beneficiary communities by "fill and draw" basis terminating at public standpipes and in residential area, house connection area to be metered

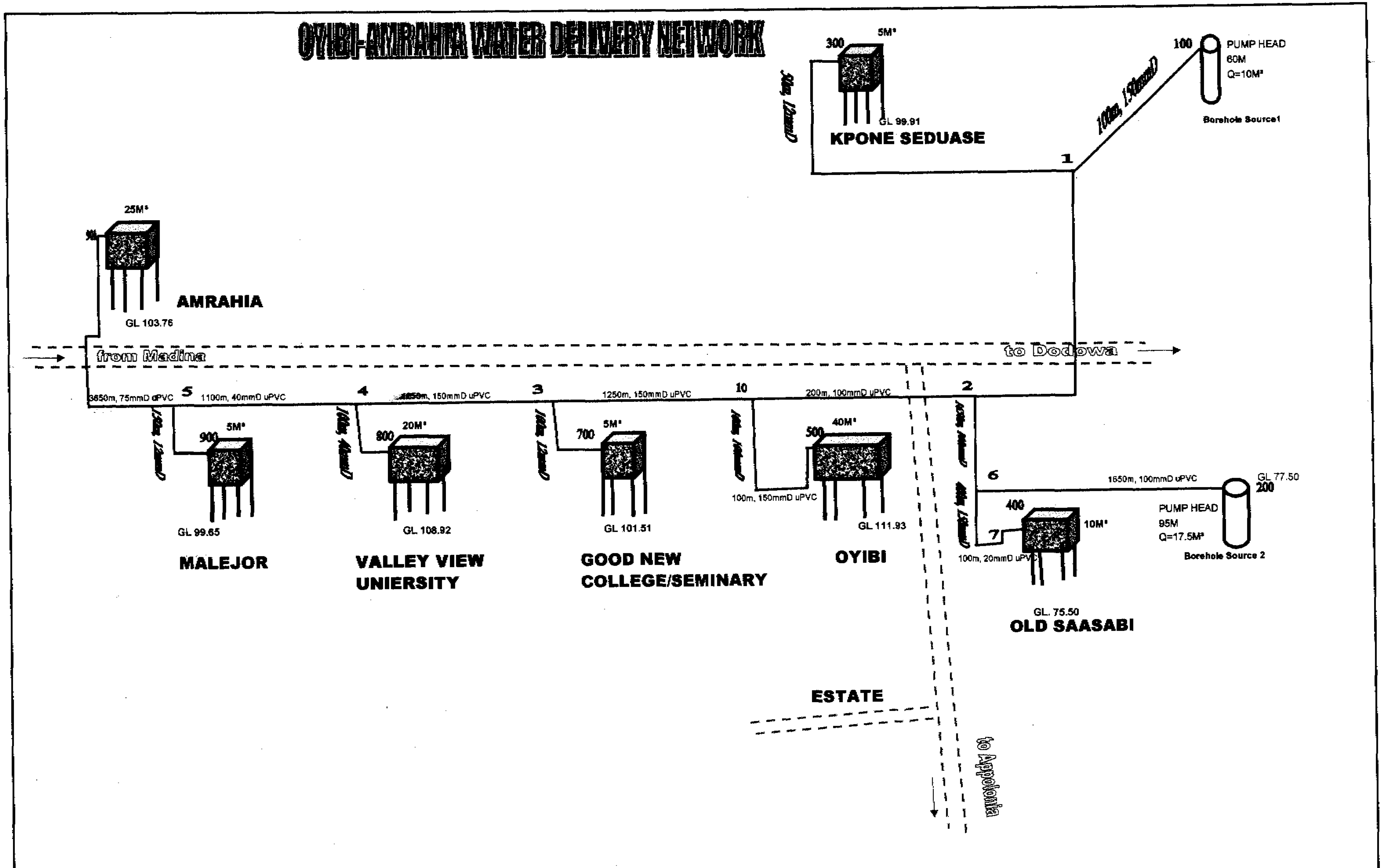
In order to address the prevailing water and sanitation issues outlined by the feasibility study, the following further recommendations are made:

- Extension work to mobilise the 5 communities and the two institutions shall be carried out in line with the guideline of CWSA, Rural water Programme. All necessary milestones would be followed to achieve the project goal.
- A team, made up of the DWST, Watsan Committees from the beneficiary communities, the Consultant and the GAR/CWSA Water Supply Engineer, should hold negotiations with the Chiefs and Elders of the beneficiary community to obtain a parcel of land for the pump house and reservoir sites.

- Design of the Facility Management Plan (FMP) would consider different management scenarios including WATSAN Committee cum WATSAN Board Management, a mixed management team of WATSAN Committee and Private Company, and lastly a wholly Private Company management with the WATSAN Board serving as an overall supervisory and regulatory board.
- The project subsidy will not be provided unless the community is able to draw up Facility Management Plan (FMP) showing how they will be able to organize and pay for this maintenance. The project will like to discuss this plan with the community before construction starts.
- Residents of the beneficiary community should be encouraged to construct household toilet units and provide suitable facilities or sites for garbage disposal.
- Institutional KVIPs are needed to solve the sanitation needs of existing educational institutions in the project area.

- It is recommended that the cost of one size of 34 bucket of water (18 litres) be fixed between ¢80 to ¢200 to cover the full operation and maintenance cost of the system. This decision is however the responsibility of the WASAN Board and the people of the community.

LIST OF FIGURE



OYIBI-AMRAHIA WATER DELIVERY NETWORK
300
5M³
GL 99.91
KPONE SEDUASE
100
PUMP HEAD
60M
Q=10M³
Borehole Source1
1
25M³
AMRAHIA
GL 103.76
from Madina
to Dodowa
5
1100m, 40mmD uPVC
4
150mmD uPVC
3
1250m, 150mmD uPVC
10
200m, 100mmD uPVC
2
900
5M³
GL 99.65
MALEJOR
800
20M³
GL 108.92
VALLEY VIEW
UNIERSITY
700
5M³
GL 101.51
GOOD NEW
COLLEGE/SEMINARY
100m, 150mmD uPVC
500
40M³
GL 111.93
OYIBI
6
1650m, 100mmD uPVC
GL 77.50
200
PUMP HEAD
95M
Q=17.5M³
Borehole Source 2
400
7
10M³
GL. 75.50
OLD SAASABI
ESTATE
to Appolonia

FIG. 2

KPONE SEDUASE

No.	Age	Sex	No. p/hs	Occupation	Income			Expenditure				Suplus	Willingness to Pay for Water			
					Main wk	Ext Acti	Total	Food	Educatn	Others	Total		No. of bkt	amt/bket	Amt/ mth	%of income
1	29	M	3	Carpenter/Farming	800,000	200,000	1,000,000	200,000	440,000	0	640,000	360,000	10	100	30000	3
2	22	F	3	Petty Trading	200,000	49,000	249,000	180,000	45,000	0	225,000	24,000	7	100	21000	8.43373494
3	25	F	2	Hair Dresser	40,000	150,000	190,000	150,000	0	0	150,000	40,000	3	100	9000	4.73684211
4	41	M	6	Farming/Trading	700,000	2,800,000	3,500,000	840,000	500,000	0	1,340,000	2,160,000	10	200	60000	1.71428571
5	32	M	4	Carpentary/Farming	50,000	84,000	134,000	40,000	50,000	0	90,000	44,000	4	100	12000	8.95522388
6	55	M	7	Driving/Farming	1,500,000	500,000	2,000,000	200,000	400,000	350,000	950,000	1,050,000	10	500	150000	7.5
7	42	F	6	Petty Trading/Farmi	300,000	0	300,000	140,000	60,000	0	200,000	100,000	12	100	36000	12
8	28	M	4	Farming	1,000,000	0	1,000,000	280,000	200,000	0	480,000	520,000	10	200	60000	6
9	40	F	3	Farming/Trading	640,000	50,000	690,000	250,000	300,000	20,000	570,000	120,000	6	200	36000	5.2173913
10	46	F	3	Trading	140,000	105,000	245,000	115,000	80,000	0	195,000	50,000	5	100	15000	6.12244898
11	24	F	4	Trading	650,000	40,000	690,000	580,000	60,000	0	640,000	50,000	8	100	24000	3.47826087
12	28	M	3	Farming/Mechanic	40,000	168,000	208,000	120,000	20,000	0	140,000	68,000	6	100	18000	8.65384615
13	39	M	6	Farming	188,000	400,000	588,000	380,000	70,000	0	450,000	138,000	10	200	60000	10.2040816
14	43	M	5	Trading	410,000	40,000	450,000	210,000	50,000	0	260,000	190,000	8	100	24000	5.33333333
Total	**494**		**59**				**11,244,000**				**6,330,000**	**4,914,000**	**109**	**2,200**	**555,000**	**91**
Average	**35.3**		**4.2**				**803142.86**				**452142.9**	**351000.0**	**7.8**	**157.1**	**39642.9**	**6.5**
Median	**35.5**		**4**				**519,000**				**355,000**	**110,000**	**8**	**100**	**27,000**	**6.1**

OLD SAASABI

No.	Age	Sex	No. p/hs	Occupation	Income			Expenditure				Suplus	Willingness to Pay for Water			
					Main wk	Ext Acti	Total	Food	Educatn	Others	Total		No. of bkt	amt/bket	Amt/ mth	%of income
1	35	M	3	Farming	300,000	0	300,000	200,000	30,000	0	230,000	70,000	5	100	15000	5
2	32	F	6	Farming/Trading	60,000	350,000	410,000	120,000	140,000	0	260,000	150,000	10	100	30000	7.31707317
3	33	F	5	Trading/Farming	40,000	160,000	200,000	160,000	10,000	0	170,000	30,000	4	100	12000	6
4	40	M	4	Farming/Charcoal B	800,000	500,000	1,300,000	150,000	210,000	0	360,000	940,000	5	200	30000	2.30769231
5	52	F	6	Farming/Trading	1,200,000	120,000	1,320,000	120,000	480,000	0	600,000	720,000	10	200	60000	4.54545455
6	40	F	6	Trading/Charcoal B	180,000	240,000	420,000	150,000	150,000	30,000	330,000	90,000	10	100	30000	7.14285714
7	30	F	5	Farming	160,000	310,000	470,000	90,000	160,000	40,000	290,000	180,000	8	200	48000	10.212766
8	28	M	3	Farming	120,000	50,000	170,000	100,000	10,000	0	110,000	60,000	4	100	12000	7.05882353
9	39	M	5	Farming/Trading	500,000	260,000	760,000	400,000	220,000	20,000	640,000	120,000	7	200	42000	5.52631579
10	25	F	5	Trading	450,000	20,000	470,000	110,000	305,000	0	415,000	55,000	6	100	18000	3.82978723
11	32	M	4	Trading/Charcoal B	200,000	40,000	240,000	80,000	105,000	0	185,000	55,000	6	100	18000	7.5
12	29	F	2	Farming/Trading	260,000	80,000	340,000	285,000	50,000	0	335,000	5,000	6	100	18000	5.29411765
13	30	M	5	Farming	160,000	150,000	310,000	140,000	94,000	0	234,000	76,000	7	100	21000	6.77419355
14	40	F	4	Trading	850,000	175,000	1,025,000	360,000	480,000	0	840,000	185,000	8	100	24000	2.34146341
15	44	F	5	Farming/Trading	605,000	47,000	652,000	400,000	150,000	0	550,000	102,000	10	200	60000	9.20245399
Total	529		68				**8,387,000**				**5,549,000**	**2,838,000**	**106**	**2,000**	**438,000**	**90**
Average	35.3		4.5				**559133.3**				**369933.3**	**189200.0**	**7.1**	**133.3**	**29200.0**	**6.0**
Median	33		5				**420,000**				**330,000**	**90,000**	**7**	**100**	**24,000**	**6**

OYIBI

No.	Age	Sex	No. p/hs	Occupation	Income			Expenditure				Suplus	Willingness to Pay for Water			
					Main wk	Ext Acti	Total	Food	Educatn	Others	Total		No. of bkt	amt/bket	Amt/ mth	%of Income
1	33	M	5	Farming/Masonery	1,600,000	1,400,000	3,000,000	900,000	30,000	110,000	1,040,000	1,960,000	3	200	18000	0.6
2	42	M	1	Carpenter/Assemmn	150,000	100,000	250,000	150,000	50,000	0	200,000	50,000	2	300	18000	7.2
3	32	M	5	Farmer	450,000	0	450,000	200,000	150,000	0	350,000	100,000	5	200	30000	6.66666667
4	25	M	5	Masonery	1,600,000	0	1,600,000	420,000	160,000	0	580,000	1,020,000	6	100	18000	1.125
5	69	F	2	Petty Trading	120,000	60,000	180,000	80,000	50,000	0	130,000	50,000	5	100	15000	8.33333333
6	35	F	4	Trading/Dress Makg	100,000	20,000	120,000	60,000	40,000	0	100,000	20,000	5	100	15000	12.5
7	33	F	6	Trading/Caretaker(B	180,000	50,000	230,000	90,000	90,000	0	180,000	50,000	5	100	15000	6.52173913
8	32	F	3	Petty Trading	150,000	160,000	310,000	50,000	120,000	0	170,000	140,000	10	100	30000	9.67741935
9	49	M	8	B Contractor/Tradin	6,500,000	250,000	6,750,000	5,000,000	600,000	800,000	6,400,000	350,000	12	200	72000	1.06666667
10	49	F	3	Farming/Dress Mak	200,000	120,000	320,000	100,000	160,000	0	260,000	60,000	4	100	12000	3.75
11	55	M	5	Business/Farming	600,000	800,000	1,400,000	420,000	325,000	0	745,000	655,000	12	100	36000	2.57142857
12	24	F	2	Trading	700,000	200,000	900,000	400,000	120,000	40,000	560,000	340,000	8	100	24000	2.66666667
13	37	M	6	Businessman	900,000	500,000	1,400,000	500,000	300,000	350,000	1,150,000	250,000	10	200	60000	4.28571429
14	23	F	4	Dressmaker	100,000	250,000	350,000	180,000	90,000	10,000	280,000	70,000	6	100	18000	5.14285714
15	50	M	6	Farming	500,000	50,000	550,000	300,000	120,000	80,000	500,000	50,000	12	100	36000	6.54545455
16	45	M	4	Farming/Mechanics	500,000	120,000	620,000	350,000	80,000	90,000	520,000	100,000	8	200	48000	7.74193548
17	29	F	6	Trading	520,000	120,000	640,000	340,000	120,000	100,000	560,000	80,000	10	100	30000	4.6875
18	33	M	4	Masonery	1,200,000	100,000	1,300,000	800,000	150,000	50,000	1,000,000	300,000	8	200	48000	3.69230769
19	51	M	3	Farming	160,000	100,000	260,000	100,000	80,000	0	180,000	80,000	6	100	18000	6.92307692
20	45	F	4	Petty Trading	800,000	105,000	905,000	550,000	150,000	120,000	820,000	85,000	7	200	42000	4.64088398
21	22	F	3	Petty Trading	200,000	49,000	249,000	180,000	45,000	0	225,000	24,000	7	100	21000	8.43373494
22	25	F	2	Hair Dresser	40,000	150,000	190,000	150,000	0	0	150,000	40,000	3	100	9000	4.73684211
23	41	M	6	Farming/Trading	700,000	600,000	1,300,000	550,000	500,000	0	1,050,000	250,000	10	200	60000	4.61538462
24	32	M	4	Carpentary/Farming	50,000	84,000	134,000	40,000	50,000	0	90,000	44,000	4	100	12000	8.95522388
25	55	M	7	Driving/Farming	1,500,000	500,000	2,000,000	200,000	400,000	350,000	950,000	1,050,000	10	500	150000	7.5
26	42	F	6	Petty Trading/Farmi	300,000	0	300,000	140,000	60,000	0	200,000	100,000	12	100	36000	12
27	28	F	3	Trading	550,000	100,000	650,000	210,000	100,000	50,000	360,000	290,000	6	200	36000	5.53846154
28	32	M	5	Petty Trading/Farmi	480,000	120,000	600,000	200,000	150,000	110,000	460,000	140,000	6	100	18000	3
29	40	M	4	Foreman/Farming	670,000	100,000	770,000	450,000	150,000	80,000	680,000	90,000	8	100	24000	3.11688312
30	36	F	5	Petty Trading	200,000	160,000	360,000	150,000	100,000	0	250,000	110,000	10	100	30000	8.33333333
31	41	F	7	Building Tecnician	1,500,000	0	1,500,000	600,000	440,000	110,000	1,150,000	350,000	14	200	84000	5.6
32	38	M	5	Farming/Masonery	850,000	50,000	900,000	550,000	200,000	0	750,000	150,000	8	100	24000	2.66666667
33	39	M	6	Businessman	2,000,000	250,000	2,250,000	850,000	700,000	480,000	2,030,000	220,000	12	200	72000	3.2
34	43	F	4	Secretary	450,000	120,000	570,000	300,000	120,000	0	420,000	150,000	6	100	18000	3.15789474
35	45	F	2	Trading	150,000	120,000	270,000	120,000	100,000	0	220,000	50,000	4	100	12000	4.44444444
36	30	M	3	Farmer	320,000	60,000	380,000	200,000	160,000	0	360,000	20,000	5	100	15000	3.94736842
37	29	F	4	Farming/Masonery	850,000	0	850,000	380,000	120,000	150,000	650,000	200,000	7	100	21000	2.47058824
38	47	M	8	Land Consultant	1,700,000	0	1,700,000	700,000	420,000	200,000	1,320,000	380,000	12	200	72000	4.23529412
39	34	M	2	Tailoring	90,000	100,000	190,000	100,000	50,000	0	150,000	40,000	4	100	12000	6.31578947
40	30	F	7	Teaching	630,000	250,000	880,000	380,000	190,000	110,000	680,000	200,000	12	100	36000	4.09090909
41	27	M	3	Land Cons/Farming	1,200,000	150,000	1,350,000	700,000	330,000	150,000	1,180,000	170,000	6	100	18000	1.33333333
42	52	F	7	Farming/Dress Mak	200,000	100,000	300,000	110,000	50,000	0	160,000	140,000	12	100	36000	12
43	38	M	4	Farming/Trading	200,000	150,000	350,000	160,000	100,000	50,000	310,000	40,000	6	100	18000	5.14285714

