Stampriet Vacuum Sewer System

Preliminary Assessment from 27-30/06/2011 for Performance Support and Capacity Building

Contents

1. BACKGROUND

A DRFN Associates/Stampriet Village Council Performance Support Team did a preliminary assessment to determine the **level and volume of performance support and capacity development needs** required for the Stampriet vacuum sewer system. The vacuum pumps of this system are constantly running, however, it was reported that the system does not meet its purpose. This preliminary assessment was carried out on 27.06 until 30.06 2011.

2. SCOPE AND LIMITATIONS

The limited scope of this preliminary assessment:

- **visual inspection** of the collection chambers and pipe network layout
- **visual inspection** of vacuum station and machinery (oil levels in vacuum pumps, unusual noises, loose parts, power on/off, general conditions etc.)
- observing existing **human resources capacity and constraints**
- observing the **managerial effectiveness capacity** of the technical staff entrusted with daily O&M
- observing existing **enablers** and **technology integration constraints**
- first **trouble shooting** through information gathering and information sharing
- based on a **rapid assessment** establishing **performance support needs** for vacuum sewer system.

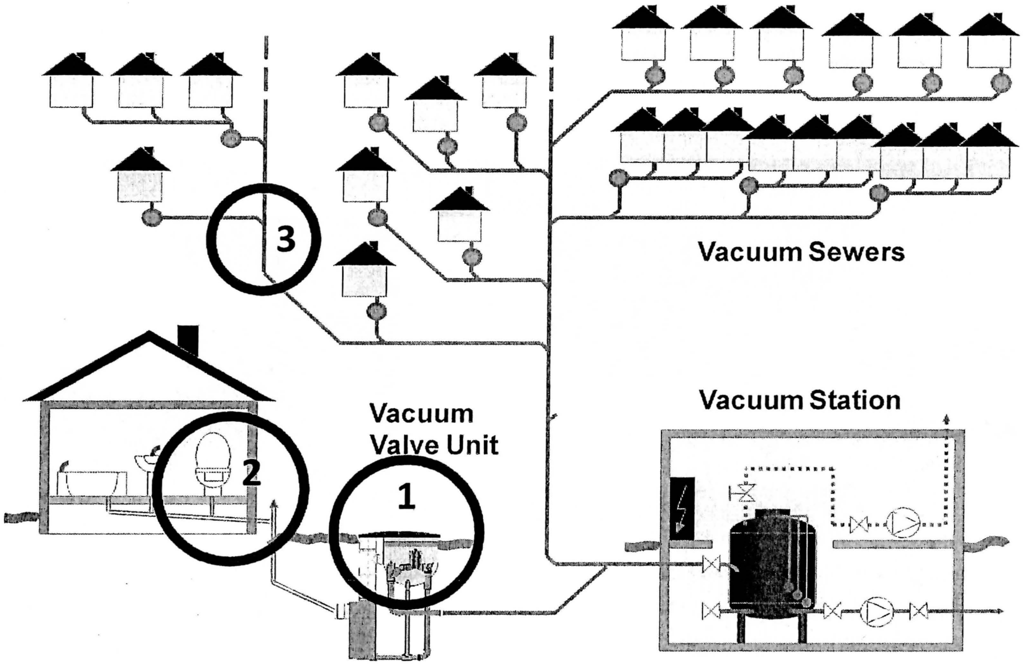
Excluded in this preliminary assessment:

- tracer studies and waste water flow measurements to understand response times and volumes transported for steering, maintenance planning and costing of services (*needs sophisticated equipment, data logging*)
- detailed vacuum tests at various vacuum test points in the village (*needs provision of as-built and as-tested information and preferably a digital vacuum gauge with data logger*)
- detailed machinery and equipment tests for proper functioning (*needs a variety of testing equipment*)
- setting performance standards (*needs management basics in place in Stampriet and benchmarking against successfully operating systems in Namibia and elsewhere*)
- observing and guiding operation and maintenance staff on emergency maintenance such as sucking out flooded valve chambers and collection sumps, exchanging and repairing dysfunctional interface valve units and vacuum control valves etc.