44	44	M	4	Business/Farming	350,000	50,000	400,000	290,000	80,000	0	370,000	30,000	5	100	15000	3.75
45	40	F	5	Masonery	800,000	180,000	980,000	420,000	280,000	90,000	790,000	190,000	8	100	24000	2.44897959
46	25	M	4	Land Consultant	1,500,000	0	1,500,000	420,000	240,000	120,000	780,000	720,000	8	200	48000	3.2
47	22	F	3	Trading/Farming	750,000	350,000	1,100,000	800,000	150,000	50,000	1,000,000	100,000	8	200	48000	4.36363636
48	50	F	4	Farming	200,000	100,000	300,000	100,000	80,000	0	180,000	120,000	6	100	18000	6
49	41	M	5	Building Foreman	890,000	150,000	1,040,000	550,000	150,000	120,000	820,000	220,000	7	200	42000	4.03846154
50	26	F	4	Petty Trading	310,000	250,000	560,000	180,000	45,000	0	225,000	335,000	7	100	21000	3.75
51	49	M	6	Teaching	710,000	140,000	850,000	150,000	0	0	150,000	700,000	3	100	9000	1.05882353
52	29	F	4	Farming/Trading	210,000	400,000	610,000	380,000	210,000	0	590,000	20,000	10	200	60000	9.83606557
53	33	F	5	Petty Trading	450,000	150,000	600,000	40,000	50,000	0	90,000	510,000	4	100	12000	2
54	39	M	5	Driving/Farming	150,000	500,000	650,000	200,000	270,000	100,000	570,000	80,000	10	500	150000	23.0769231
55	43	M	5	Petty Trading/Farmi	180,000	400,000	580,000	140,000	60,000	0	200,000	380,000	12	100	36000	6.20689655
56	26	F	4	Farming/Trading	450,000	50,000	500,000	280,000	200,000	0	480,000	20,000	10	200	60000	12
57	35	M	5	Building Contractor	1,800,000	450,000	2,250,000	60,000	40,000	0	100,000	2,150,000	5	100	15000	0.66666667
58	41	F	6	Trading/Hair Dresse	200,000	50,000	250,000	90,000	90,000	0	180,000	70,000	5	100	15000	6
59	37	M	4	Farming/Masonery	150,000	800,000	950,000	50,000	120,000	0	170,000	780,000	10	100	30000	3.15789474
60	42	F	6	Foreman/Farming	970,000	100,000	1,070,000	500,000	400,000	120,000	1,020,000	50,000	12	200	72000	6.72897196
61	52	M	6	Farming/Masonery	1,500,000	0	1,500,000	600,000	420,000	120,000	1,140,000	360,000	20	50	30000	2
62	49	M	6	Clerk	800,000	0	800,000	200,000	450,000	0	650,000	150,000	16	200	96000	12
63	32	F	4	Secretary	720,000	300,000	1,020,000	410,000	350,000	100,000	860,000	160,000	10	100	30000	2.94117647
64	29	F	5	Trading	250,000	1,200,000	1,450,000	650,000	400,000	210,000	1,260,000	190,000	10	200	60000	4.13793103
65	40	M	3	Administrator	1,200,000	500,000	1,700,000	600,000	250,000	170,000	1,020,000	680,000	20	200	120000	7.05882353
66	35	F	5	Clerk	900,000	550,000	1,450,000	700,000	400,000	250,000	1,350,000	100,000	12	200	72000	4.96551724
67	41	M	6	Businessman	2,000,000	0	2,000,000	1,000,000	500,000	300,000	1,800,000	200,000	20	200	120000	6
68	39	F	4	Administrator	750,000	600,000	1,350,000	700,000	350,000	150,000	1,200,000	150,000	12	200	72000	5.33333333
69	27	M	3	Engineer	1,700,000	0	1,700,000	500,000	450,000	400,000	1,350,000	350,000	14	100	42000	2.47058824
70	38	F	4	Teaching	1,020,000	200,000	1,220,000	550,000	300,000	200,000	1,050,000	170,000	10	100	30000	2.45901639
71	54	F	3	Trading	200,000	800,000	1,000,000	650,000	150,000	100,000	900,000	100,000	12	100	36000	3.6
72	42	M	4	Teaching	980,000	200,000	1,180,000	450,000	300,000	280,000	1,030,000	150,000	10	200	60000	5.08474576
Total	2737		325				70,138,000				50,845,000	19,293,000	624	10,650	2,980,000	388
Average	38.01		4.51				974,139				706,181	267,958	9	148	40,000	5
Median	38		4				825,000				565,000	150,000	8	100	30,000	4.5

ADIGON

No.	Age	Sex	No.	Occupation	Income			Expenditure				Suplus	Willingness to Pay for Water			
			p/hs		Main wk	Ext Acti	Total	Food	Educatn	Others	Total		No. of bkt	amt/bket	Amt/ mth	%of income
1	40	M	1	Farming	500,000	20,000	520,000	300,000	0	150,000	450,000	70,000	8	200	48000	9.23076923
2	52	M	4	Farming/Painting	250,000	200,000	450,000	300,000	100,000	0	400,000	50,000	3	200	18000	4
3	43	M	5	Farming/Mechanics	800,000	100,000	900,000	600,000	150,000	80,000	830,000	70,000	6	200	36000	4
4	24	F	4	Teaching/Farming	60,000	75,000	135,000	50,000	20,000	0	70,000	65,000	6	100	18000	13.3333333
5	38	F	6	Farming	440,000	240,000	680,000	280,000	225,000	70,000	575,000	105,000	10	200	60000	8.82352941
6	39	M	5	Farming	240,000	220,000	460,000	300,000	100,000	0	400,000	60,000	3	200	18000	3.91304348
7	24	F	2	Trading	250,000	50,000	300,000	150,000	0	100,000	250,000	50,000	5	100	15000	5
8	52	F	5	Trading/Farming	120,000	100,000	220,000	110,000	50,000	10,000	170,000	50,000	5	100	15000	6.81818182
9	43	M	4	Farming/Masonery	400,000	50,000	450,000	200,000	120,000	50,000	370,000	80,000	5	200	30000	6.66666667
10	24	F	5	Trading/Farming	80,000	100,000	180,000	50,000	20,000	0	70,000	110,000	8	100	24000	13.3333333
Total	379		41				**4,295,000**				**3,585,000**	**710,000**	**59**	**1,600**	**282,000**	**75**
Average	37.9		4.1				**429500**				**358500**	**71000**	**5.9**	**160**	**28200**	**7.5**
Median	39.5		4.5				**450,000**				**385,000**	**67,500**	**5.5**	**200**	**21,000**	**6.7**

QUESTIONAIRRE FOR SOCIO-ECONOMIC STUDIES ON TEMA / GA DISTRICT COMMUNITIES

Section A: Demographic Characteristics of Respondents

1. Age: ....

2. Sex: Male (1) Female (2)

3. Marital Status: Married (1) Separated (2) Divorced (3) Widowed (4)

4. Number of children being Fostered: ....

5. Level of Education: No education(1) Primary(2) Middle/TSS(3)Sec/Tech/Voc(4) TT/Nursing (5) Poly/Univ(6) Other-specify(7)..............................

6. Current main Occupation: ....

7. Any other supplementary activity?: ....

Section B: Income and Expenditure

8. How much money do you get from your occupation per month? ¢ ....

9. About how much do you get as remittances from children/spouse/relatives¢ ....

10. How much do you get from other sources?.......................................

11. About how much do you spend in a month on food? ¢..

12. How much do you spend on other expenses in a month other than food? ¢....................

13. Do you own any facility that brings you income like cornmill, car etc: Yes ☐ No ☐

14. About how much do you get from this source in a month?
¢..................................

Section C: Capacity and Willingness to Pay for Water

15. Are you satisfied with current water conditions? Why?:........................

16. How many bucket of water do you need per day? ....

17. How much can you afford to pay per a bucket of water?

18. Will you pay the amount you have indicated?

19. Why will you pay some money for the water you fetch?

20. How will you get the money to pay?

21. What benefits would you derive from this scheme?

Section D: Assessment of Perception and Acceptability of Borehole Water for Mechanization.

21. What are your present sources of water?..

22. Do you have a borehole in your community? Yes No

23. Do you like the borehole water Yes No

24. Give reasins for your answer above:..

....

....

25. Would you agree for the borehole water to be mechanized into a pipe system? Yes No

26 Provide reasond for your answer in 25 above:..

....

....

ANNEX 2

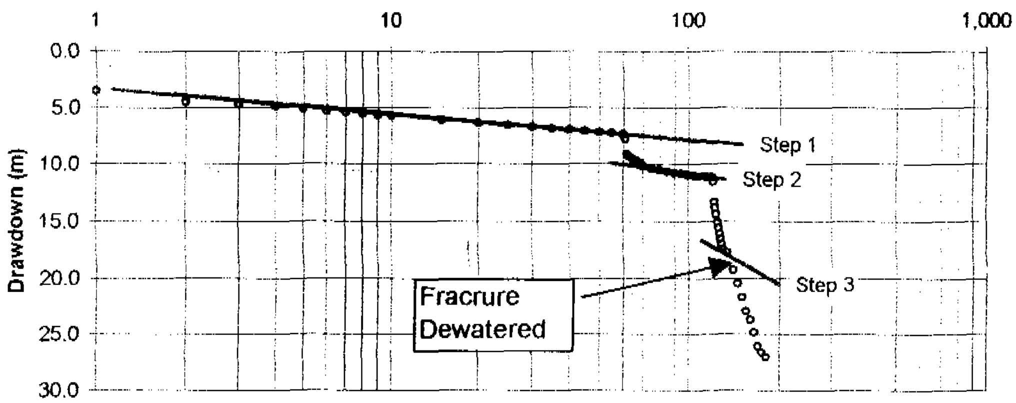
Kpone Seduase 062/H/06/BH-1

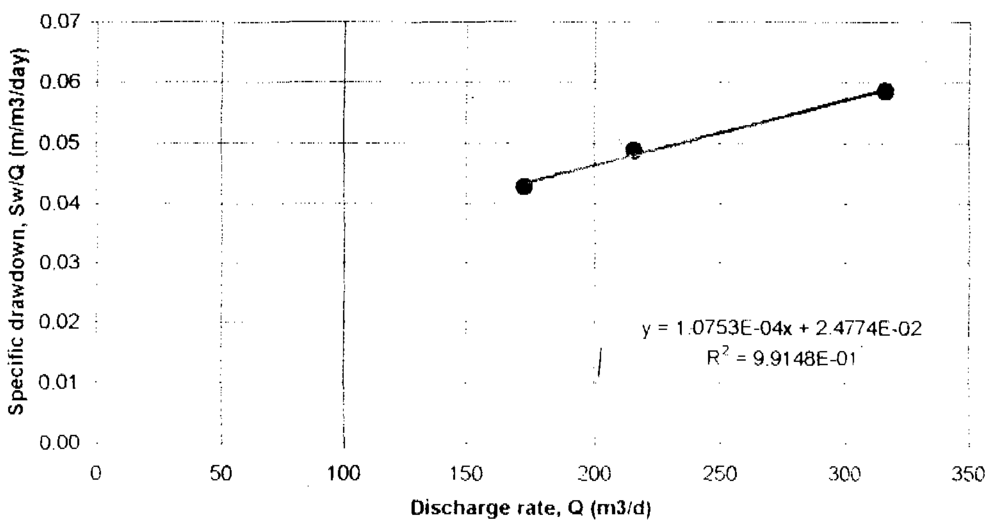
Project : RWST
District : Ga
Community : Kpone Seduase
Name of Well : 062/H/06/BH-1
Borehole Depth : 54 m
Pump Setting : 44 m
Measured by : VENT-3 Ltd
Interpreted by : ENDD

Length of Each Step : 60 min
Number of Steps : 3
Reference point : Top of PVC
Height above ground : 0.8m m
Depth to Static Water Level : 5.32 m
Pump on : 07/09/2002 11:40 AM
Pump off : 07/09/2002 11:40 AM

Bierschenk Wilson Step Test Analysis						
Step	Discharge	Measured Sw	Sw/Q	Calc. Sw	Well Loss (m)*	Well Loss (%)*
Step 1	172.8 m3/d	7.4 m	0.0428	7.5	3.21	42.86%
Step 2	216.0 m3/d	10.5 m	0.0488	10.4	5.02	48.39%
Step 3	316.8 m3/d	**18.6 m**	**0.0586**	18.6	**10.79**	**57.89%**
Step 4						
Well Drawdown Equation at 60 min pumping : sw = 0.0247743162817277Q + 0.000107528234765085Q(2)						
Estimated Transmissivity (Logan 1964) : 49.2 m2/d						

** Note that well losses includes turbulent flow losses within the aquifer*





D:\EDWIN\UniHydro pumping test\unihydro pumpingtest 2\[STEP TEST KPONE SEDUASE.xls]Plot

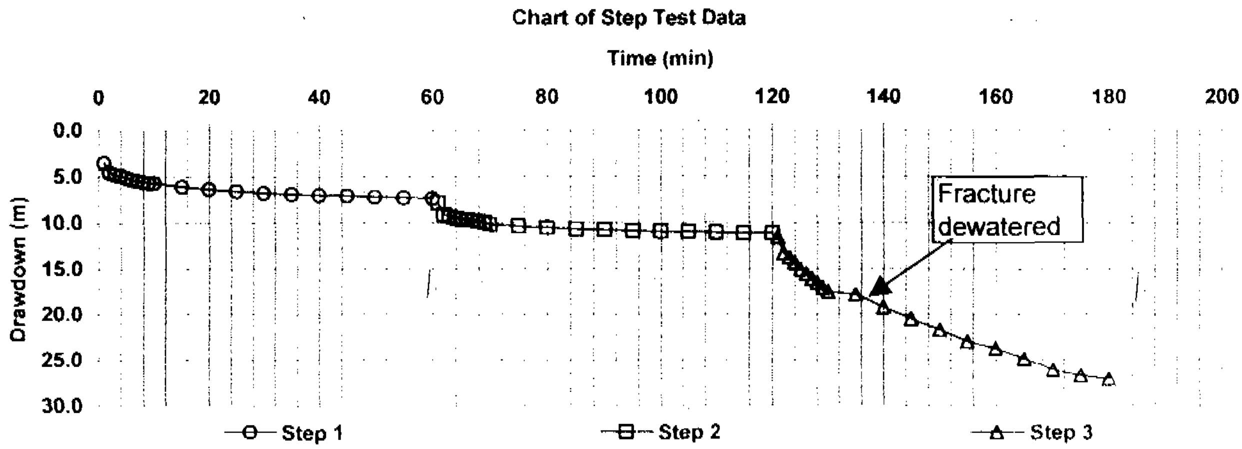
Kpone Seduase 062/H/06/BH-1

Project : RWST
District : Ga
Community : Kpone Seduase
Name of Well : 062/H/06/BH-1
Borehole Depth : 54 m
Pump Setting : 44 m
Measured by : VENT-3 Ltd
Interpreted by : ENDD

Length of Each Step : 60 min
Number of Steps : 3
Reference point : Top of PVC
Height above ground : 0.8m
Depth to Static Water Level : 5.32 m
Pump on : 07/09/2002 11:40 AM
Pump off : 07/09/2002 11:40 AM

D:\EDWIN\UniHydro pumping test\unihydro pumpingtest-2\[STEP TEST KPONE SEDUASE.xls]Plot

Step 1			Step 2			Step 3			Step 4			Recovery		
Q : 172.8 m3/d			Q : 216.0 m3/d			Q : 316.8 m3/d			Q : 316.8 m3/d					
Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Recovery (m)
1	8.86	3.54	61	13.15	7.83	121	16.89	11.57	181			241		
2	9.91	4.59	62	14.43	9.11	122	18.64	13.32	182			242		
3	10.13	4.81	63	14.64	9.32	123	19.14	13.82	183			243		
4	10.20	4.88	64	14.80	9.48	124	19.72	14.40	184			244		
5	10.47	5.15	65	14.91	9.59	125	20.41	15.09	185			245		
6	10.65	5.33	66	14.99	9.67	126	20.93	15.61	186			246		
7	10.78	5.46	67	15.08	9.76	127	21.47	16.15	187			247		
8	10.90	5.58	68	15.18	9.86	128	21.89	16.57	188			248		
9	10.99	5.67	69	15.23	9.91	129	22.37	17.05	189			249		
10	11.07	5.75	70	15.53	10.21	130	22.79	17.47	190			250		
15	11.45	6.13	75	15.74	10.42	135	23.10	17.78	195			255		
20	11.71	6.39	80	15.88	10.56	140	24.62	19.30	200			260		
25	11.92	6.60	85	16.03	10.71	145	25.80	20.48	205			265		
30	12.11	6.79	90	16.12	10.80	150	27.03	21.71	210			270		
35	12.22	6.90	95	16.22	10.90	155	28.27	22.95	215			275		
40	12.34	7.02	100	16.29	10.97	160	29.08	23.76	220			280		
45	12.44	7.12	105	16.36	11.04	165	30.20	24.88	225			285		
50	12.52	7.20	110	16.43	11.11	170	31.41	26.09	230			290		
55	12.61	7.29	115	16.48	11.16	175	31.98	26.66	235			295		
60	12.68	7.36	120	16.50	11.18	180	32.37	27.05	240			300		
75												315		
90												330		
105												345		
120												360		
135												375		
150												390		
165												405		
180												420		
195												435		
210												450		
225												465		
240												480		
255												495		
270												510		



Kpone Seduase 062/H/06/BH-1 Constant Rate Test

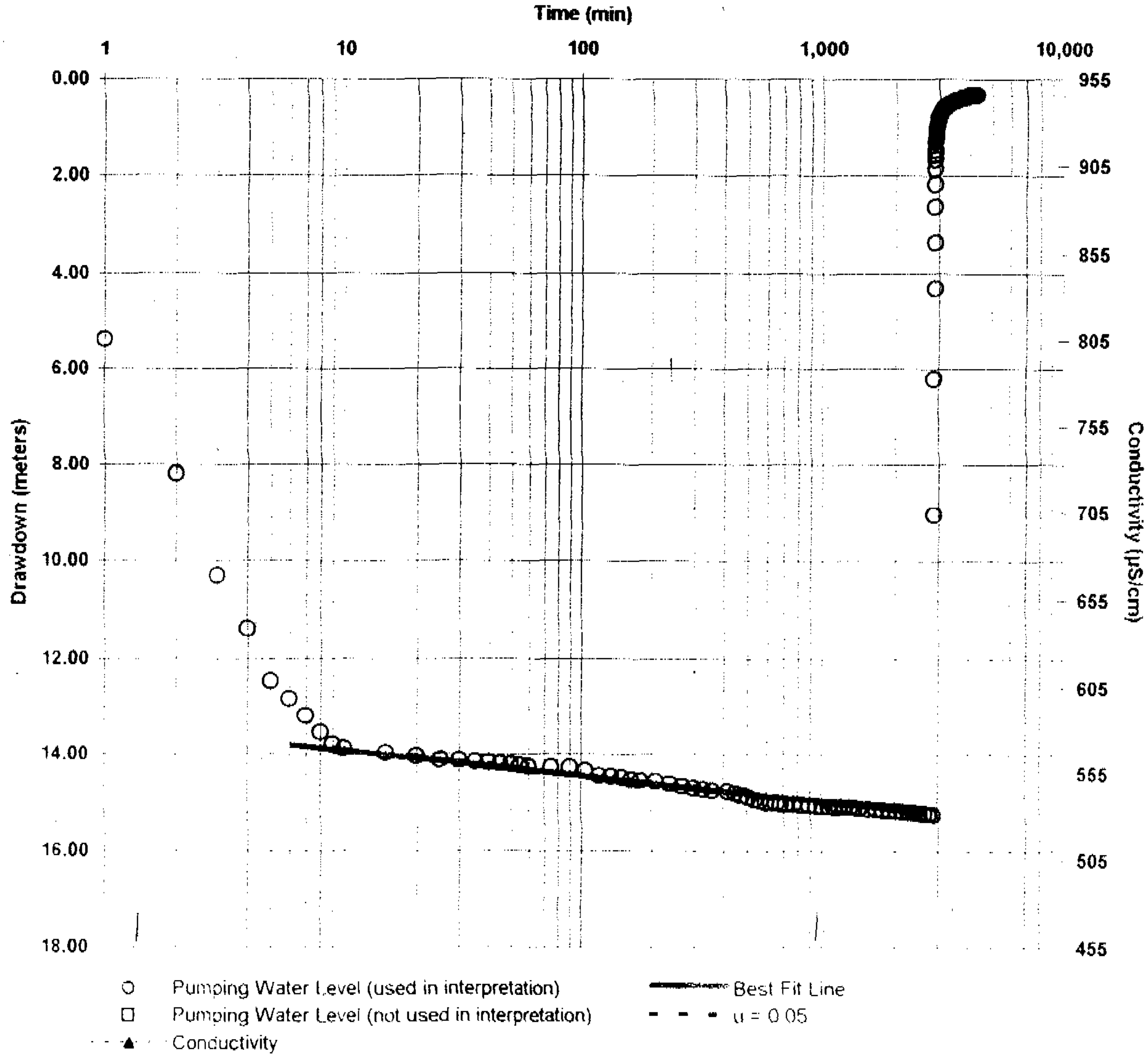
Project : CWSA
District : Ga
Community : Kpone Seduase
Pumping Well : 062/H/06/BH-1
Observation Well : 062/H/06/BH-1
Borehole Depth : 54m
Pump Setting : 44m
Height of datum : 0.8m amgl

Distance to Pumping Well : 0.1 m
Pumping rate : 259.2 m3/d
Static Water level : 5.34 m
Measurement Datum : Top of PVC
Pump on : 08/02/2003 6:00:00 PM
Pump off : 10/02/2003 6:00:00 PM
Measured by : VENT-3
Interpreted by : ENDD

Transmissivity : 90.50 m^2/d

Mean Fitting Error : 675.43 %
Drawdown over 1 log cycle : 0.5241 m

Straight Line Pumping Test Analysis (Cooper & Jakob, 1946)
Note that this method does not apply to data when u > 0.05, to the left of the dotted line and that Storativity cannot be calculated without observation wells



#N/A

Kpone Seduase 062/H/06/BH-1 Constant Rate Test

Project : CWSA
District : Ga
Community : Kpone Seduase
Pumping Well : 062/H/06/BH-1
Observation Well : 062/H/06/BH-1
Borehole Depth : 54m
Pump Setting : 44m
Height of datum : 0.8m amgl

Distance to Pumping Well : 0.1 m
Pumping rate : 259.2 m3/d
Static Water level : 5.34 m
Measurement Datum : Top of PVC
Pump on : 08/02/2003 6:00:00 PM
Pump off : 10/02/2003 6:00:00 PM
Measured by : VENT-3
Interpreted by : ENDD

#N/A

Data #	Time (GMT)	Time (min)	Water level (meters)	Discharge (l/min)	Cond. (µS/cm)	Drawdown (meters)	Calculated Drawdown	Error %	Included in analysis
1	18:01	1.0	10.72	180.0		5.38	13.41	149.2	yes
2	18:03	2.0	13.55	180.0		8.21	13.56	65.2	yes
3	18:04	3.0	15.65	180.0		10.31	13.66	32.4	yes
4	18:05	4.0	16.74	180.0		11.40	13.72	20.4	yes
5	18:06	5.0	17.82	180.0		12.48	13.77	10.4	yes
6	18:07	6.0	18.18	180.0		12.84	13.81	7.6	yes
7	18:08	7.0	18.54	180.0		13.20	13.85	4.9	yes
8	18:09	8.0	18.88	180.0		13.54	13.88	2.5	yes
9	18:10	9.0	19.13	180.0		13.79	13.91	0.8	yes
10	18:11	10.0	19.22	180.0		13.88	13.93	0.4	yes
11	18:16	15.0	19.31	180.0		13.97	14.02	0.4	yes
12	18:21	20.0	19.39	180.0		14.05	14.09	0.3	yes
13	18:26	25.0	19.46	180.0		14.12	14.14	0.1	yes
14	18:31	30.0	19.48	180.0		14.14	14.18	0.3	yes
15	18:36	35.0	19.50	180.0		14.16	14.21	0.4	yes
16	18:41	40.0	19.52	180.0		14.18	14.25	0.5	yes
17	18:46	45.0	19.54	180.0		14.20	14.27	0.5	yes
18	18:51	50.0	19.56	180.0		14.22	14.30	0.5	yes
19	18:56	55.0	19.58	180.0		14.24	14.32	0.5	yes
20	19:01	60.0	19.60	180.0		14.26	14.34	0.5	yes
21	19:16	75.0	19.62	180.0		14.28	14.39	0.8	yes
22	19:31	90.0	19.62	180.0		14.28	14.43	1.0	yes
23	19:46	105.0	19.69	180.0		14.35	14.46	0.8	yes
24	20:01	120.0	19.79	180.0		14.45	14.50	0.3	yes
25	20:16	135.0	19.81	180.0		14.47	14.52	0.4	yes
26	20:31	150.0	19.84	180.0		14.50	14.55	0.3	yes
27	20:46	165.0	19.87	180.0		14.53	14.57	0.3	yes
28	21:01	180.0	19.90	180.0		14.56	14.59	0.2	yes
29	21:31	210.0	19.91	180.0		14.57	14.62	0.4	yes
30	22:01	240.0	19.96	180.0		14.62	14.65	0.2	yes
31	22:31	270.0	20.01	180.0		14.67	14.68	0.1	yes
32	23:01	300.0	20.05	180.0		14.71	14.70	0.0	yes
33	23:31	330.0	20.07	180.0		14.73	14.73	0.0	yes
34	00:01	360.0	20.10	180.0		14.76	14.75	0.1	yes
35	01:01	420.0	20.11	180.0		14.77	14.78	0.1	yes
36	01:31	450.0	20.15	180.0		14.81	14.80	0.1	yes
37	02:01	480.0	20.20	180.0		14.86	14.81	0.3	yes
38	02:31	510.0	20.24	180.0		14.90	14.82	0.5	yes
39	03:01	540.0	20.29	180.0		14.95	14.84	0.8	yes
40	03:31	570.0	20.32	180.0		14.98	14.85	0.9	yes
41	04:01	600.0	20.36	180.0		15.02	14.86	1.1	yes
42	04:31	630.0	20.36	180.0		15.02	14.87	1.0	yes
43	05:01	660.0	20.37	180.0		15.03	14.88	1.0	yes
44	05:31	690.0	20.38	180.0		15.04	14.89	1.0	yes
45	06:01	720.0	20.39	180.0		15.05	14.90	1.0	yes
46	07:01	780.0	20.39	180.0		15.05	14.92	0.9	yes
47	08:01	840.0	20.40	180.0		15.06	14.94	0.8	yes
48	09:01	900.0	20.41	180.0		15.07	14.95	0.8	yes
49	10:01	960.0	20.42	180.0		15.08	14.97	0.7	yes
50	11:01	1,020.0	20.43	180.0		15.09	14.98	0.7	yes
51	12:01	1,080.0	20.43	180.0		15.09	15.00	0.6	yes
52	13:01	1,140.0	20.44	180.0		15.10	15.01	0.6	yes
53	14:01	1,200.0	20.44	180.0		15.10	15.02	0.5	yes
54	15:01	1,260.0	20.45	180.0		15.11	15.03	0.5	yes
55	16:01	1,320.0	20.45	180.0		15.11	15.04	0.5	yes

Kpone Seduase 062/H/06/BH-1 Constant Rate Test

Project : CWSA
District : Ga
Community : Kpone Seduase
Pumping Well : 062/H/06/BH-1
Observation Well : 062/H/06/BH-1
Borehole Depth : 54m
Pump Setting : 44m
Height of datum : 0.8m amgl

Distance to Pumping Well : 0.1 m
Pumping rate : 259.2 m3/d
Static Water level : 5.34 m
Measurement Datum : Top of PVC
Pump on : 08/02/2003 6:00:00 PM
Pump off : 10/02/2003 6:00:00 PM
Measured by : VENT-3
Interpreted by : ENDD

#N/A

Data #	Time (GMT)	Time (min)	Water level (meters)	Discharge (l/min)	Cond. (µS/cm)	Drawdown (meters)	Calculated Drawdown	Error %	Included in analysis
56	17:01	1,380.0	20.46	180.0		15.12	15.05	0.5	yes
57	18:01	1,440.0	20.47	180.0		15.13	15.06	0.5	yes
58	20:01	1,560.0	20.48	180.0		15.14	15.08	0.4	yes
59	22:01	1,680.0	20.49	180.0		15.15	15.10	0.4	yes
60	00:01	1,800.0	20.51	180.0		15.17	15.11	0.4	yes
61	02:01	1,920.0	20.52	180.0		15.18	15.13	0.4	yes
62	04:01	2,040.0	20.52	180.0		15.18	15.14	0.3	yes
63	06:01	2,160.0	20.53	180.0		15.19	15.15	0.2	yes
64	08:01	2,280.0	20.54	180.0		15.20	15.17	0.2	yes
65	10:01	2,400.0	20.55	180.0		15.21	15.18	0.2	yes
66	12:01	2,520.0	20.57	180.0		15.23	15.19	0.3	yes
67	14:01	2,640.0	20.57	180.0		15.23	15.20	0.2	yes
68	16:01	2,760.0	20.58	180.0		15.24	15.21	0.2	yes
69	18:01	2,880.0	20.60	180.0		15.26	15.22	0.3	yes
70	18:02	2,881.0	14.38	RECOVERY		9.04	15.22	68.3	yes
71	18:03	2,882.0	11.55			6.21	15.22	145.1	yes
72	18:04	2,883.0	9.66			4.32	15.22	252.3	yes
73	18:05	2,884.0	8.70			3.36	15.22	352.9	yes
74	18:06	2,885.0	7.98			2.64	15.22	476.5	yes
75	18:07	2,886.0	7.52			2.18	15.22	598.1	yes
76	18:08	2,887.0	7.21			1.87	15.22	713.9	yes
77	18:09	2,888.0	7.02			1.68	15.22	805.9	yes
78	18:10	2,889.0	6.92			1.58	15.22	863.2	yes
79	18:11	2,890.0	6.83			1.49	15.22	921.4	yes
80	18:16	2,895.0	6.65			1.31	15.22	1061.8	yes
81	18:21	2,900.0	6.56			1.22	15.22	1147.6	yes
82	18:26	2,905.0	6.49			1.15	15.22	1223.5	yes
83	18:31	2,910.0	6.44			1.10	15.22	1283.7	yes
84	18:36	2,915.0	6.38			1.04	15.22	1363.6	yes
85	18:41	2,920.0	6.37			1.03	15.22	1377.8	yes
86	18:46	2,925.0	6.35			1.01	15.22	1407.1	yes
87	18:51	2,930.0	6.32			0.98	15.22	1453.3	yes
88	18:56	2,935.0	6.30			0.96	15.22	1485.7	yes
89	19:01	2,940.0	6.28			0.94	15.22	1519.5	yes
90	19:16	2,955.0	6.22			0.88	15.22	1630.0	yes
91	19:31	2,970.0	6.18			0.84	15.23	1712.6	yes
92	19:46	2,985.0	6.14			0.80	15.23	1803.3	yes
93	20:01	3,000.0	6.12			0.78	15.23	1852.3	yes
94	20:16	3,015.0	6.09			0.75	15.23	1930.5	yes
95	20:31	3,030.0	6.07			0.73	15.23	1986.3	yes
96	20:46	3,045.0	6.05			0.71	15.23	2045.2	yes
97	21:01	3,060.0	6.03			0.69	15.23	2107.6	yes
98	21:31	3,090.0	5.99			0.65	15.23	2243.8	yes
99	22:01	3,120.0	5.95			0.61	15.24	2397.8	yes
100	22:31	3,150.0	5.95			0.61	15.24	2398.2	yes
101	23:01	3,180.0	5.92			0.58	15.24	2527.8	yes
102	23:31	3,210.0	5.91			0.57	15.24	2574.3	yes
103	00:01	3,240.0	5.91			0.57	15.25	2574.6	yes
104	00:31	3,270.0	5.89			0.55	15.25	2672.3	yes
105	01:01	3,300.0	5.86			0.52	15.25	2832.6	yes
106	01:31	3,330.0	5.85			0.51	15.25	2890.5	yes
107	02:01	3,360.0	5.84			0.50	15.25	2950.7	yes
108	02:31	3,390.0	5.83			0.49	15.26	3013.4	yes
109	03:01	3,420.0	5.82			0.48	15.26	3078.7	yes
110	03:31	3,450.0	5.81			0.47	15.26	3146.7	yes

Kpone Seduase 062/H/06/BH-1 Constant Rate Test

Project :	CWSA	Distance to Pumping Well :	0.1 m
District :	Ga	Pumping rate :	259.2 m3/d
Community :	Kpone Seduase	Static Water level :	5.34 m
Pumping Well :	062/H/06/BH-1	Measurement Datum :	Top of PVC
Observation Well :	062/H/06/BH-1	Pump on :	08/02/2003 6:00:00 PM
Borehole Depth :	54m	Pump off :	10/02/2003 6:00:00 PM
Pump Setting :	44m	Measured by :	VENT-3
Height of datum :	0.8m amgl	Interpreted by :	ENDD

#N/A

Data #	Time (GMT)	Time (min)	Water level (meters)	Discharge (l/min)	Cond. (µS/cm)	Drawdown (meters)	Calculated Drawdown	Error %	Included in analysis
111	04:01	3,480.0	5.80			0.46	15.26	3217.7	yes
112	04:31	3,510.0	5.80			0.46	15.26	3218.2	yes
113	05:01	3,540.0	5.79			0.45	15.27	3292.3	yes
114	05:31	3,570.0	5.79			0.45	15.27	3292.8	yes
115	06:01	3,600.0	5.78			0.44	15.27	3370.3	yes
116	07:01	3,660.0	5.77			0.43	15.27	3451.9	yes
117	08:01	3,720.0	5.75			0.41	15.28	3626.1	yes
118	09:01	3,780.0	5.75			0.41	15.28	3626.9	yes
119	10:01	3,840.0	5.74			0.40	15.28	3721.0	yes
120	11:01	3,900.0	5.72			0.38	15.29	3923.0	yes
121	12:01	3,960.0	5.71			0.37	15.29	4032.7	yes
122	13:01	4,020.0	5.70			0.36	15.29	4148.5	yes
123	14:01	4,080.0	5.69			0.35	15.30	4270.8	yes
124	15:01	4,140.0	5.69			0.35	15.30	4271.8	yes
125	16:01	4,200.0	5.68			0.34	15.30	4401.3	yes
126	17:01	4,260.0	5.68			0.34	15.31	4402.3	yes
127	18:01	4,320.0	5.68			0.34	15.31	4403.2	yes
128	19:01	4,380.0							yes

Kpone Seduase BH-1

Estimated Maximum Sustainable Well Yield Calculation

Pumping Test & Borehole Parameters			
Q	180	l/min	Constant rate pumping test yield
	10.8	m^3/h	
	259.2	m^3/d	
$t_{pumptest}$	2,880	minutes	Pumping test duration
	2	days	
r	8.5	inch	Effective well diameter
	0.10795	m	Effective well radius
swl	5.32	m	Static water level below datum before pumping test
s	15.26	m	*Drawdown at end of pumping test*
Δs	0.5241	m	Change in drawdown over one log cycle of time
pwl_{max}	37	m	Maximum allowable pumping water level below datum
$\Delta s_{seasonal}$	3	m	Estimated seasonal water level decline
s_{max}	**28.68**	m	Maximum allowable drawdown
T	90.5	m^2/d	Transmissivity calculated from pumping test data
S_{min}	0.005		*Minimum likely storativity*
S_{max}	0.03		Maximum likely storativity
$E_{steptest}$	0.36		Well efficiency estimated from step test
E_{min}	**0.24**		Well efficiency estimated from Transmissivity & minimum likely Storativity
E_{max}	**0.21**		Well efficiency estimated from Transmissivity & maximum likely Storativity
E_{min}	**0.24**		Well Efficiency used for calculations. E = 1 if calculated E > 1
E_{max}	**0.21**		Well Efficiency used for calculations. E = 1 if calculated E > 1
t	300	d	Length of hydrological year without recharge - the time between two rainy seasons

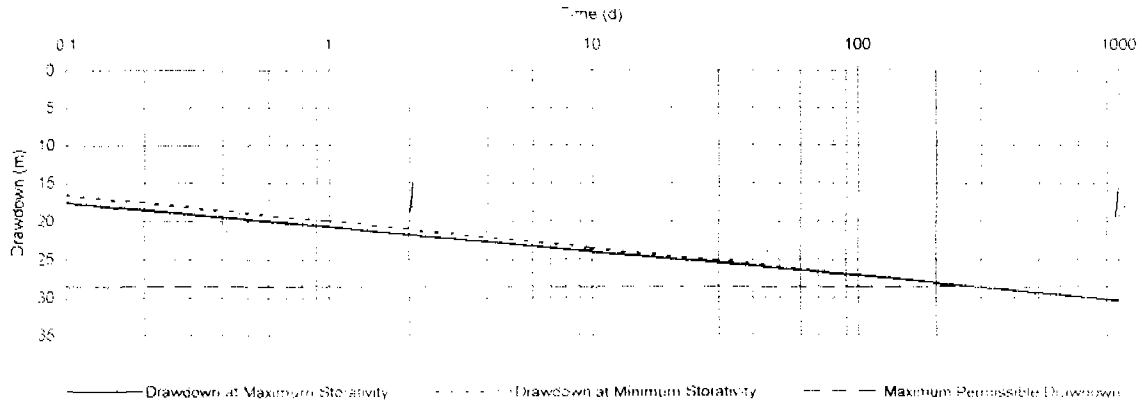
$$Q_{max} = \frac{E \cdot s_{max} \cdot T}{0.183 \log (2.25\, Tt / r^2 S)}$$