3. Summary of Technical Observations with System Overview

During the preliminary assessment, the vacuum sewer system in Stampriet was not performing as it is supposed to do. The vacuum pumps were constantly running, building up a maximum vacuum of -0.6 bar at the pump station. The vacuum dropped to -0.25 bar around 400m upstream dropped further to -0.05 bar along the furthest vacuum test points in south-east Stampriet Proper. This drop of vacuum caused the collection chambers in this part of the village to flood like some collection chambers further upstream in Soetdoring Laagte. It was further observed that lack of an adequately strong vacuum caused the main suction lines to the east to become water logged and that constant emergency maintenance is needed to convey at least some sewage. Many collection chambers were blocked with excessive solids and the area around them was flooded. Vacuum tests on such blocked collection chambers showed that the vacuum was not sufficient to operate the vacuum control valves or the interface valves.

A. Critical Interfaces (Users/Technology)

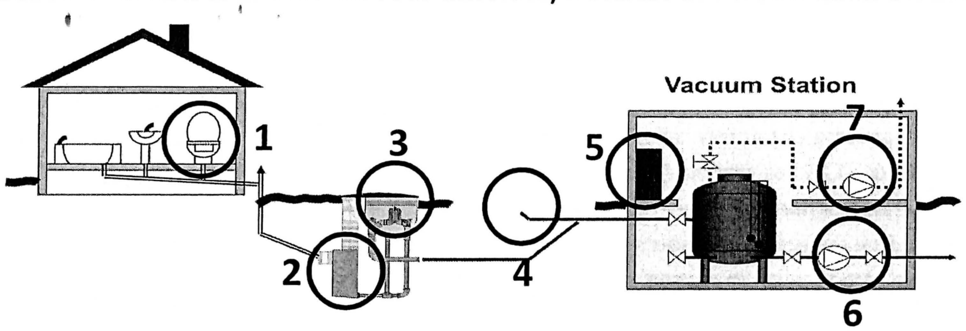


Critical interfaces between users and technology are marked with red circles

Three critical interfaces between users and technology need to be managed first. Only then can system functioning in Stampriet be tested.

- (circle 1) **security and protection of collection chambers and vacuum valve units** to avoid vandalism or "children just playing with lids or throwing stones and other solids down the collection sumps"
- (circle 2) **unwanted solids entry** into the system like shoes, rags, large bones, stones, news paper, plastic bags etc. at **household/user level** and
- (circle 3) **security and protection of protruding components** such as division valves and inspection pipes or **shallow and eroded vacuum pipes along sloped ground or in river bed** which can easily get damaged through traffic, fire, playing children, animals crossing etc.

B. Observed Interdependencies and Impacts/Burden of Major Components



Impacting Components in the System are marked with black circles

1	solids entry at household/user level(>40mm)
2	collection sump (av. 63mm pass into vacuum pipe)
3	interface valve (av. 35mm solids pass) and vacuum control valve (switch)
4	protruding components
5	central control unit (DB) in pump station; currently serves as "**indicator**" if observed timely and interpreted correctly
6	discharge pump(s) and non-return valves
7	vacuum pump(s)

Observed and disregarded interdependencies/cross impacts between components 1 to 7 from the above table

cross impact[1]	1	2	3	4	5	6	7
1	*none*[2]	sub-system blockage	sub-system blockage	system blockage[3]	*none*	system blockage	*none*
2	retains solids >63mm	sub-system blockage	flooding suffocating[4]	*none*	*none*[5]	system blockage[6]	*none*
3	retains solids >35mm	flooding and blockage	regeneration stops (flood)	*none*	*none*[7]	*none*	extended running[8]
4	"invitation to play"[9]	support blockage	support blockage	*none*	*none*[10]	support blockage	permanent running
5	*none*[11]	*none*	*none*	*none*	*none*[12]	*none*[13]	manages vac. pumps
6	*none*	*none*	*none*	*none*	ERROR message only	can run for too long	*none*
7	*none*	provide vacuum	provide vacuum	allow for vac. testing	supplies vacuum level	*none*	overheating wear & tear

The 'row-sum' represents the **impact strength on the whole system**; the 'column-sum' represents the **burden on a component** in the system (*is influenced by*). **Red cells** mark strong impacts, **orange cells** mark less strong impacts, **purple cells** mark disregarded impacts during planning and installation which are needed **to close feedback loops** (*disregarded impacts generally increase the burden on the whole system*) and **green cells** mark planned impacts. The system failure indicating colours (**red**, **orange**, **purple**) dominate in this cross impact analysis. Red arrows mark the interfaces user/technology.

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1 Cross impact refers to: components 1-7 in rows 1-7 **directly impact** on columns 1-7 which again represent components 1-7

2 **Ideally households/clients should receive appropriate instructions (poster, awareness sessions) about solids handling and disposal**

3 **Either washed in solids or thrown in solids through damaged inspection pipes cause system blockage**

4 **Flooding and suffocating of vacuum control valves did happen in underground version of vacuum chambers**

5 **Ideally there should be a blockage-signal to the control unit (DB) and further to the Technical Office in the VC**

6 **The solids still passing into the suction pipe of the collection sump obviously cause discharge pump blockage**

7 **Ideally there should be a "no-regeneration" signal to the control unit (DB) and further to the Technical Office in the VC**

8 E.g. dust or sewage or storm water entry into the vacuum control valves prevents them from regenerating

9 **Open or damaged inspections pipes seem to attract children to play** *(throwing stones and listen how they disappear)*

10 **Ideally there should be a "sudden vacuum drop"-signal to the control unit (DB) and further to the Technical Office in the VC**

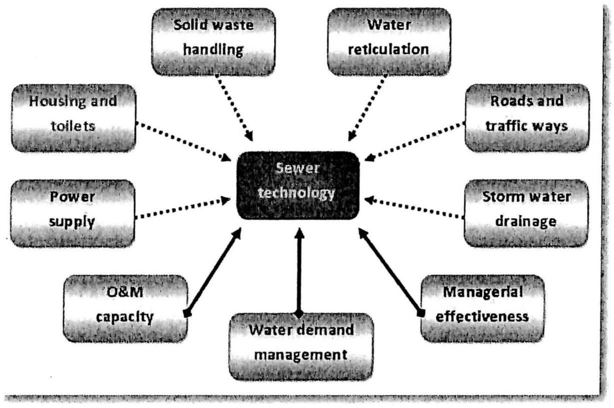
11 **Ideally households/users should receive appropriate feedback via the VC regarding "abnormal changes" and expected behaviour change**

12 **Ideally the DB should also serve as an interface monitoring unit to report "abnormal changes" to the Technical Office in the VC**

13 **There is no cut-off point installed to stop the pumps (only ERROR Message: 'pump is running too long')**

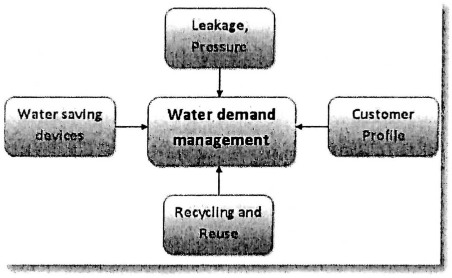
4. OBSERVED INTEGRATION CHALLENGES (WITH EXISTING TECHNOLOGIES)

Like previously in Kalkrand and Gibeon it was observed in Stampriet again that poor vacuum sewer technology performance primarily relates to the **lack of integration of the vacuum sewer technology into the <u>existing environment</u>** which in all three cases e.g. lacks appropriately designed and built road and traffic ways, storm water drainage etc. It is often observed that a lack of proper technology integration in an **environment needing substantial adaptation to accommodate a new technology** may eventually discredit an elsewhere proven and highly successful technology.



The simple MindMap above shows six *hardware* related -dotted arrows- and three *software* related **integration challenges** which are ideally taken into consideration **before** a system is installed and commissioned.