The sustainable yield formula is based on the Modified Nonequilibrium Equation, Cooper & Jakob (1946)

Estimated Maximum Sustainable Well Yield at Continuous 24/24 Hour Pumping										
Qmax	Q_{max} (1a)		Q_{max} (1b)		Q_{max} (2a)		Q_{max} (2b)		Lowest Q_{max}	
S	0.005		0.03		0.005		0.03		0.03	
E	0.36		0.36		0.24		0.21		0.208356219	
24/24 h Pumping Cycle	566 m^3/d	23.6 m^3/h	619 m^3/d	25.8 m^3/h	370 m^3/d	15.4 m^3/h	359 m^3/d	14.9 m^3/h	359 m^3/d	14.9 m^3/h

Note that these estimates are very theoretical and that all production wells should be monitored regularly

Predicted Drawdown at Estimated Maximum Sustainable Yield



Kpone Seduase BH-1

Estimated Maximum Sustainable Well Yield Calculation

$$Q_{max} = \frac{E \cdot 0.228 \cdot s_{max} \cdot T}{t_1 \log(t_2 - 1 + t_1/t_1) + \log(2.25\, T t_1 / (r^2 S))}$$

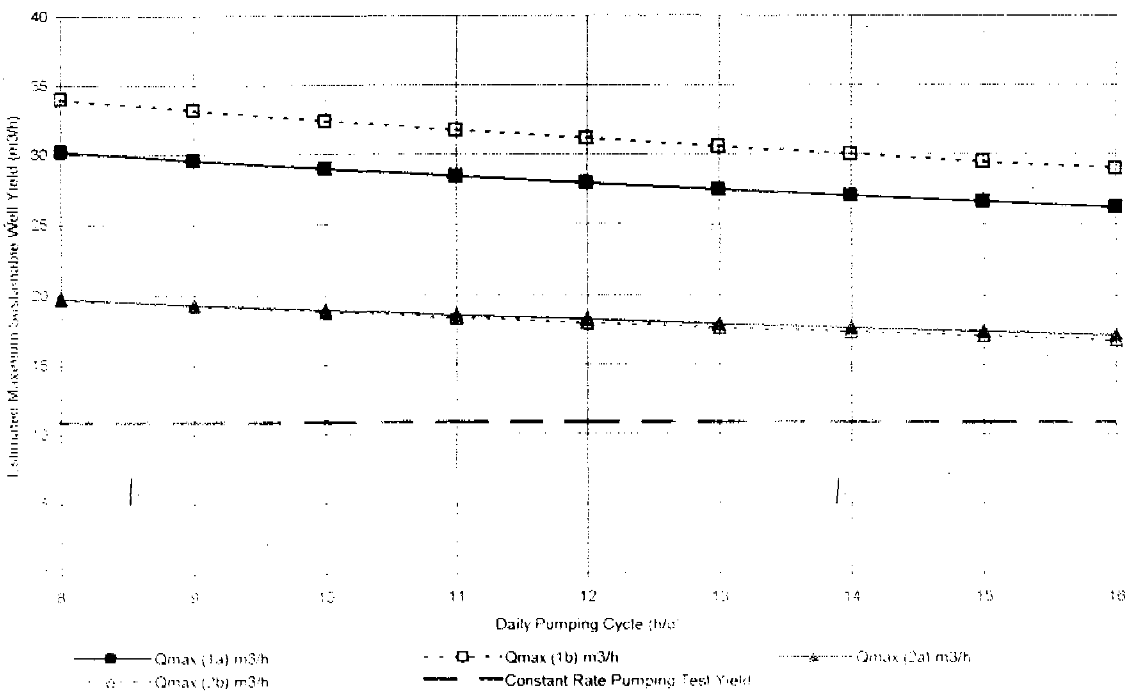
The sustainable yield formula for intermittent pumping is based on the Modified Nonequilibrium Equation, Cooper & Jakob (1946) and the imaginary well procedure outlined in "Groundwater & Wells" Driscoll, 1986.

Estimated Maximum Sustainable Well Yields at Intermittent Pumping Rates

	Q_{max} (1a)		Q_{max} (1b)		Q_{max} (2a)		Q_{max} (2b)		Lowest Q_{max}	
S	0.005		0.03		0.005		0.03		-	
E	0.36		0.36		0.24		0.21		-	
Daily Pumping Cycle (hrs)	Q_{max} (1a) m^3/h	Volume (1a) m^3/d	Q_{max} (1b) m^3/h	Volume (1b) m^3/d	Q_{max} (2a) m^3/h	Volume (2a) m^3/d	Q_{max} (2b) m^3/h	Volume (2b) m^3/d	Lowest Q_{max} m^3/h	Lowest Volume m^3/d
8	30.2	242	34.0	272	19.7	158	19.7	157	19.7	157
9	29.6	266	33.1	298	19.3	174	19.2	173	19.2	173
10	29.0	290	32.4	324	18.9	189	18.8	188	18.8	188
11	28.4	313	31.7	349	18.6	204	18.4	202	18.4	202
12	27.9	335	31.1	373	18.2	219	18.0	216	18.0	216
13	27.4	357	30.5	397	17.9	233	17.7	229	17.7	229
14	27.0	378	30.0	419	17.6	247	17.3	243	17.3	243
15	26.6	399	29.4	442	17.4	260	17.0	256	17.0	256
16	26.2	419	29.0	463	17.1	274	16.8	268	16.8	268

Note that these estimates are very theoretical and that all production wells should be monitored regularly.
It is unwise to select a pumping rate that exceeds those used during the pumping tests, without further tests.

Estimated Maximum Sustainable Well Yields at Intermittent Pumping Rates



Kpone Seduase BH-1

Estimated Maximum Sustainable Well Yield Calculation

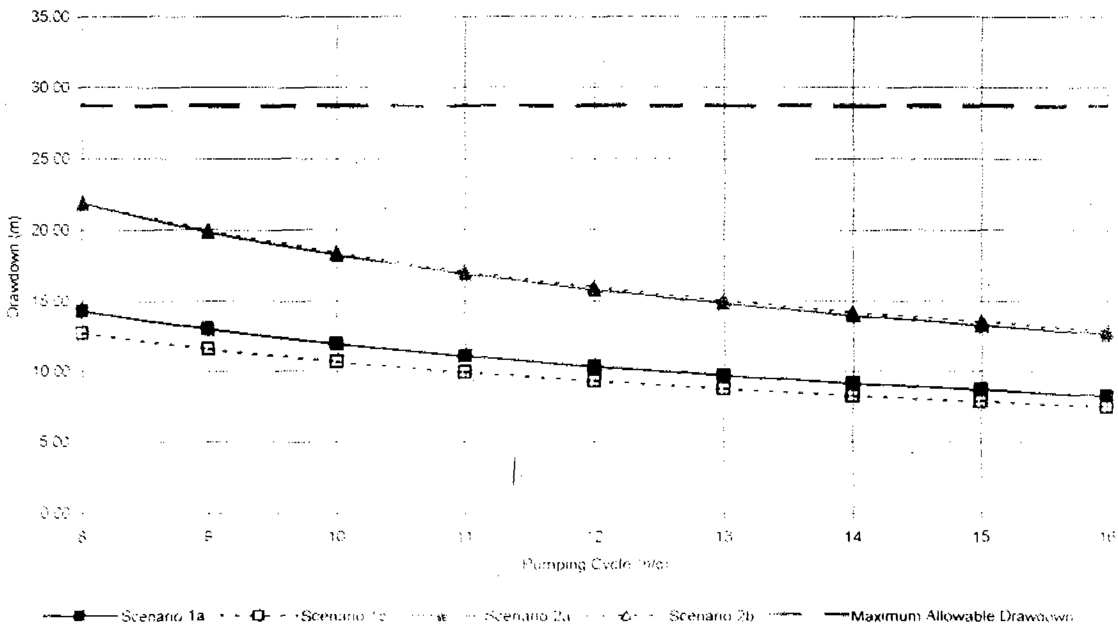
$$s = \frac{0.183\,Q}{E.T}\left[t_1 \log\left((t_2 - 1 + t_1)/t_1\right) + \log\left(2.25\,Tt_1/(r^2 S)\right)\right]$$

The formula for estimated drawdown due to intermittent pumping is based on the imaginary well procedure outlined in "Groundwater & Wells", Driscoll, 1986.

Estimated Drawdown at Intermittent Pumping Rates						
		Scenario	1a	1b	2a	2b
		Storativity (S)	0.005	0.03	0.005	0.03
		Well Efficiency (E)	0.36	0.36	0.24	0.21
Water Demand (m^3/d)	Daily Pumping Cycle (hrs)	Q_{abs} m^3/h	Estimated Drawdown (m) at end of Dry Season	Estimated Drawdown (m) at end of Dry Season	Estimated Drawdown (m) at end of Dry Season	Estimated Drawdown (m) at end of Dry Season
120.0	8	15.0	14.3	12.7	21.8	21.9
	9	13.3	13.0	11.6	19.8	20.0
	10	12.0	11.9	10.6	18.2	18.4
	11	10.9	11.0	9.9	16.9	17.1
	12	10.0	10.3	9.2	15.8	16.0
	13	9.2	9.7	8.7	14.8	15.0
	14	8.6	9.1	8.2	14.0	14.2
	15	8.0	8.6	7.8	13.2	13.5
	16	7.5	8.2	7.4	12.6	12.9

Note that these estimates are very theoretical and that all production wells should be monitored regularly

Estimated Drawdown at the End of the Dry Season at Various Pumping Cycles



Water Demand = 120 m3/d

Note that drawdown cannot exceed the maximum allowable drawdown, s_{max}

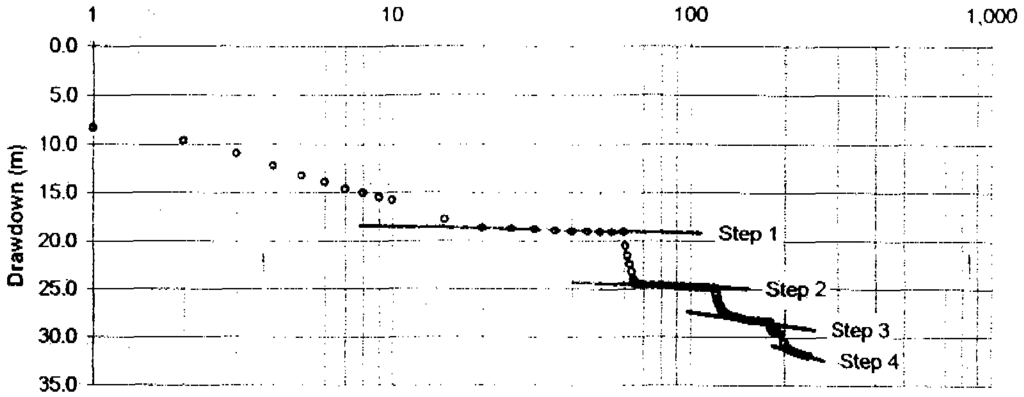
Oyibi B01

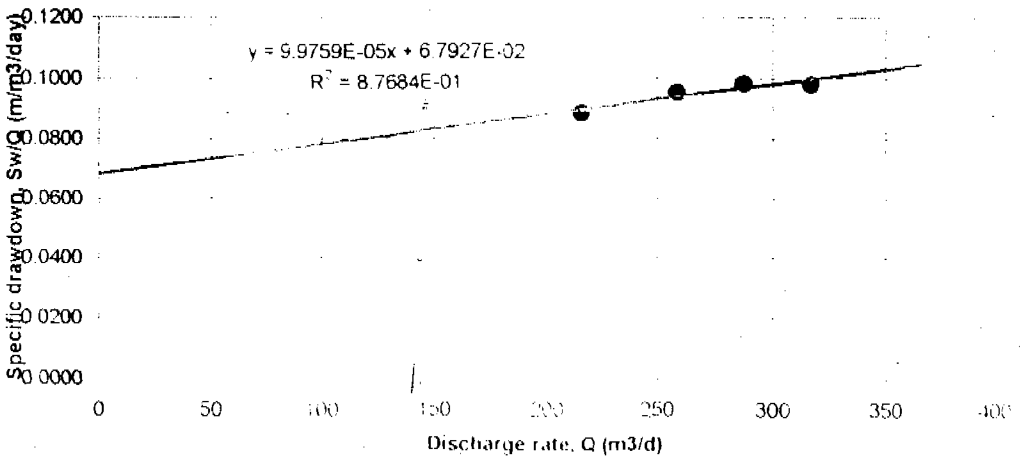
Project : CWSA GAR
District : Tema
Community : Oyibi
Name of Well : B01
Eastings : E 00° 00' 00.0"
Northings : N 00° 00' 00.0"
Measured by : Vent-3 Ltd
Interpreted by : UniHydro

Length of Each Step : 60 min
Number of Steps : 4
Reference point : Top of casing
Height above ground : 1 m
Depth to Static Water Level : 20.27 m
Pump on : 18/10/2002 4:00 PM
Pump off : 18/10/2002 8:00 PM

Bierschenk Wilson Step Test Analysis						
Step	Discharge	Measured Sw	Sw/Q	Calc. Sw	Well Loss (m)*	Well Loss (%)*
Step 1	216.0 m3/d	19.1 m	0.0883	19.3	4.65	24.08%
Step 2	259.2 m3/d	24.7 m	0.0951	24.3	6.70	27.57%
Step 3	288.0 m3/d	28.2 m	0.0981	27.8	8.27	29.72%
Step 4	316.8 m3/d	31.0 m	0.0979	31.5	10.01	31.75%
Well Drawdown Equation at 60 min pumping : sw = 0.0679267923573392Q + 9.97585941773415E-05Q(2)						
Estimated Transmissivity (Logan 1964) : 18.0 m2/d						

** Note that well losses includes turbulent flow losses within the aquifer*





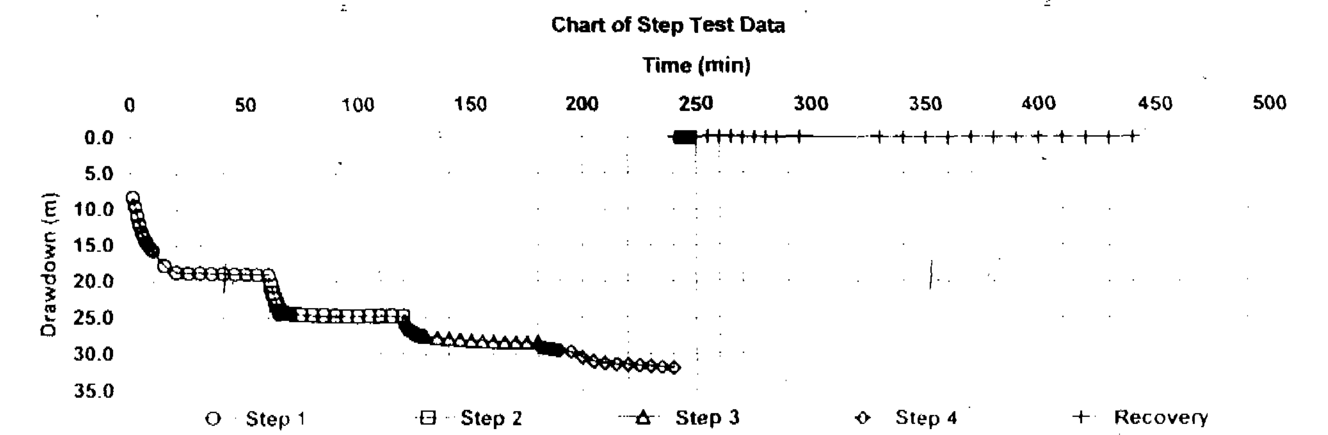
Oyibi B01

Project : CWSA GAR
District : Tema
Community : Oyibi
Name of Well : B01
Eastings : E 00° 00' 00.0"
Northings : N 00° 00' 00.0"
Measured by : Vent-3 Ltd
Interpreted by : UniHydro

Length of Each Step : 60 min
Number of Steps : 4
Reference point : Top of casing
Height above ground : 1.00 m
Depth to Static Water Level : 20.27 m
Pump on : 18/10/2002 4:00 PM
Pump off : 18/10/2002 8:00 PM

D:\EDWIN\UniHydro pumping test\unihydro pumpingtest-2\[STEP TEST OYIBI.xls]Plot

Step 1			Step 2			Step 3			Step 4			Recovery		
Q : 216.0 m3/d			Q : 259.2 m3/d			Q : 288.0 m3/d			Q : 316.8 m3/d					
Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Recovery (m)
1	28.64	8.37	61	40.89	20.62	121	45.84	25.57	181	49.39	29.12	241		
2	29.94	9.67	62	41.90	21.63	122	46.37	26.10	182	49.51	29.24	242		
3	31.22	10.95	63	42.79	22.52	123	46.70	26.43	183	49.60	29.33	243		
4	32.47	12.20	64	43.59	23.32	124	47.00	26.73	184	49.66	29.39	244		
5	33.51	13.24	65	44.34	24.07	125	47.22	26.95	185	49.69	29.42	245		
6	34.21	13.94	66	44.73	24.46	126	47.41	27.14	186	49.73	29.46	246		
7	34.89	14.62	67	44.79	24.52	127	47.58	27.31	187	49.78	29.51	247		
8	35.31	15.04	68	44.83	24.56	128	47.72	27.45	188	49.84	29.57	248		
9	35.77	15.50	69	44.85	24.58	129	47.83	27.56	189	49.88	29.61	249		
10	36.08	15.81	70	44.87	24.60	130	47.91	27.64	190	49.91	29.64	250		
15	38.07	17.80	75	44.94	24.67	135	48.09	27.82	195	50.03	29.76	255		
20	39.00	18.73	80	44.99	24.72	140	48.26	27.99	200	50.84	30.57	260		
25	39.07	18.80	85	45.04	24.77	145	48.38	28.11	205	51.42	31.15	265		
30	39.13	18.86	90	45.08	24.81	150	48.51	28.24	210	51.63	31.36	270		
35	39.22	18.95	95	45.11	24.84	155	48.57	28.30	215	51.77	31.50	275		
40	39.29	19.02	100	45.13	24.86	160	48.63	28.36	220	51.89	31.62	280		
45	39.34	19.07	105	45.15	24.88	165	48.67	28.40	225	52.00	31.73	285		
50	39.37	19.10	110	45.18	24.91	170	48.70	28.43	230	52.09	31.82	290		
55	39.39	19.12	115	45.20	24.93	175	48.71	28.44	235	52.17	31.90	295		
60	39.39	19.12	120	45.21	24.94	180	48.73	28.46	240	52.23	31.96	300		
70												310		
80												320		
90												330		
100												340		
110												350		
120												360		
130												370		
140												380		
150												390		
160												400		
170												410		
180												420		
190												430		
200												440		