<u>Example 1</u>: Central to any planning effort should be **water demand management-** (*refer to detailed information and the Water Demand Management Strategy in the Integrated Water Resources Management Plan for Namibia, 2010*). The four key dependencies for **minimal WDM** may follow the planning card below. To master the 'first integration hurdle' the following four information blocks must be known and applied in the **technology selection** and subsequent preliminary design process:



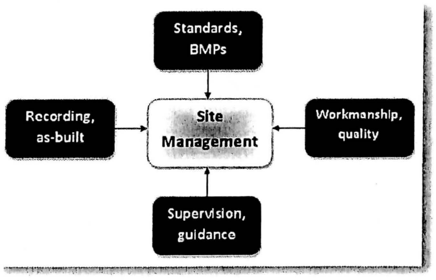
Four basic information blocks for technology selection and preliminary design

1. **Leakages** on the water reticulation network occurring throughout the village and **pressure management** of the network. If unknown like in Stampriet, a system may be under sized and the sewer technology may not perform satisfactorily, i.e. flooding with all negative health consequences will occur. (e.g. refer to PDHengineer.com, document No# C-4029)
2. The **water consumption customer profile** provides for water consumption distribution across a village and provides a good indication for sewer system sizing and layout. Again, if unknown like in Stampriet, a system may be under sized and the sewer technology will certainly not perform satisfactorily.
3. Understanding on-site collection and treatment options for **recycling and reuse** first to avoid bottlenecks in a sewer system and excessive material and energy use and future maintenance.
4. Integration of appropriate **water saving devices** like low flush toilets, low flow shower heads etc. to optimise sewer technology operation, maintenance and to save on villagers' budget (water, electricity, sewage disposal).

Example 2: Rural villages in Namibia have very basic or poor infrastructure in terms of their roads and water reticulation and drainage networks, and have poor sanitation facilities in general. Such villages have little income generating activities and have to battle hard to receive enough revenue to pay for water and electricity and very basic maintenance of other infrastructure. Unemployment and poverty levels are high in rural villages in Namibia with an overall unemployment rate above 50%. Deciding for the light duty, non flood protected vacuum valve units in such villages may soon after commissioning bring a negative image for the chosen vacuum sewer technology if road and traffic ways and storm water drainage are not built as per best design standards or if they are completely **missing** like in Kalkrand, Gibeon and Stampriet. To initially limit capital costs in an area where people can drive and water can flow everywhere **will certainly increase the recurrent costs and maintenance requirements** for such a technology. People will certainly drive over insufficiently secured and unprotected infrastructure and storm water will certainly infiltrate. Where there is **no storm water drainage system installed,** a moderate rainfall will end up forming large puddles in depressions or even forming small dams where the unprotected tracks were built higher than the surrounding erven levels. This will soon annul potential benefits and frustrate the users. In all three assessed villages 'dam building' and erosion is a key challenge which does not allow the installed technology and components to provide the full benefits to the user (benefits e.g. low ecological foot print, energy efficiency, water use efficiency, health&safety for the people etc.). In fact, the user has to cope with **flooded infrastructure** and related **health hazards.** The commendable effort to improve sanitation for the respective villages has become not credible not because of vacuum sewer technology failure in the first place but because of a **lack of appropriate technology selection, lack of technology integration, lack of adequate component selection** (the technology allows for component selection to accommodate integration) and **lack of adequate infrastructure protection** often paired with **poor site management** and **poor workmanship.**

Example 3: Ideally a **capacity threshold assessment** should be done before deciding on any sewer technology. Such an assessment provides the decision makers and eventually the planners and contractors with vital information to build **operation and management capacity** in the respective villages concurrently while installing the most appropriate system. Essentials coming from such an assessment relate to **O&M manuals design** (not one shoe fits all), procurement of **adequate storage/workshop facilities** and **tools** to perform maintenance tasks, developing the necessary **skills and attitudes** of the operation and maintenance team, procuring the best mix for a **spare parts inventory.** If this assessment is not done and villagers are not prepared accordingly, routine maintenance is neglected and emergency maintenance will have to kick in, increasing costs with all known consequences.

Example 4: A new sewer technology needs a **decent briefing and constant follow-through with regards to planning, procurement, construction and site supervision.** The planning card below shows the **minimal** information blocks needed.



1. The current **standards** and **best management practices** [BMPs] must be known by all parties (decision makers, planners, contractors, users). If unknown like in Stampriet, the work quite often has to be remedied or the job has to be done twice, increasing capital and recurrent costs. E.g. inspection/vacuum test points should be installed at maximum every 100 meters on suction lines and not only a handful across the village most of them sealed and buried, else water logged suction pipes and a flooded village remain a challenge.
2. **Workmanship and quality** need to be pre-defined. If not, the parties are forced into litigation.
3. **Guidance and supervision** must enable the contractors/workforce to meet the standards and BMPs.
4. **As-built and as-tested records** need to be kept and provided to the users. If not, operation and maintenance becomes a major challenge in itself.

5. OBSERVED SUSTAINABILITY CHALLENGES (RAPID ASSESSMENT)

The following is a rapid assessment of the vacuum sewer technology (design/procurement/construction/operation) in its environment (*client perspective*) with the aid of **20 sustainability imperatives** over four domains of human interference and benefit (*refer to Integrated Water Resources Management Plan for Namibia, Strategy and Action Plan and Integrated Framework for Institutional and Human Resources Capacity Building, 2010*). This rapid assessment fuzzyfies and smoothens the sustainability related observations and information obtained during the preliminary assessment to provide a 'barometer' glimpse. In this rapid assessment, the assessment variety is reduced with **imperative variety** being confined to: 'thumb up' = recognizable; 'thumb down' = not or poorly recognizable. Both indications are without the degree to which the respective imperative is met to provide for a first fuzzy but holistic overview and to show where improvements/adaptations could ideally be made through performance support and capacity building. The table below shows the four domains in columns and twenty sustainability imperatives in rows, assessed in 1|0 variety as in general yes/no. Again, such a rapid assessment does not go into details where some of them surely may matter. Instead it provides a first overview to better understand the direction of remedial efforts. The yellow highlighted fields **ought to be integrated** to allow for continued resource flows, use and benefits of the technology. Regarding the white field: here the focus must be on water and sanitation oriented client education and **integration into the social and cultural environment of the client** not the manufacturer/planner/supplier (a client focus is needed).

	ECOL [Ecology]	ECON [Economy]	SOC [Society]	TECH [Technology]
1.	innovative use of resources (*)	affordability	health&safety	'do it yourself'-suitability
2.	waste minimization	manageability	security and protection	extendibility of structures and processes
3.	energy use efficiency	value creation	integration in social and cultural environment	durability of materials and processes
4.	water use efficiency	cost recovery	attractiveness and acceptance	maintainability and serviceability
5.	land use efficiency	profitability	well being of people	adaptability to changing environment

The **blue icons** assess the vacuum sewer technology as it is experienced in a well managed 1st world environment (EC); the **red icons** assess the **integration/adaptation** of the said technology into the villagers' environment in Stampriet. I.e. what can the technology do for people in an **EC village (blue[14])?** ...and what did the planners/providers/contractors/operators do to support and/or enhance the inherent capabilities of the technology in the **system Stampriet (red)?** This system "Stampriet" includes {technology, people/users, internal constraints, boundary conditions, external influences/influxes of resources into Stampriet} and is **highly interconnected.** A more in depth study is recommended to understand this system "Stampriet" to provide management support also for other installations in Namibia (Kalkrand, Gibeon, Henties Bay, Ondangwa, Gobabis and in future for Outapi etc.).

(*)Addendum to the table above following cybernetic principles (*F. Vester; S. Beer et al.*): ***Innovative use of resources*** (*systemic use of resources*) is the first of the twenty sustainability imperatives and relates to natural, financial, human, information resources and their flow over time. It includes a subset of cybernetic principles which are: ***the principle of self regulation*** through negative feedback; ***the principle of multiple use*** such as serving a number of purposes/functions at the same time; ***the principle of recycling*** requiring the re-integration of processes, services or products; ***the principle of symbiosis*** or the exploitation of differences, mutual coupling and exchange; ***the principle of biological design*** through feedback planning and integration.

[14] The technology may not be the most 'user friendly' in the EC, it comes with a 'price tag': dependency on the manufacturer/supplier and 24/7 O&M, this has cost and tariff implications; e.g. for a 15mm connection the waste water basic is around N$250/m, the discharge tariff around N$ 35/m^3, this exludes the installation of the system for which users have to contribute per square metre property additional N$ 40.