Oyibi BO1 Constant Rate Test

Project : CWSA
District : Ga
Community : Oyibi
Pumping Well : BO1
Observation Well : BO1
Borehole Depth : 71m
Pump Setting : 60m
Height of datum : 0.8m amgl

Distance to Pumping Well : 0.1 m
Pumping rate : 288.0 m3/d
Static Water level : 20.31 m
Measurement Datum : Top of PVC
Pump on : 08/02/2003 6:00:00 PM
Pump off : 10/02/2003 6:00:00 PM
Measured by : VENT-3
Interpreted by : ENDD

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Data #	Time (GMT)	Time (min)	Water level (meters)	Discharge (l/min)	Cond. (µS/cm)	Drawdown (meters)	Calculated Drawdown	Error %	Included in analysis
1	18:01	1.0	34.84	200.0		14.53	26.61	83.1	yes
2	18:03	2.0	39.93			19.62	26.85	36.9	yes
3	18:04	3.0	42.15			21.84	27.00	23.6	yes
4	18:05	4.0	43.74			23.43	27.10	15.7	yes
5	18:06	5.0	44.08	200.0		23.77	27.18	14.3	yes
6	18:07	6.0	44.26			23.95	27.25	13.8	yes
7	18:08	7.0	44.38			24.07	27.30	13.4	yes
8	18:09	8.0	44.47			24.16	27.35	13.2	yes
9	18:10	9.0	44.56			24.25	27.39	12.9	yes
10	18:11	10.0	44.62			24.31	27.43	12.8	yes
11	18:16	15.0	44.86			24.55	27.57	12.3	yes
12	18:21	20.0	44.99			24.68	27.67	12.1	yes
13	18:26	25.0	45.11			24.80	27.75	11.9	yes
14	18:31	30.0	45.19	200.0		24.88	27.82	11.8	yes
15	18:36	35.0	45.30			24.99	27.87	11.5	yes
16	18:41	40.0	45.38			25.07	27.92	11.4	yes
17	18:46	45.0	45.45			25.14	27.96	11.2	yes
18	18:51	50.0	45.53			25.22	28.00	11.0	yes
19	18:56	55.0	45.59			25.28	28.03	10.9	yes
20	19:01	60.0	45.66	200.0		25.35	28.06	10.7	yes
21	19:16	75.0	45.82			25.51	28.14	10.3	yes
22	19:31	90.0	45.96	200.0		25.65	28.21	10.0	yes
23	19:46	105.0	46.12			25.81	28.26	9.5	yes
24	20:01	120.0	46.28	200.0		25.97	28.31	9.0	yes
25	20:16	135.0	46.41			26.10	28.35	8.6	yes
26	20:31	150.0	46.54	200.0		26.23	28.39	8.2	yes
27	20:46	165.0	46.66			26.35	28.42	7.9	yes
28	21:01	180.0	46.77	200.0		26.46	28.45	7.5	yes
29	21:31	210.0	47.06			26.75	28.51	6.6	yes
30	22:01	240.0	47.37	200.0		27.06	28.56	5.5	yes
31	22:31	270.0	47.54			27.23	28.60	5.0	yes
32	23:01	300.0	47.71	200.0		27.40	28.64	4.5	yes
33	23:31	330.0	47.88			27.57	28.67	4.0	yes
34	00:01	360.0	48.04	200.0		27.73	28.70	3.5	yes
35	00:31	390.0	48.23			27.92	28.73	2.9	yes
36	01:01	420.0	48.43	200.0		28.12	28.76	2.3	yes
37	01:31	450.0	48.67			28.36	28.78	1.5	yes
38	02:01	480.0	48.94	200.0		28.63	28.80	0.6	yes
39	02:31	510.0	49.01			28.70	28.82	0.4	yes
40	03:01	540.0	49.04	200.0		28.73	28.84	0.4	yes
41	03:31	570.0	49.09			28.78	28.86	0.3	yes
42	04:01	600.0	49.13	200.0		28.82	28.88	0.2	yes
43	04:31	630.0	49.20			28.89	28.90	0.0	yes
44	05:01	660.0	49.26	200.0		28.95	28.92	0.1	yes
45	05:31	690.0	49.29	200.0		28.98	28.93	0.2	yes
46	06:01	720.0	49.33	200.0		29.02	28.95	0.3	yes
47	07:01	780.0	49.35			29.04	28.98	0.2	yes
48	08:01	840.0	49.38			29.07	29.00	0.2	yes
49	09:01	900.0	49.39			29.08	29.03	0.2	yes
50	10:01	960.0	49.41			29.10	29.05	0.2	yes
51	11:01	1,020.0	49.42			29.11	29.07	0.1	yes
52	12:01	1,080.0	49.42			29.11	29.09	0.1	yes
53	13:01	1,140.0	49.45	200.0		29.14	29.11	0.1	yes
54	14:01	1,200.0	49.47			29.16	29.13	0.1	yes
55	15:01	1,260.0	49.48			29.17	29.15	0.1	yes

Oyibi BO1 Constant Rate Test

Project : CWSA
District : Ga
Community : Oyibi
Pumping Well : BO1
Observation Well : BO1
Borehole Depth : 71m
Pump Setting : 60m
Height of datum : 0.8m amgl

Distance to Pumping Well : 0.1 m
Pumping rate : 288.0 m3/d
Static Water level : 20.31 m
Measurement Datum : Top of PVC
Pump on : 08/02/2003 6:00:00 PM
Pump off : 10/02/2003 6:00:00 PM
Measured by : VENT-3
Interpreted by : ENDD

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Data #	Time (GMT)	Time (min)	Water level (meters)	Discharge (l/min)	Cond. (µS/cm)	Drawdown (meters)	Calculated Drawdown	Error %	Included in analysis
56	16:01	1,320.0	49.49			29.18	29.16	0.1	yes
57	17:01	1,380.0	49.51			29.20	29.18	0.1	yes
58	18:01	1,440.0	49.54	200.0		29.23	29.19	0.1	yes
59	20:01	1,560.0	49.58			29.27	29.22	0.2	yes
60	22:01	1,680.0	49.65	200.0		29.34	29.25	0.3	yes
61	00:01	1,800.0	49.69			29.38	29.27	0.4	yes
62	02:01	1,920.0	49.73	200.0		29.42	29.30	0.4	yes
63	04:01	2,040.0	49.75			29.44	29.32	0.4	yes
64	06:01	2,160.0	49.79	200.0		29.48	29.34	0.5	yes
65	08:01	2,280.0	49.83			29.52	29.36	0.6	yes
66	10:01	2,400.0	49.85	200.0		29.54	29.38	0.6	yes
67	12:01	2,520.0	49.87			29.56	29.39	0.6	yes
68	14:01	2,640.0	49.88	200.0		29.57	29.41	0.5	yes
69	16:01	2,760.0	49.88			29.57	29.42	0.5	yes
70	18:01	2,880.0	49.91	200.0		29.60	29.44	0.5	yes
71	20:01	3,000.0	49.94			29.63	29.45	0.6	yes
72	22:01	3,120.0	49.97	200.0		29.66	29.47	0.6	yes
73	00:01	3,240.0	49.99			29.68	29.48	0.7	yes
74	02:01	3,360.0	50.03	200.0		29.72	29.49	0.8	yes
75	04:01	3,480.0	50.05			29.74	29.51	0.8	yes
76	06:01	3,600.0	50.04	200.0		29.73	29.52	0.7	yes
77	08:01	3,720.0	50.08			29.77	29.53	0.8	yes
78	10:01	3,840.0	50.09	200.0		29.78	29.54	0.8	yes
79	12:01	3,960.0	50.08			29.77	29.55	0.7	yes
80	14:01	4,080.0	50.09	200.0		29.78	29.56	0.7	yes
81	16:01	4,200.0	50.11			29.80	29.57	0.8	yes
82	18:01	4,320.0	50.10	200.0		29.79	29.58	0.7	yes

Oyibi BH-1

Estimated Maximum Sustainable Well Yield Calculation

Pumping Test & Borehole Parameters			
Q	200	l/min	Constant rate pumping test yield
	12.0	m^3/h	
	288	m^3/d	
$t_{pumptest}$	4,320	minutes	Pumping test duration
	3	days	
r	6	inch	Effective well diameter
	0.0762	m	Effective well radius
swl	20.31	m	Static water level below datum before pumping test
s	29.83	m	Drawdown at end of pumping test
Δs	0.8186	m	Change in drawdown over one log cycle of time
pwl_{max}	54	m	Maximum allowable pumping water level below datum
$\Delta s_{seasonal}$	3	m	Estimated seasonal water level decline
s_{max}	**30.69**	m	Maximum allowable drawdown
T	64.39	m^2/d	Transmissivity calculated from pumping test data
S_{min}	0.005		Minimum likely storativity
S_{max}	0.03		Maximum likely storativity
$E_{steptest}$	0.70		Well efficiency estimated from step test
E_{min}	**0.20**		Well efficiency estimated from Transmissivity & minimum likely Storativity
E_{max}	**0.18**		Well efficiency estimated from Transmissivity & maximum likely Storativity
E_{min}	**0.20**		Well Efficiency used for calculations. E = 1 if calculated E > 1
E_{max}	**0.18**		Well Efficiency used for calculations. E = 1 if calculated E > 1
t	300	d	Length of hydrological year without recharge - the time between two rainy seasons

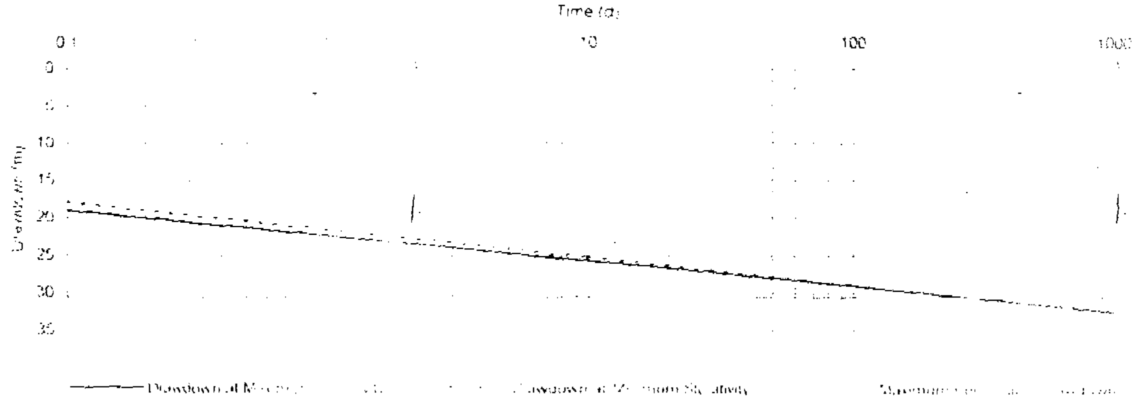
$$Q_{max} = \frac{E \cdot s_{max} \cdot T}{0.183 \log (2.25\, Tt / r^2 S)}$$

The sustainable yield formula is based on the Modified Nonequilibrium Equation, Cooper & Jakob (1946)

Estimated Maximum Sustainable Well Yield at Continuous 24/24 Hour Pumping										
Qmax	Q_{max} (1a)		Q_{max} (1b)		Q_{max} (2a)		Q_{max} (2b)		Lowest Q_{max}	
S	**0.005**		0.03		**0.005**		**0.03**		0.03	
E	**0.70**		0.70		**0.20**		**0.18**		0.175531243	
24/24 h Pumping Cycle	**824 m^3/d**	**34.3 m^3/h**	900 m^3/d	37.5 m^3/h	**232 m^3/d**	**9.7 m^3/h**	**226 m^3/d**	**9.4 m^3/h**	**226 m^3/d**	**9.4 m^3/h**

Note that these estimates are very theoretical and that all production wells should be monitored regularly

Predicted Drawdown at Estimated Maximum Sustainable Yield



Oyibi BH-1

Estimated Maximum Sustainable Well Yield Calculation

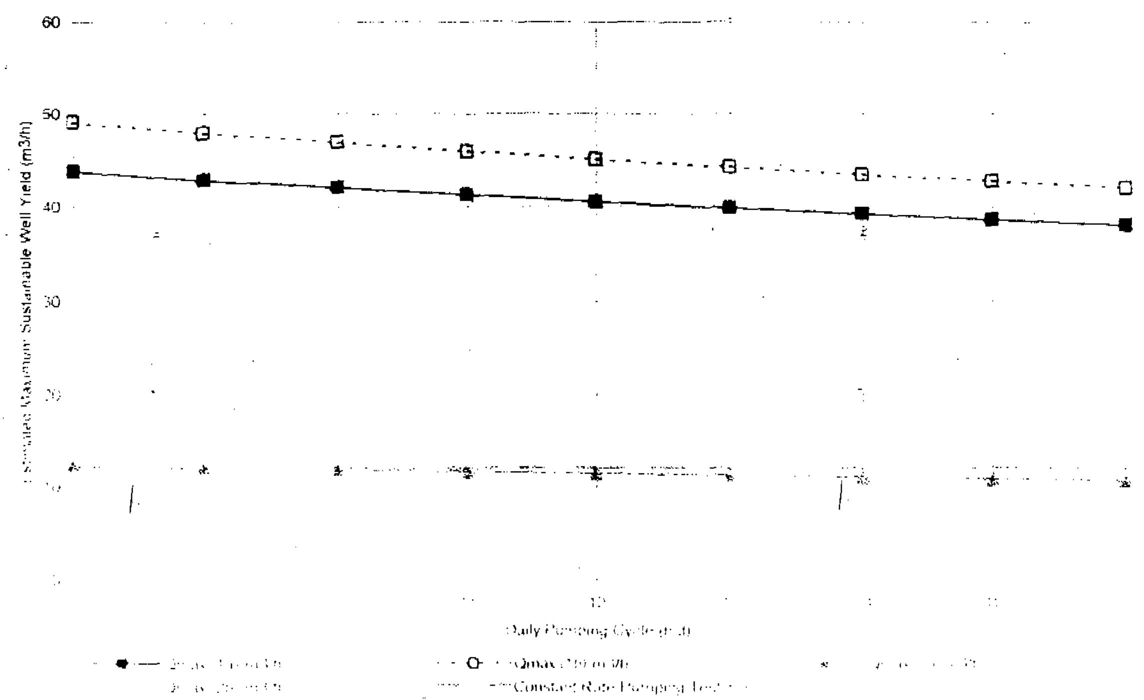
$$Q_{max} = \frac{E \cdot 0.228 \cdot s_{max} \cdot T}{t_i \log(t_2 - 1 + t_1 / t_1) + \log(2.25\, T t_1 / (r^2 S))}$$

The sustainable yield formula for intermittent pumping is based on the Modified Nonequilibrium Equation, Cooper & Jakob (1946) and the imaginary well procedure outlined in "Groundwater & Wells" Driscoll, 1986.

Estimated Maximum Sustainable Well Yields at Intermittent Pumping Rates										
	Q_{max} (1a)		Q_{max} (1b)		Q_{max} (2a)		Q_{max} (2b)		Lowest Q_{max}	
S	0.005		0.03		0.005		0.03		-	
E	0.70		0.70		0.20		0.18		-	
Daily Pumping Cycle (hrs)	Q_{max} (1a) m^3/h	Volume (1a) m^3/d	Q_{max} (1b) m^3/h	Volume (1b) m^3/d	Q_{max} (2a) m^3/h	Volume (2a) m^3/d	Q_{max} (2b) m^3/h	Volume (2b) m^3/d	Lowest Q_{max} m^3/h	Lowest Volume m^3/d
8	43.8	350	49.1	393	12.3	98	12.3	98	12.3	98
9	42.8	386	47.9	431	12.1	108	12.0	108	12.0	108
10	42.0	420	46.9	469	11.8	118	11.8	118	11.8	118
11	41.2	454	45.9	505	11.6	128	11.5	127	11.5	127
12	40.5	486	45.0	540	11.4	137	11.3	135	11.3	135
13	39.8	518	44.2	574	11.2	146	11.1	144	11.1	144
14	39.2	549	43.4	608	11.0	154	10.9	152	10.9	152
15	38.6	579	42.7	640	10.9	163	10.7	161	10.7	161
16	38.0	609	42.0	672	10.7	171	10.5	168	10.5	168

*Note that these estimates are very theoretical and that **all production wells should** be monitored regularly.*
*It is unwise to select a pumping rate that exceeds those **used during the pumping** tests, without further tests.*

Estimated Maximum Sustainable Well Yields at Intermittent Pumping Rates



Oyibi BH-1

Estimated Maximum Sustainable Well Yield Calculation

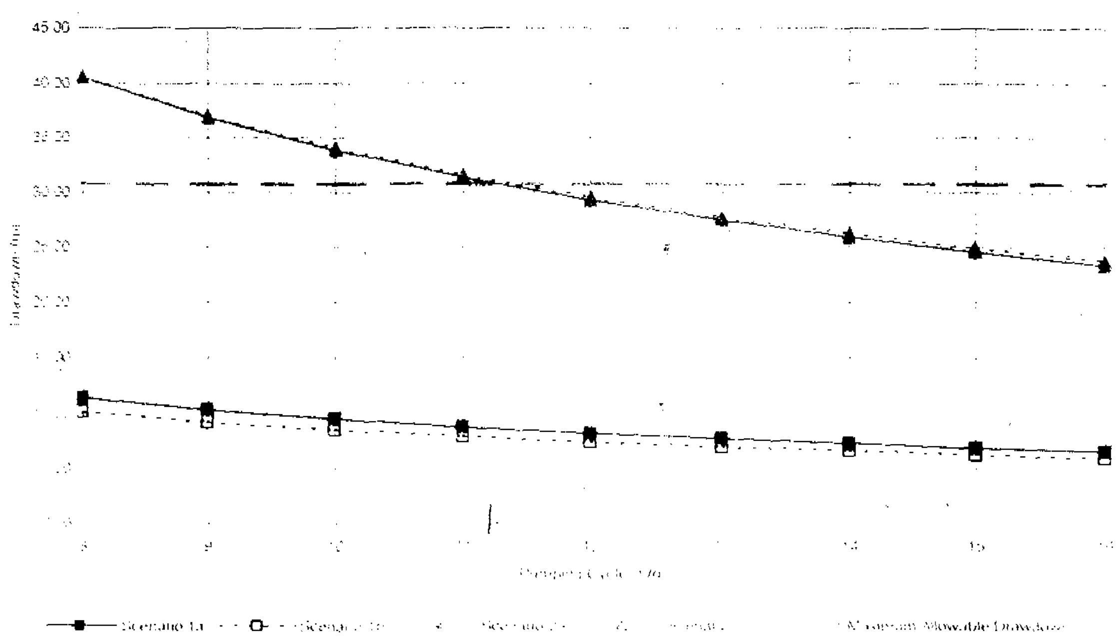
$$s = \frac{0.183\,Q}{E\,.T}\left[t_1 \log\left((t_2 - 1 + t_1)/t_1\right) + \log\left(2.25\,Tt_1/(r^2S)\right)\right]$$