A. NOTES TO THUMBS UP OR DOWN ICONS IN SUSTAINABILITY DOMAIN AND IMPERATIVES TABLE (*SUSTAINABILITY-BAROMETER*)

The rosé[15] highlighted cells indicate sustainability imperative ***deficiencies*** *of technology and integration, based on observations made during this preliminary assessment* <u>*and*</u> *feedback received from an EC village -similar in size as Kalkrand- on 12 years of 24/7 technology use. Both villages use the same technology.*

Mind: The purpose of a system is what it does, and a system does what it is established for! Only if all sustainability imperatives[16] - which are highly interconnected- <u>are met at the same time</u> system viability[17] may be given for that point in time.

imperative	technology capability (feedback)	integration of technology (Stampriet)
ECOL 1. innovative use of resources	👍 e.g. vacuum control valve **stabilizes and regenerates through negative feedback** and **multipurpose use of processes** (e.g. suction support and timed -5 sec- regeneration while mixing air/water for self cleaning and transport)	👎 **System stagnation** (water logging), system has no regenerating and self-starting capability, needs constant emergency management. Critical feedback loops are not installed or not observed in time, not interpreted correctly and communicated; dust and water entry in vacuum control valves causes system break down
ECOL 2. waste minimisation	👍 specific technology is designed for **waste separation at source** based on **strict EC waste minimization standards,** (e.g. also complete recycling and reuse of components and eventually the waste water itself)	👎 **waste separation at source and client education was not picked up,** current lack of integration allows for solid waste disposal into collection sumps or toilet pans blocking parts of or the entire system
ECOL 3. energy use efficiency	👍 **energy use efficiency is a design feature of the technology** (e.g. only sporadic discharge pumping and vacuum 'top-up' is needed to maintain the purpose of the system)	👎 **energy wastage** because system tipping point is unknown and no early warning and cut-off point installed (e.g. the **vacuum pumps run unproductively for days** without anybody noticing it; no early warning system/algedonic signal installed or observed and interpreted)
ECOL 4. water use efficiency	👍 **water use efficiency is designed into the technology as a basic EC requirement,** (it is a prerequisite in the EC for EC designed and manufactured technologies), using minimal additional water to maintain and clean the system; the system is in principle **self-cleaning** if fed with the right consistency and quality of waste water (e.g. air/water mix)	👎 **no water demand management measures observed and installed** in Stampriet households (e.g. customer profile, leakage management, low flush toilets, waste separation at source etc.). For details refer to customer profile: *water consumption pattern* in main report
ECOL 5. land use efficiency	👍 land use efficiency is designed into the technology requiring only a **small foot print** (e.g. small (de)centralised vacuum stations, narrow and shallow trenches for vacuum pipes etc.)	👎 **no land use efficiency** picked up in Stampriet, the dysfunctional system occupies 20-50 times the land surface it is built on due to constant overflow of collection sumps and flooding

[15] In b/w print this may be light grey in both right hand side columns (capability and integration)

[16] The four domain/twenty imperatives table used in this preliminary assessment only captures the most obvious connection points, i.e. it follows the *Pareto principle* of 20% specific imperatives bringing the 80% result. **These imperatives have <u>to be met all at the same time</u>.**

[17] System viability is defined as a system's ability to survive, i.e. **to maintain its own independent existence because of its unique purpose and identity.** The system can only do that if a sustainable flow of resources (human, financial, natural, information) is achieved at any point in time, i.e. sustainability relates to resource distribution and resource flows and system adaptation to maintain resource flows.