The formula for estimated drawdown due to intermittent pumping is based on the imaginary well procedure outlined in "Groundwater & Wells", Driscoll, 1986

Estimated Drawdown at Intermittent Pumping Rates						
		Scenario	1a	1b	2a	2b
		Storativity (S)	0.005	0.03	0.005	0.03
		Well Efficiency (E)	0.70	0.70	0.20	0.18
Water Demand (m^3/d)	Daily Pumping Cycle (hrs)	Q_{abs} m^3/h	Estimated Drawdown (m) at end of Dry Season	Estimated Drawdown (m) at end of Dry Season	Estimated Drawdown (m) at end of Dry Season	Estimated Drawdown (m) at end of Dry Season
130.0	8	16.3	11.4	10.2	40.6	40.6
	9	14.4	10.4	9.3	36.8	36.9
	10	13.0	9.5	8.5	33.8	34.0
	11	11.8	8.8	7.9	31.3	31.6
	12	10.8	8.2	7.4	29.2	29.5
	13	10.0	7.7	7.0	27.4	27.7
	14	9.3	7.3	6.6	25.9	26.2
	15	8.7	6.9	6.2	24.5	24.9
	16	8.1	6.6	5.9	23.3	23.7

Note that these estimates are very theoretical and that all production wells should be monitored regularly

Estimated Drawdown at the End of the Dry Season at Various Pumping Cycles



Water Demand = 130 m3/d

Note that drawdown cannot exceed the maximum allowable drawdown

OLD SAASABI

SUSTAINABLE YIELD RESULTS

Old Saasabi 062/H/18/BH-1

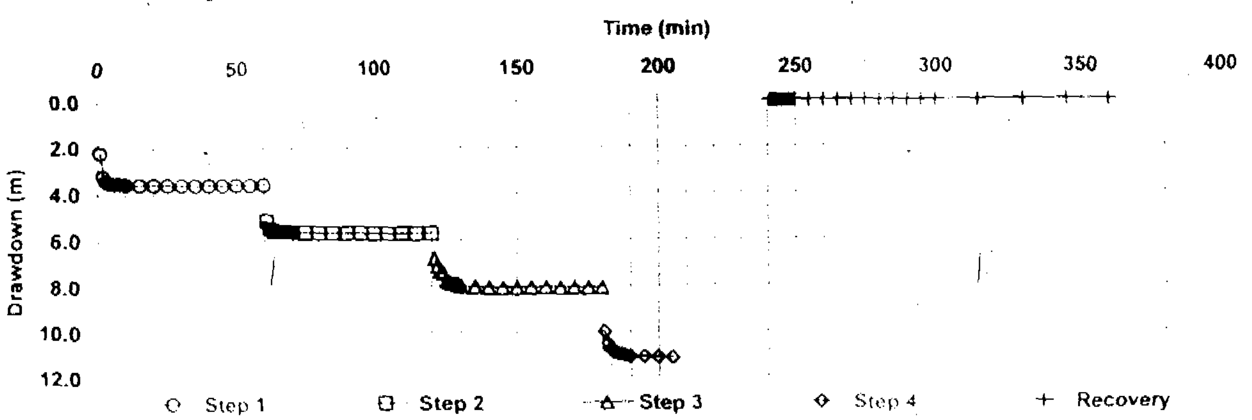
Project : RWST
District : Ga
Community : Old Saasabi
Name of Well : 062/H/18/BH-1
Borehole Depth : 45 m
Pump Setting : 33 m
Measured by : VENT-3 Ltd
Interpreted by : ENDD

Length of Each Step : 60 min
Number of Steps : 4
Reference point : Top of PVC
Height above ground : 0.72m
Depth to Static Water Level : 13.40 m
Pump on : 08/02/2003 9:30 PM
Pump off : 08/02/2003 11:55 PM

D:\EDWIN\UniHydro pumping test\unihydro pumpingtest-2\[STEP TEST OLD SAASABI.xls]Plot

Step 1			Step 2			Step 3			Step 4			Recovery		
Q : 158.4 m3/d			Q : 201.6 m3/d			Q : 259.2 m3/d			Q : 316.8 m3/d					
Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Draw-down (m)	Time (min)	Water Level (m)	Recovery (m)
1	15.61	2.21	61	18.58	5.18	121	20.24	6.84	181	23.42	10.02	241		
2	16.62	3.22	62	18.91	5.51	122	20.56	7.16	182	23.94	10.54	242		
3	16.81	3.41	63	18.96	5.56	123	20.79	7.39	183	24.19	10.79	243		
4	16.89	3.49	64	19.00	5.60	124	20.86	7.46	184	24.30	10.90	244		
5	16.92	3.52	65	19.01	5.61	125	21.20	7.80	185	24.34	10.94	245		
6	16.95	3.55	66	19.02	5.62	126	21.27	7.87	186	24.41	11.01	246		
7	16.94	3.54	67	19.03	5.63	127	21.32	7.92	187	24.42	11.02	247		
8	16.95	3.55	68	19.04	5.64	128	21.35	7.95	188	24.45	11.05	248		
9	16.95	3.55	69	19.05	5.65	129	21.38	7.98	189	24.48	11.08	249		
10	16.96	3.56	70	19.05	5.65	130	21.43	8.03	190	24.51	11.11	250		
15	16.99	3.59	75	19.07	5.67	135	21.45	8.05	195	24.53	11.13	255		
20	17.00	3.60	80	19.09	5.69	140	21.48	8.08	200	24.54	11.14	260		
25	17.02	3.62	85	19.10	5.70	145	21.49	8.09	205	24.55	11.15	265		
30	17.02	3.62	90	19.12	5.72	150	21.49	8.09	210	24.57	11.17	270		
35	17.03	3.63	95	19.13	5.73	155	21.48	8.08	215	24.59	11.19	275		
40	17.03	3.63	100	19.15	5.75	160	21.48	8.08	220	24.60	11.20	280		
45	17.03	3.63	105	19.15	5.75	165	21.49	8.09	225	24.59	11.19	285		
50	17.03	3.63	110	19.15	5.75	170	21.50	8.10	230	24.60	11.20	290		
55	17.03	3.63	115	19.16	5.76	175	21.50	8.10	235	24.61	11.21	295		
60	17.03	3.63	120	19.16	5.76	180	21.51	8.11	240	24.61	11.21	300		
75												315		
90												330		
105												345		
120												360		
135												375		
150												390		
165												405		
180												420		
195												435		
210												450		
225												465		
240												480		
255												495		
270												510		

Chart of Step Test Data



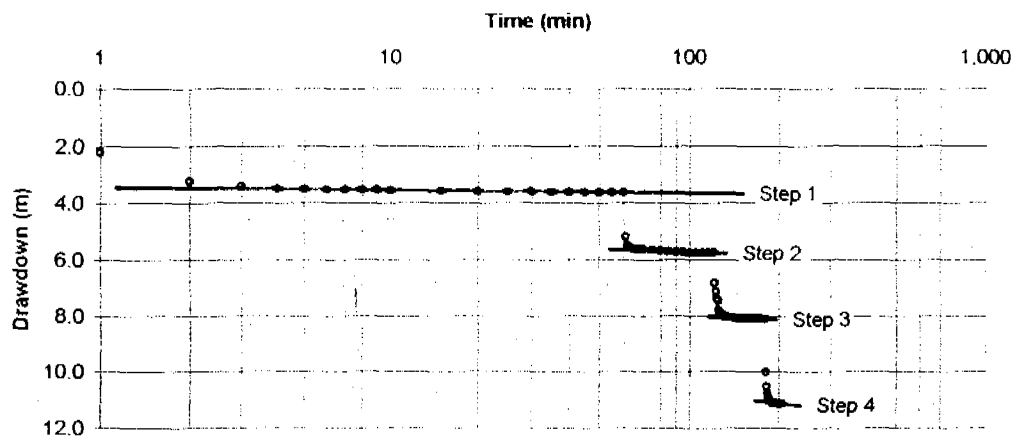
Old Saasabi 062/H/18/BH-1

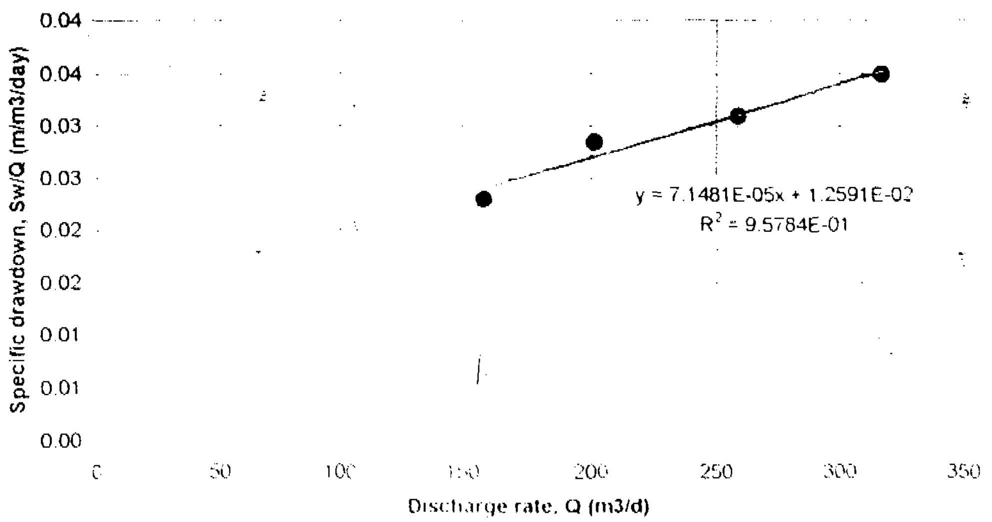
Project : RWST
District : Ga
Community : Old Saasabi
Name of Well : 062/H/18/BH-1
Borehole Depth : 45 m
Pump Setting : 33 m
Measured by : VENT-3 Ltd
Interpreted by : ENDD

Length of Each Step : 60 min
Number of Steps : 4
Reference point : Top of PVC
Height above ground : 0.72m m
Depth to Static Water Level : 13.4 m
Pump on : 08/02/2003 9:30 PM
Pump off : 08/02/2003 11:55 PM

Bierschenk Wilson Step Test Analysis						
Step	Discharge	Measured Sw	Sw/Q	Calc. Sw	Well Loss (m)*	Well Loss (%)*
Step 1	158.4 m3/d	3.6 m	0.0229	3.8	1.79	47.35%
Step 2	201.6 m3/d	5.[illegible] m	0.0284	5.4	2.91	53.37%
Step 3	259.2 m3/d	8.[illegible] m	0.0310	8.1	4.80	59.54%
Step 4	316.8 m3/d	11.1 m	0.0349	11.2	7.17	64.27%
Well Drawdown Equation at 60 min pumping : sw = 0.0125911821340293Q + 7.14814652695305E-05Q(2)						
Estimated Transmissivity (Logan 1964) : 96.9 m2/d						

** Note that well losses includes turbulent flow losses within the aquifer*





Old Saasabi 062/H/18/BH-1 Constant Rate Test

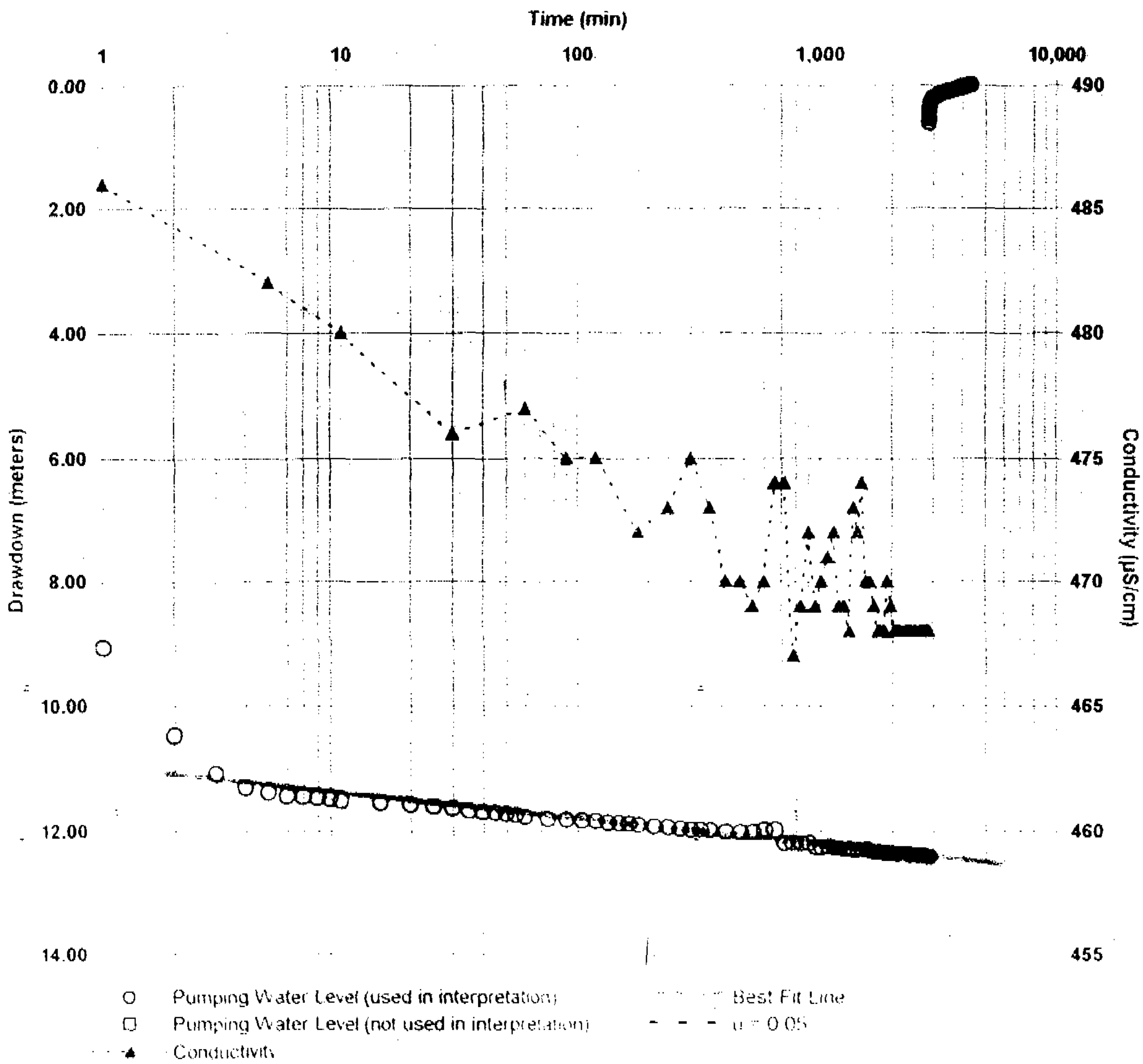
Project : CWSA
District : Ga
Community : Old Saasabi
Pumping Well : 062/H/18/BH-1
Observation Well : 062/H/18/BH-1
Borehole Depth : 45m
Pump Setting : 33m
Height of datum : 0.72m amgl

Distance to Pumping Well : 0.1 m
Pumping rate : 316.8 m3/d
Static Water level : 13.4 m
Measurement Datum : Top of PVC
Pump on : 08/02/2003 6:00:00 PM
Pump off : 10/02/2003 6:00:00 PM
Measured by : VENT-3
Interpreted by : ENDD

Transmissivity : 139.42 m^2/d

Mean Fitting Error : 1,569.10 %
Drawdown over 1 log cycle : 0.4158 m

Straight Line Pumping Test Analysis (Cooper & Jakob, 1946)
Note that this method does not apply to data when u > 0.05, to the left of the dotted line and that Storativity cannot be calculated without observation wells



Old Saasabi 062/H/18/BH-1 Constant Rate Test

Project : CWSA
District : Ga
Community : Old Saasabi
Pumping Well : 062/H/18/BH-1
Observation Well : 062/H/18/BH-1
Borehole Depth : 45m
Pump Setting : 33m
Height of datum : 0.72m amgl

Distance to Pumping Well : 0.1 m
Pumping rate : 316.8 m3/d
Static Water level : 13.40 m
Measurement Datum : Top of PVC
Pump on : 08/02/2003 6:00:00 PM
Pump off : 10/02/2003 6:00:00 PM
Measured by : VENT-3
Interpreted by : ENDD

#N/A

Data #	Time (GMT)	Time (min)	Water level (meters)	Discharge (l/min)	Cond. (µS/cm)	Drawdown (meters)	Calculated Drawdown	Error %	Included in analysis
1	18:01	1.0	22.47	220.0	486	9.07	10.96	20.8	yes
2	18:03	2.0	23.88			10.48	11.08	5.8	yes
3	18:04	3.0	24.48			11.08	11.16	0.7	yes
4	18:05	4.0	24.71			11.31	11.21	0.9	yes
5	18:06	5.0	24.79	220.0	482	11.39	11.25	1.2	yes
6	18:07	6.0	24.84			11.44	11.28	1.4	yes
7	18:08	7.0	24.85			11.45	11.31	1.2	yes
8	18:09	8.0	24.87			11.47	11.33	1.2	yes
9	18:10	9.0	24.89			11.49	11.36	1.2	yes
10	18:11	10.0	24.91		480	11.51	11.38	1.2	yes
11	18:16	15.0	24.94			11.54	11.45	0.8	yes
12	18:21	20.0	24.97			11.57	11.50	0.6	yes
13	18:26	25.0	25.00			11.60	11.54	0.5	yes
14	18:31	30.0	25.03	220.0	476	11.63	11.57	0.5	yes
15	18:36	35.0	25.07			11.67	11.60	0.6	yes
16	18:41	40.0	25.09			11.69	11.63	0.6	yes
17	18:46	45.0	25.10			11.70	11.65	0.5	yes
18	18:51	50.0	25.12			11.72	11.67	0.5	yes
19	18:56	55.0	25.14			11.74	11.68	0.5	yes
20	19:01	60.0	25.17	220.0	477	11.77	11.70	0.6	yes
21	19:16	75.0	25.20			11.80	11.74	0.5	yes
22	19:31	90.0	25.21	220.0	475	11.81	11.77	0.3	yes
23	19:46	105.0	25.23			11.83	11.80	0.3	yes
24	20:01	120.0	25.24	220.0	475	11.84	11.82	0.1	yes
25	20:16	135.0	25.26			11.86	11.85	0.1	yes
26	20:31	150.0	25.27			11.87	11.86	0.0	yes
27	20:46	165.0	25.28			11.88	11.88	0.0	yes
28	21:01	180.0	25.30	220.0	472	11.90	11.90	0.0	yes
29	21:31	210.0	25.33			11.93	11.93	0.0	yes
30	22:01	240.0	25.34	220.0	473	11.94	11.95	0.1	yes
31	22:31	270.0	25.36			11.96	11.97	0.1	yes
32	23:01	300.0	25.38	220.0	475	11.98	11.99	0.1	yes
33	23:31	330.0	25.38			11.98	12.01	0.2	yes
34	00:01	360.0	25.39	220.0	473	11.99	12.02	0.3	yes
35	01:01	420.0	25.42	220.0	470	12.02	12.05	0.3	yes
36	02:01	480.0	25.42	220.0	470	12.02	12.07	0.5	yes
37	03:01	540.0	25.42	220.0	469	12.02	12.10	0.6	yes
38	04:01	600.0	25.38	220.0	470	11.98	12.11	1.1	yes
39	05:01	660.0	25.38	220.0	474	11.98	12.13	1.3	yes
40	06:01	720.0	25.60	220.0	474	12.20	12.15	0.4	yes
41	07:01	780.0	25.60	220.0	467	12.20	12.16	0.3	yes
42	08:01	840.0	25.60	220.0	469	12.20	12.18	0.2	yes
43	09:01	900.0	25.59	220.0	472	12.19	12.19	0.0	yes
44	10:01	960.0	25.66	220.0	469	12.26	12.20	0.5	yes
45	11:01	1,020.0	25.67	220.0	470	12.27	12.21	0.5	yes
46	12:01	1,080.0	25.65	220.0	471	12.25	12.22	0.2	yes
47	13:01	1,140.0	25.67	220.0	472	12.27	12.23	0.3	yes
48	14:01	1,200.0	25.68	220.0	469	12.28	12.24	0.3	yes
49	15:01	1,260.0	25.70	220.0	469	12.30	12.25	0.4	yes
50	16:01	1,320.0	25.69	220.0	468	12.29	12.26	0.3	yes
51	17:01	1,380.0	25.71	220.0	473	12.31	12.27	0.4	yes
52	18:01	1,440.0	25.71	220.0	472	12.31	12.27	0.3	yes
53	19:01	1,500.0	25.70	220.0	474	12.30	12.28	0.2	yes
54	20:01	1,560.0	25.69	220.0	470	12.29	12.29	0.0	yes
55	21:01	1,620.0	25.72	220.0	470	12.32	12.29	0.2	yes

Old Saasabi 062/H/18/BH-1 Constant Rate Test

Project : CWSA
District : Ga
Community : Old Saasabi
Pumping Well : 062/H/18/BH-1
Observation Well : 062/H/18/BH-1
Borehole Depth : 45m
Pump Setting : 33m
Height of datum : 0.72m amgl

Distance to Pumping Well : 0.1 m
Pumping rate : 316.8 m3/d
Static Water level : 13.40 m
Measurement Datum : Top of PVC
Pump on : 08/02/2003 6:00:00 PM
Pump off : 10/02/2003 6:00:00 PM
Measured by : VENT-3
Interpreted by : ENDD

#N/A

Data #	Time (GMT)	Time (min)	Water level (meters)	Discharge (l/min)	Cond. (µS/cm)	Drawdown (meters)	Calculated Drawdown	Error %	Included in analysis
56	22:01	1,680.0	25.74	220.0	469	12.34	12.30	0.3	yes
57	23:01	1,740.0	25.74	220.0	468	12.34	12.31	0.3	yes
58	00:01	1,800.0	25.75	220.0	468	12.35	12.31	0.3	yes
59	01:01	1,860.0	25.76	220.0	468	12.36	12.32	0.3	yes
60	02:01	1,920.0	25.76	220.0	470	12.36	12.32	0.3	yes
61	03:01	1,980.0	25.76	220.0	469	12.36	12.33	0.2	yes
62	04:01	2,040.0	25.77	220.0	468	12.37	12.34	0.3	yes
63	05:01	2,100.0	25.78	220.0	468	12.38	12.34	0.3	yes
64	06:01	2,160.0	25.77	220.0	468	12.37	12.35	0.2	yes
65	07:01	2,220.0	25.76	220.0	468	12.36	12.35	0.1	yes
66	08:01	2,280.0	25.77	220.0	468	12.37	12.36	0.1	yes
67	09:01	2,340.0	25.78	220.0	468	12.38	12.36	0.2	yes
68	10:01	2,400.0	25.80	220.0	468	12.40	12.37	0.3	yes
69	11:01	2,460.0	25.79	220.0	468	12.39	12.37	0.2	yes
70	12:01	2,520.0	25.80	220.0	468	12.40	12.37	0.2	yes
71	13:01	2,580.0	25.80	220.0	468	12.40	12.38	0.2	yes
72	14:01	2,640.0	25.80	220.0	468	12.40	12.38	0.1	yes
73	15:01	2,700.0	25.80	220.0	468	12.40	12.39	0.1	yes
74	16:01	2,760.0	25.80	220.0	468	12.40	12.39	0.1	yes
75	17:01	2,820.0	25.82	220.0	468	12.42	12.39	0.2	yes
76	18:01	2,880.0	25.82	220.0	468	12.42	12.40	0.2	yes
77	18:02	2,881.0	14.02	RECOVERY		0.62	12.40	1899.7	yes
78	18:03	2,882.0	14.01			0.61	12.40	1932.5	yes
79	18:04	2,883.0	13.95			0.55	12.40	2154.2	yes
80	18:05	2,884.0	13.92			0.52	12.40	2284.3	yes
81	18:06	2,885.0	13.89			0.49	12.40	2430.3	yes
82	18:07	2,886.0	13.87			0.47	12.40	2537.9	yes
83	18:08	2,887.0	13.85			0.45	12.40	2655.2	yes
84	18:09	2,888.0	13.84			0.44	12.40	2717.8	yes
85	18:10	2,889.0	13.83			0.43	12.40	2783.4	yes
86	18:11	2,890.0	13.82			0.42	12.40	2852.0	yes
87	18:16	2,895.0	13.78			0.38	12.40	3162.9	yes
88	18:21	2,900.0	13.76			0.36	12.40	3344.2	yes
89	18:26	2,905.0	13.74			0.34	12.40	3546.9	yes
90	18:31	2,910.0	13.72			0.32	12.40	3774.9	yes
91	18:36	2,915.0	13.70			0.30	12.40	4033.4	yes
92	18:41	2,920.0	13.69			0.29	12.40	4176.0	yes
93	18:46	2,925.0	13.68			0.28	12.40	4328.8	yes
94	18:51	2,930.0	13.67			0.27	12.40	4493.0	yes
95	18:56	2,935.0	13.66			0.26	12.40	4669.7	yes
96	19:01	2,940.0	13.66			0.26	12.40	4669.9	yes
97	19:16	2,955.0	13.64			0.24	12.40	5067.7	yes
98	19:31	2,970.0	13.63			0.23	12.40	5292.8	yes
99	19:46	2,985.0	13.62			0.22	12.40	5538.4	yes
100	20:01	3,000.0	13.62			0.22	12.41	5538.8	yes
101	20:16	3,015.0	13.61			0.21	12.41	5807.7	yes
102	20:31	3,030.0	13.61			0.21	12.41	5808.1	yes
103	20:46	3,045.0	13.60			0.20	12.41	6104.0	yes
104	21:01	3,060.0	13.60			0.20	12.41	6104.4	yes
105	21:31	3,090.0	13.58			0.18	12.41	6794.8	yes
106	22:01	3,120.0	13.57			0.17	12.41	7201.4	yes
107	22:31	3,150.0	13.56			0.16	12.41	7658.8	yes
108	23:01	3,180.0	13.56			0.16	12.42	7659.9	yes
109	23:31	3,210.0	13.55			0.15	12.42	8178.3	yes
110	00:01	3,240.0	13.54			0.14	12.42	8770.9	yes

Old Saasabi 062/H/18/BH-1 Constant Rate Test

Project : CWSA
District : Ga
Community : Old Saasabi
Pumping Well : 062/H/18/BH-1
Observation Well : 062/H/18/BH-1
Borehole Depth : 45m
Pump Setting : 33m
Height of datum : 0.72m amgl

Distance to Pumping Well : 0.1 m
Pumping rate : 316.8 m3/d
Static Water level : 13.40 m
Measurement Datum : Top of PVC
Pump on : 08/02/2003 6:00:00 PM
Pump off : 10/02/2003 6:00:00 PM
Measured by : VENT-3
Interpreted by : ENDD

#N/A

Data #	Time (GMT)	Time (min)	Water level (meters)	Discharge (l/min)	Cond. (µS/cm)	Drawdown (meters)	Calculated Drawdown	Error %	Included in analysis
111	01:01	3,300.0	13.53			0.13	12.42	9455.8	yes
112	02:01	3,360.0	13.52			0.12	12.43	10254.8	yes
113	03:01	3,420.0	13.51			0.11	12.43	11199.1	yes
114	04:01	3,480.0	13.50			0.10	12.43	12332.1	yes
115	05:01	3,540.0	13.50			0.10	12.44	12335.2	yes
116	06:01	3,600.0	13.49			0.09	12.44	13720.3	yes
117	07:01	3,660.0	13.48			0.08	12.44	15451.5	yes
118	08:01	3,720.0	13.47			0.07	12.44	17677.4	yes
119	09:01	3,780.0	13.46			0.06	12.45	20645.1	yes
120	10:01	3,840.0	13.45			0.05	12.45	24799.8	yes
121	11:01	3,900.0	13.44			0.04	12.45	31031.7	yes
122	12:01	3,960.0	13.43			0.03	12.46	41418.1	yes
123	13:01	4,020.0	13.44			0.04	12.46	31045.4	yes
124	14:01	4,080.0	13.43			0.03	12.46	41436.1	yes
125	15:01	4,140.0	13.42			0.02	12.46	62217.3	yes
126	16:01	4,200.0	13.41			0.01	12.47	124560.6	yes
127	17:01	4,260.0	13.40			0.00	12.47	#DIV/0!	yes
128	18:01	4,320.0	13.40			0.00	12.47	#DIV/0!	yes

Old Saasabi 062/H/18/BH-1

Estimated Maximum Sustainable Well Yield Calculation

Pumping Test & Borehole Parameters			
	220	l/min	Constant rate pumping test yield
Q	13.2	m^3/h	
	316.8	m^3/d	
$t_{pumptest}$	2,880	minutes	Pumping test duration
	2	days	
r	6.5	inch	Effective well diameter
	0.08255	m	Effective well radius
swl	13.4	m	Static water level below datum before pumping test
s	12.42	m	Drawdown at end of pumping test
Δs	0.4158	m	Change in drawdown over one log cycle of time
pwl_{max}	32	m	Maximum allowable pumping water level below datum
$\Delta s_{seasonal}$	3	m	Estimated seasonal water level decline
s_{max}	15.6	m	Maximum allowable drawdown
T	139.42	m^2/d	Transmissivity calculated from pumping test data
S_{min}	0.005		Minimum likely storativity
S_{max}	0.03		Maximum likely storativity
$E_{steptest}$	0.36		Well efficiency estimated from step test
E_{min}	0.24		Well efficiency estimated from Transmissivity & minimum likely Storativity
E_{max}	0.22		Well efficiency estimated from Transmissivity & maximum likely Storativity
E_{min}	0.24		Well Efficiency used for calculations. E = 1 if calculated E > 1
E_{max}	0.22		Well Efficiency used for calculations. E = 1 if calculated E > 1
t	300	d	Length of hydrological year without recharge - the time between two rainy seasons

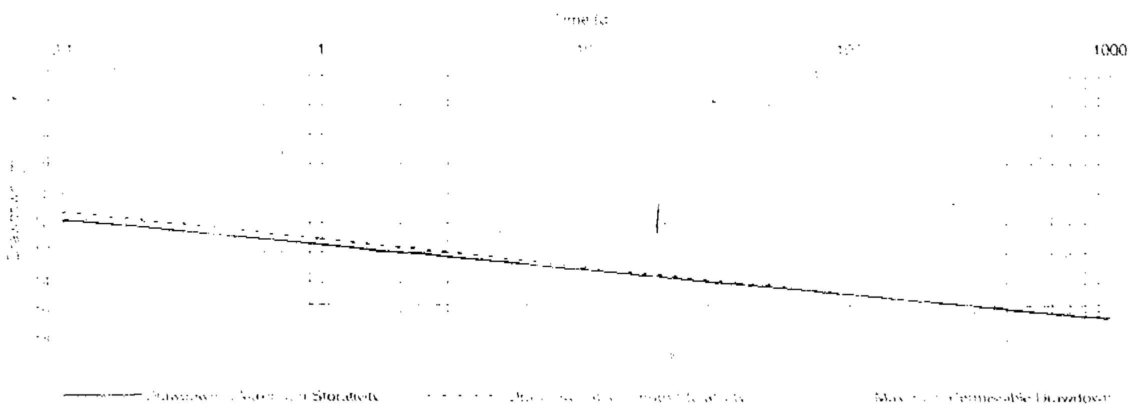
$$Q_{max} = \frac{E \cdot s_{max} \cdot T}{0.183 \log (2.25\, Tt / r^2 S)}$$

The sustainable yield formula is based on the Modified Nonequilibrium Equation. Cooper & Jakob (1946)

Estimated Maximum Sustainable Well Yield at Continuous 24/24 Hour Pumping										
Qmax	Q_{max} (1a)		Q_{max} (1b)		Q_{max} (2a)		Q_{max} (2b)		Lowest Q_{max}	
S	0.005		0.03		0.005		0.03		0.03	
E	0.36		0.36		0.24		0.22		0.217186233	
24/24 h Pumping Cycle	453 m^3/d	18.9 m^3/h	494 m^3/d	20.6 m^3/h	306 m^3/d	12.8 m^3/h	298 m^3/d	12.4 m^3/h	298 m^3/d	12.4 m^3/h

Note that these estimates are very theoretical and that all production wells should be monitored regularly

Predicted Drawdown at Estimated Maximum Sustainable Yield



Old Saasabi 062/H/18/BH-1

Estimated Maximum Sustainable Well Yield Calculation

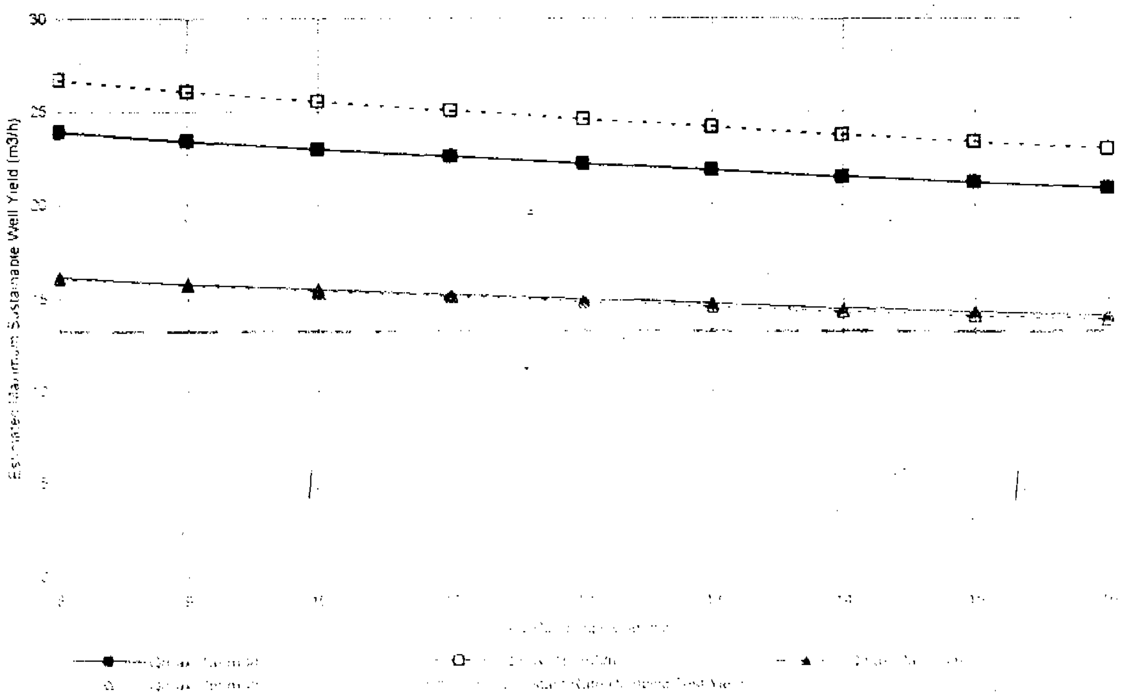
$$Q_{max} = \frac{E \,.\, 0.228 \,.\, s_{max} \,.\, T}{t_1 \log(t_2 - 1 + t_1/t_1) + \log(2.25\, Tt_1/(r^2 S))}$$

The sustainable yield formula for intermittent pumping is based on the Modified Nonequilibrium Equation, Cooper & Jakob (1946) and the imaginary well procedure outlined in "Groundwater & Wells" Driscoll, 1986

Estimated Maximum Sustainable Well Yields at Intermittent Pumping Rates										
	Q_{max} (1a)		Q_{max} (1b)		Q_{max} (2a)		Q_{max} (2b)		Lowest Q_{max}	
S	0.005		0.03		0.005		0.03		-	
E	0.36		0.36		0.24		0.22		-	
Daily Pumping Cycle (hrs)	Q_{max} (1a) m^3/h	Volume (1a) m^3/d	Q_{max} (1b) m^3/h	Volume (1b) m^3/d	Q_{max} (2a) m^3/h	Volume (2a) m^3/d	Q_{max} (2b) m^3/h	Volume (2b) m^3/d	Lowest Q_{max} m^3/h	Lowest Volume m^3/d
8	23.9	191	26.7	213	16.1	129	16.1	129	16.1	129
9	23.4	211	26.1	235	15.8	142	15.7	142	15.7	142
10	23.0	230	25.5	255	15.5	155	15.4	154	15.4	154
11	22.6	248	25.0	275	15.2	168	15.1	166	15.1	166
12	22.2	266	24.5	295	15.0	180	14.8	178	14.8	178
13	21.8	284	24.1	313	14.7	192	14.5	189	14.5	189
14	21.5	301	23.7	332	14.5	203	14.3	200	14.3	200
15	21.2	317	23.3	350	14.3	214	14.1	211	14.1	211
16	20.9	334	23.0	367	14.1	226	13.8	222	13.8	222

Note that these estimates are very theoretical and that all production wells should be monitored regularly.
It is unwise to select a pumping rate that exceeds those used during the pumping tests, without further tests.