ECON 1. affordability	affordability for various sizes of communities through modular structure is a sales strategy behind the technology (e.g. manufacturer claims up to 25% more cost efficient than some gravity fed systems if installed with appropriate toilet/sanitation technology). **However, waste water tariffs may be prohibitively high due to the 24/7[18] need for highly qualified O&M[19] staff and expensive spare parts**	The system is partly functional only in the immediate surrounding of the pump station, the cost situation needs to be established once the client/technology interface is properly managed, only then can affordability be determined. The current state of the system and the lack of quality service provided to clients indicate that the system in its current state is **not affordable.**
ECON 2. manageability	**not as easily manageable as gravity fed systems** e.g. due to many moving parts and substantial pneumatic/electronic controls, 24/7 maintenance stand-by needed, **(dependency on manufacturer/service providers!)**	**poorly manageable technology in its current state of integration** e.g. because no training and education to Stampriet O&M workers provided, no regular follow-through and follow-up and rectifying of system malfunctioning from planners and installers given, no client education provided to people of Stampriet, no appropriate toilet technology and solids traps installed, no power supply back-up installed.
ECON 3. value creation	value creation could **generally be possible in high income countries** with well educated and skilled work force, 24/7 O&M, short distances to suppliers and providers, risk distribution amongst stakeholders	**no value creation** for Stampriet if the system is dysfunctional most of the time and can not be used AND if technology integration is poorly managed AND if peoples' ability to pay is severely stressed AND if raw sewage flooding provides a **health hazard**
ECON 4. cost recovery	cost recovery **generally possible in high income countries**, willingness to pay and managerial effectiveness is generally given, users are bound through contracts which they have to honour	The system is only partially functional, the cost situation needs to be established once the client/technology interface is properly managed, only then can cost recovery be determined. The current state of the system and the overall poor ability to pay indicates that the system in its current state is **not recovering its costs.**
ECON 5. profitability	profitability **generally possible in high income countries**, willingness to pay and managerial effectiveness is generally given (refer also to EC policy landscape on environmental protection and investment)	The system is only partially functioning; the cost situation needs to be established once the client/technology interface is properly managed. The services provided with the technology are currently **not profitable** due to the overall poor ability to pay.
SOC 1. health&safety	health&safety requirements for population are **generally met through sealed system;** the wider population has generally no contact to waste water	**no health&safety for Stampriet population given** as collection chambers are flooded and large puddles and streams of raw sewage along village roads and on premises **expose people to health risks!!**
SOC 2. security& protection	security&protection of technology **generally given through small technology footprint and sealed system,** vacuum stations in EC have to follow strict standards for security&protection of technology and people	**no protection of technology** given if people can open lids freely, dump solid waste into collection chambers or into toilet pans, protruding components are not secured, the vacuum station is only marginally secured, no cross ventilation installed

18 24/7 is an abbreviation for 24 hours per day for 7 days a week, no break possible

19 O&M = operation and maintenance

SOC 3. cultural integration	developed for EC cultural, technical and social environment, **can not serve as comparison** for Africa where different integration strategies have to be developed and applied	**very poor integration** into peoples' social and cultural environment in Stampriet e.g. due to **lack of customer education and lack of feedback mechanisms either installed or followed** (*who is supposed to learn from whom*?)
SOC 4. attractiveness	**generally good attractiveness and acceptance** due to small technology footprint and little to be seen above ground other than small tidy lids and a small vacuum station with a biological air filter	**very poor attractiveness and acceptance** if technology often is dysfunctional and allows for raw sewage puddle and stream building around collection chambers (**health risk, odour nuisance in the village, attraction of flies, rodents and snakes** etc.)
SOC 5. well being of people	**generally supports good quality of life** due to sealed and rapid response technology, clean set-up, small footprint; prerequisite=skilled 24/7 O&M and regular preventive maintenance and good management	**does not support people's quality of life** due to frequent breakdowns, odour nuisance, exposure to **health risks** via puddles of raw sewage, long lasting blockages or system failure altogether etc.
TECH 1. do-it-yourself suitability	**limited "do-it-yourself" suitability,** reduced to diaphragm exchange on interface valve units and minor repairs e.g. NOT to overhaul vacuum control valves (**dependency on supplier and service providers!**)	**not "do-it-yourself" suitable** if work force is left untrained, and no workshop and no repair manuals are provided other than standard Roediger documentation kept in some offices but not on site (**maximum dependency on supplier and contractors, this drains the villagers' budget and eventually fails the technology**)
TECH 2. extendibility of structures and processes	extendibility of pipe network within limits of vacuum station capacity, modular set-up to **increase capacity by up to 20%** for existing system	there are **serious doubts about process extendibility** (e.g. sufficiently strong vacuum) if new sections to be connected to a **currently dysfunctional system**
TECH 3. durability of materials and processes	durability of materials given if installed as per prescribed EC standards; however, **process durability may not be given, requires 24/7 on-call maintenance personnel AND highly trained workforce AND substantial spare parts inventory**	**NO process durability given, the system is too instable** (power failure, discharge pump blockage, debris entry, whole system blockage, flooding of valve chambers, permanent running of vacuum pumps with no usable vacuum building up, wear&tear of system, poor maintenance capacity etc.) **NO material durability given** if solvent weld fittings are reported cracking
TECH 4. maintainability and serviceability	**limited maintainability and serviceability** due to **dependency on suppliers and service providers AND highly trained work force AND high level of 24/7 O&M**	**currently NO maintainability and serviceability given** due to untrained workforce, no solids traps installed, access roads washed away, **maximum dependency on supplier/ contractor**
TECH 5. adaptability to changing environment	adaptability to changing environment is not critical as long as the waste water quality does not change (**strict standards in EC about waste water quality, disposal and testing frequency**)	there are **serious doubts about adaptability to changing environments** e.g. to any disposed fluids and solids. In rural Namibia there are no quality testing standards for waste water disposal applied and followed. The technology calls for BMPs and adaptation of the larger environment first to become fully functional (e.g. roads, storm water drains, solid waste management etc.)