Estimated Maximum Sustainable Well Yields at Intermittent Pumping Rates



Old Saasabi 062/H/18/BH-1

Estimated Maximum Sustainable Well Yield Calculation

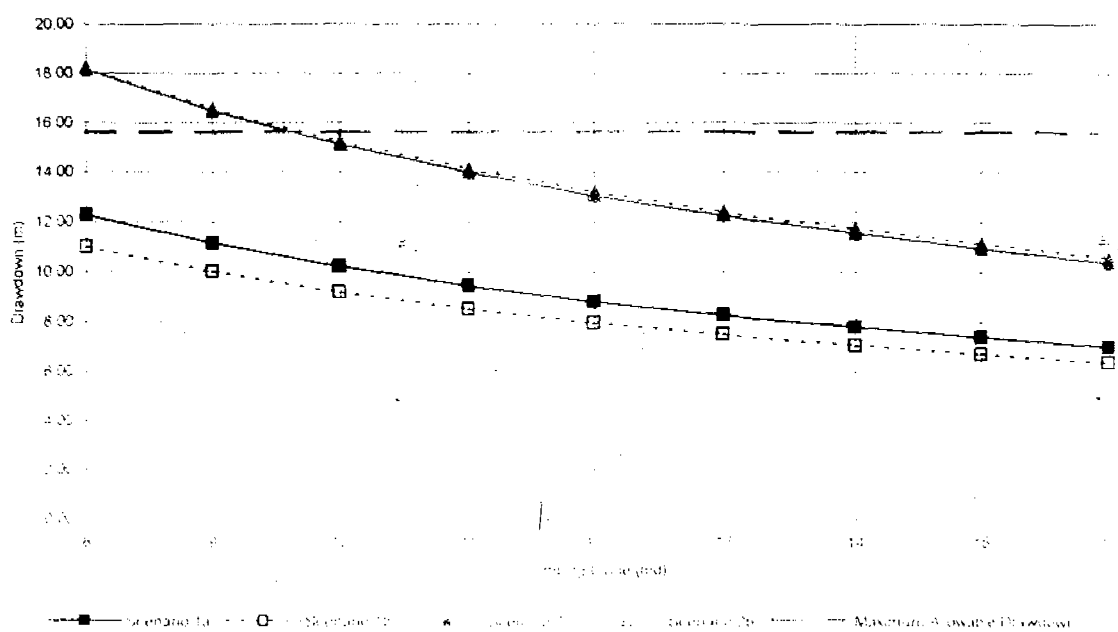
$$s = \frac{0.183\,Q}{E.T}\left[t_1 \log\left((t_2 - 1 + t_1)/t_1\right) + \log\left(2.25\,Tt_1/(r^2S)\right)\right]$$

The formula for estimated drawdown due to intermittent pumping is based on the imaginary well procedure outlined in "Groundwater & Wells", Driscoll, 1986

Estimated Drawdown at Intermittent Pumping Rates						
		Scenario	1a	1b	2a	2b
		Storativity (S)	0.005	0.03	0.005	0.03
		Well Efficiency (E)	0.36	0.36	0.24	0.22
Water Demand (m^3/d)	Daily Pumping Cycle (hrs)	Q_{abs} m^3/h	Estimated Drawdown (m) at end of Dry Season	Estimated Drawdown (m) at end of Dry Season	Estimated Drawdown (m) at end of Dry Season	Estimated Drawdown (m) at end of Dry Season
150.0	8	18.8	12.3	11.0	18.1	18.2
	9	16.7	11.1	10.0	16.5	16.6
	10	15.0	10.2	9.2	15.1	15.2
	11	13.6	9.4	8.5	14.0	14.1
	12	12.5	8.8	8.0	13.0	13.2
	13	11.5	8.3	7.5	12.2	12.4
	14	10.7	7.8	7.1	11.5	11.7
	15	10.0	7.4	6.7	10.9	11.1
	16	9.4	7.0	6.4	10.4	10.6

Note that these estimates are very theoretical and that all production wells should be monitored regularly

Estimated Drawdown at the End of the Dry Season at Various Pumping Cycles



Water Demand = 150 m3.d

Note that drawdown cannot exceed the maximum allowable drawdown s_{max}

ANNEX 3

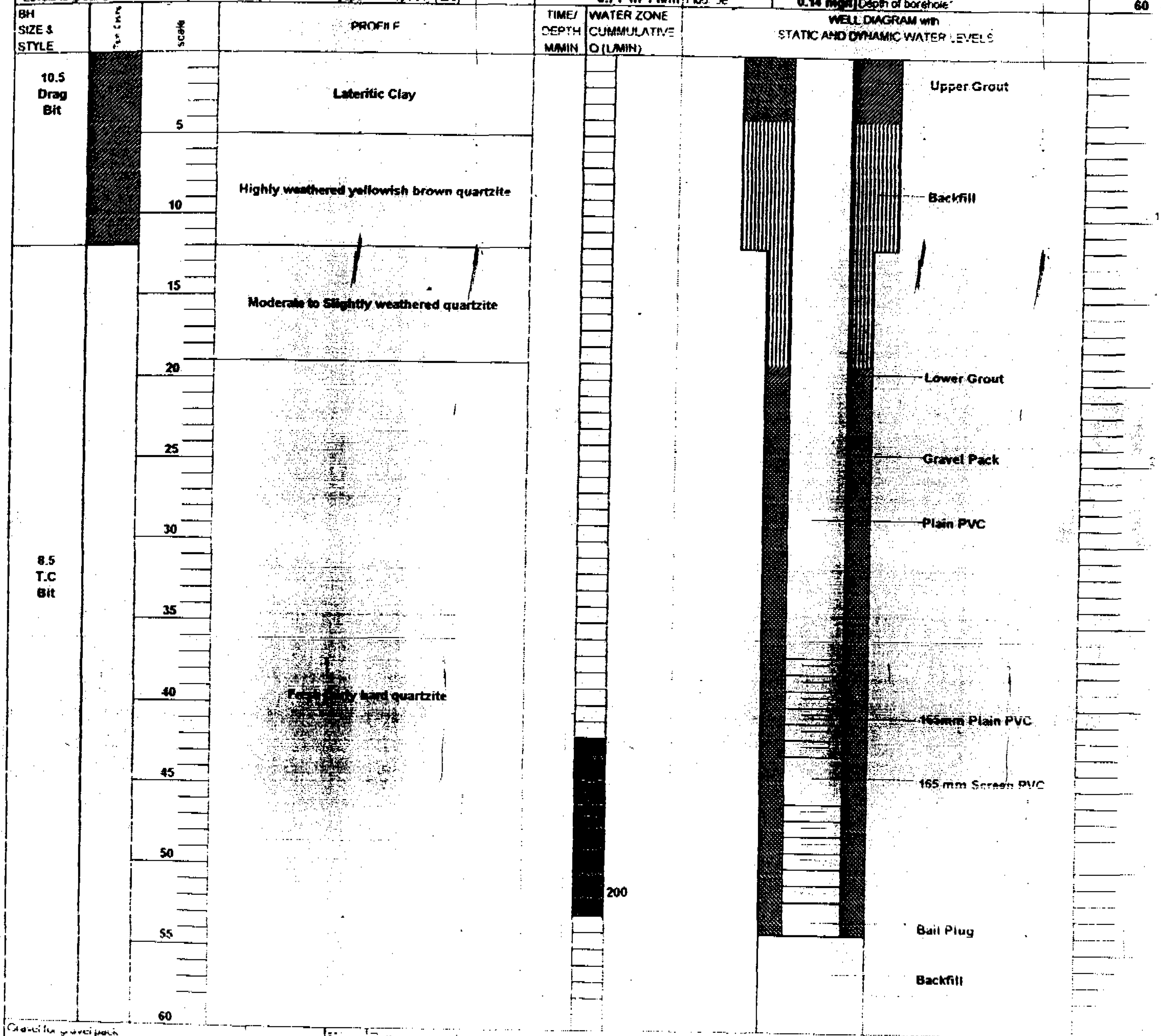
Geophysics ref. No B 30

Greater Accra Region Community Water and Sanitation Programme

BH Status: Successful

BOREHOLE RECORD

Community	KPONE SEDUASI	BH REF No	062-H-06-BOO	Nat. Grid ref			
Drilling Contractor	VENT 3 LIMITED		ROTARY			AIR / MUD DRILLING	
Drilling Start date	26-08-02	Complet. Date	27-08-02	Operator		F. OSEI	
TEST PUMPING		Date	24-09-02	Conductivity	609 us/cm	Top of Screen*	37
Dynamic WL	20.60 m	Pump type	Submersible	Total Iron	0.09 mg/l	Static WL*	
Static WL	5.34 m	Pumping rate (Q)	10.8 m³/h	Manganese	0.07mg/l	Potential drawdown	
Drawdown (s)	15.26 m	Duration	48 h	Nitrate	0.01 mg/l	Potential Yield	m
*Levels to ground level datum		Specific Capacity (Q/s)	0.71 m³/h/m	Fluoride	0.14 mg/l	Depth of borehole*	60



Gravel for gravel pack		
Cement for grouting	0.2	KG
Bentonite for grouting	100	KG
Installation of grout seal	5	M3
Cleaning and Development	2	HRS
Centralizers Fitted	Yes	No
Safety cap fitted	Yes	No
Paddle/shoe fitted	Yes	No
Disinfection Date		
Platform construction date		
Platform transport aquat.		
Distance from Last Borehole		KM

Prepared:

Certified:

Approved:

UNIHYDRO LIMITED

(Contractor)

GAR Project Hydrogeologist

GAR Hydrogeologist

WATER RESEARCH INSTITUTE, (CSIR)
RESULTS OF WATER QUALITY ANALYSIS FOR
EASTERN RCWS PROGRAMME

Community: KPONE SEDUASE
District:
Source Name:

Location Code:
Source Ref. No.
Date: 27/09/02

Parameter	Units	GWCL Guideline values	Permissible limits	Sample Value
Turbidity	NTU	0 - 5		1
Color (Apparent)	Hz	0 - 15	50	<5
Color (True)	Hz	0 - 15	25	<5
pH		6.5 - 8.5	> 5.0	6
Electrical Conductivity	µS/cm			609
Total Suspended Solids (TSS)	mg/l	0		0.4
Total Dissolved Solids (TDS)	mg/l	1000		396
Sodium (Na+)	mg/l			42.3
Potassium (K+)	mg/l			2.5
Calcium (Ca2+)	mg/l	No health related guideline		20
Magnesium(Mg)	mg/l			16
Total Iron (Fe)	mg/l	0 - 0.3	1	0.09
Manganese (Mn)	mg/l	0 - 0.1	0.5	0.07
Ammonia (NH3-N)	mg/l	0 - 0.5		<0.01
Chloride (Cl-)	mg/l	0 - 250	600	99.3
Sulphate (SO42-)	mg/l	0 - 400		0
Nitrite(NO2-N)	mg/l	0 - 3.0		<0.01
Nitrate (NO3-N)	mg/l	0 - 10	50	0.01
Total Alkalinity	mg/l	No health related guideline		56
Permanent Hardness	mg/l			50.9
Temporary Hardness	mg/m			50.1
Fluoride (F-)	mg/l	0 - 1.5		0.14
Bicarbonate	mg/l			68.3
Carbonate	mg/l			0
Ionic Balance	%		(- 5 to 5)	-3.65

MPN (Total Coliform 10/100ml)		(Untreated suppliers)		0.00
MPN (Faecal Coliform 10/100ml)		0	50	0

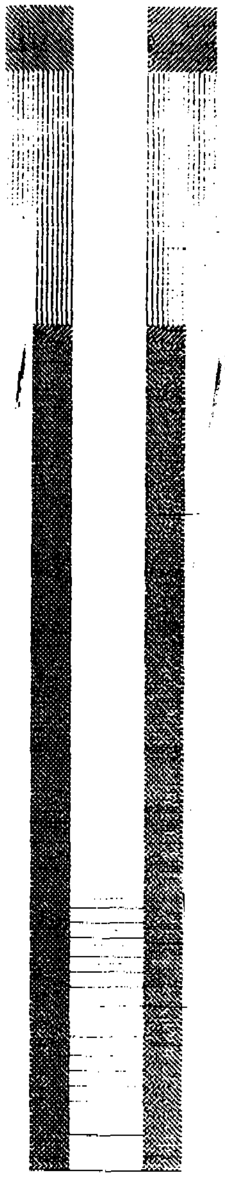
Remarks: The physico-chemical and bacteriological quality of the water sample are satisfactory. The water is recommended for potable use.

Greater Accra Region Community Water and Sanitation Project

BOREHOLE RECORD

20.31 m
49
28.9
Submerged table
0.41
1050 uS/cm
0.01 mg/l
0.04 mg/l
9.8 mg/l
0.12 mg/l

0–20	Highly weathered ... brown ...
20–40	Moderate to slightly weathered greenish grey phyllite
40–55	Slightly weathered light grey acidic gneiss
55–75	Slightly weathered semi-hard acidic gneiss



BOREHOLE RECORD

OLD SAASABI — BH REF. No. 062-H-18-BO1

22-08-02 — Complet. Date 23-08-02 — Operator OSEI

TEST PUMPING

24.09 m	15-09-02	1006 us/cm	
13.90 m	Submersible	0.26 mg/l	
10.19 m	10.8 m³/h	0.13 mg/l	
	6 h	0.02 mg/l	
	1.06 m³/h/m	0.1 mg/l	

8.5 Drag Bit

Stiff chocolate brown clay

Highly weathered pale yellowish brown acid gneiss

Moderate to slightly weathered acid gneiss

Fresh hard acid gniess

6.5 DTH

50

112

140

Upper Grout

Backfill

Lower Grout

Gravel Pack

Bail Plug

0.15

100

1

UNIHYDRO LIMITED

WATER RESEARCH INSTITUTE, (CSIR)
RESULTS OF WATER QUALITY ANALYSIS FOR EASTERN
RCWS PROGRAMME

Community: OYIBI (AFTER 48 HRS)
District:
Source Name:

Location Code:
Source Ref. No:
Date: 20/10/02

Parameter	Units	GWCL Guideline values	Permissible limits	Sample Value
Turbidity	NTU	0 - 5		1.8
Color (True)	Hz	0 - 5	25	<5
Color (Apparent)	Hz	0 - 15	50	<5
pH		6.5 - 8.5	> 5.0	5.7
Electrical Conductivity	µS/cm			1850
Total Suspended Solids (TSS)	mg/l	0		0.4
Total Dissolved Solids (TDS)	mg/l	1000		1036
Sodium (Na+)	mg/l			48.4
Potassium (K+)	mg/l			7.7
Calcium (Ca2+)	mg/l	No health related guideline		59.3
Magnesium(Mg)	mg/l			52.4
Total Iron (Fe)	mg/l	0 - 0.3	1	0.01
Manganese (Mn)	mg/l	0 - 0.1		0.04
Ammonia (NH3-N)	mg/l	0 - 0.5		<0.01
Chloride (Cl-)	mg/l	0 - 250	600	240
Sulphate (SO42-)	mg/l	0 - 400		38.9
Nitrite(NO2-N)	mg/l	0 - 3.0		<0.01
Nitrate (NO3-N)	mg/l	0 - 10	50	9.6
Total Alkalinity	mg/l	No health related guideline		48
Permanent Hardness	mg/l			216
Temporary Hardness				146
Fluoride (F-)	mg/l	0 - 1.5		0.12
Bicarbonate	mg/l			58.6
Carbonate	mg/l			[illegible]
Ionic Balance			(-5 to 5)	[illegible]

REMARKS: The [illegible] of the water sample were satisfactory
The water is [illegible]

ANNEX 4

T I T L E	:	G.A.R. Rural W.S.(Trans. Net.)
NO. OF PIPES	:	19
NO. OF NODES	:	20
PEAK FACTOR	:	1
MAX HEADLOSS/Km	:	10
MAX UNBAL(LPS)	:	0

PIPE NO.	FROM Node	TO Node	LENGTH (M)	DIA (MM)	HWC	FLOW (LPS)	VELOCITY (MPS)	HEADLOSS (M/KM)	HEADLOSS (M)
1	101	100	35.00	100	130	2.80	0.36	1.83	0.06
2	100	1	100.00	150	130	2.80	0.16LO	0.25	0.03
3	1	300	50.00	12	130	0.15	1.33	250.28HI	12.51
4	1	2	1600.00	150	130	2.65	0.15LO	0.23	0.37
5	6	2	1650.00	100	130	2.79	0.36	1.82	3.01
6	201	200	45.00	100	130	3.50	0.45	2.77	0.12
7	200	6	100.00	150	130	3.50	0.20LO	0.38	0.04
8	7	400	100.00	20	130	0.71	2.26	366.47HI	36.65
9	6	7	400.00	150	130	0.71	0.04LO	0.02	0.01
10	2	10	2200.00	150	130	5.44	0.31	0.87	1.91
11	11	500	100.00	150	130	2.96	0.17LO	0.28	0.03
13	10	3	1250.00	150	130	2.48	0.14LO	0.20	0.26
14	3	700	100.00	12	130	0.08	0.72	79.76HI	7.98
15	3	4	1300.00	100	130	2.40	0.31	1.38	1.80
16	4	800	100.00	40	130	1.36	1.08	41.79HI	4.18
17	4	5	1100.00	100	130	1.04	0.13LO	0.30	0.32
18	5	900	150.00	12	130	0.07	0.61	59.03HI	8.85
19	5	901	3650.00	75	130	0.97	0.22LO	1.06	3.85
20	10	11	100.00	100	130	2.96	0.38	2.03	0.20

NODE NO.	FLOW (LPS)	ELEVATION (M)	H G L (M)	PRESSURE (M)
1	0.000	99.91	132.51	32.60
2	0.000	77.41	132.15	54.74
3	0.000	101.60	129.98	28.38
4	0.000	109.10	128.18	19.08
5	0.000	93.20	127.85	34.65
6	0.000	77.50	135.16	57.66
7	0.000	78.50	135.15	56.65
10	0.000	112.40	130.23	17.83
11	0.000	112.00	130.03	18.03
100	0.000	98.50	132.54	34.04
101	2.800	63.50	132.60	69.10
200	0.000	77.50	135.19	57.69
201	3.500	32.50	135.32	102.82
300 R	-0.150	99.91	120.00	20.09
400 R	-0.709	79.00	98.50	19.50
500 R	-2.957	112.00	130.00	18.00
700 R	-0.081	102.00	122.00	20.00

NODE NO.	FLOW (LPS)	ELEVATION (M)	H G L (M)	PRESSURE (M)
800 R	-1.360	109.00	124.00	15.00
900 R	-0.069	99.65	119.00	19.35
901 R	-0.974	103.76	124.00	20.24