6. Additional Observations Made

A. Planning | Layout | Installation

System dimensioning and vacuum station layout and planning was done by **Roediger**/Bilfinger&Berger in Germany, so was most of the component planning/manufacturing for the system. Site layout and pipe network planning was done by **WML Consulting Engineers**, Windhoek, Namibia. Component/Consumables/Spares provision is done through **VACSEW Maintenance**, Windhoek, Namibia. The contractor was named as **Strydom Construction** Namibia. **There is no as-built and as-tested information available to the Stampriet Village Council.**

B. System Management

Summarizing the equipment available and in use to support continuous operation and maintenance:

1. **No air filter/cleaner installed**, odour nuisance in vicinity of pump station (*depending on wind direction*)
2. **No power supply backup system installed**
3. **The suction tanker is currently 'out of order'**
4. **No lockable and appropriately equipped workshop available** (only one small table under a tree)
5. **No appropriate tools and machinery available**
6. One store room at village council available, however, the facility is filled up with building materials

Summarizing the system management process:

1. **Basic skilled** management personnel in Technical Office, only **basic skills** available on site
2. **No** operation and maintenance, monitoring and evaluation and occupational health and safety policies in place from the Technical Office of the Stampriet Village Council
3. **No** monitoring and evaluation [M&E] records exist
4. **No** usable maintenance records are kept on site or in Technical Office of the Stampriet Village Council (only oil top-up records are kept at the pump station)
5. **Very poor** education and skills training to maintenance personnel provided
6. **No** operation and maintenance related assignments are discussed, supervised, followed through and followed up
7. **Basic** trouble shooting knowledge and trouble shooting strategy, the system layout and as planned documentation does not support any usable strategy (*refer also to disregarded impacts above*)
8. **No** cost figures are readily available, such figures need to be established after successful user/technology interface management
9. **No** cost recovery targets are set and followed up
10. System solvency is **unknown**
11. System profitability target is **unknown**
12. System productivity target is **unknown**
13. System performance is **unknown** (*ratio of what is done to what should be done*)
14. System latency is **unknown** (*development potential for HR and technology integration*)
15. Attraction of the best suitable people does **not** happen, two drivers are entrusted with day-to-day operation and maintenance
16. **No** responsibilities for system O&M documented
17. **No** accountability pathways and feedback signals formalised
18. **No** early warning system in place

C. SYSTEM OPERATION

There are currently only operators of the vacuum sewer system in Stampriet; they are employed as drivers with the Stampriet Village Council. They are entrusted with *ad hoc* on-site jobs related to operation and maintenance [O&M] of the vacuum sewer system. Their involvement is 8/5 instead of 24/7.

Such *ad-hoc* jobs include but are not limited to:

1. exchanging and cleaning vacuum interface valves,
2. exchanging vacuum controllers; however, on hand over not all vacuum valve units were equipped with vacuum control valves and on many of the installed control valves the seal is broken.
3. sucking out flooded valve chambers, however, a suction lance needs to be bought first
4. rarely removing solids from sumps due to unavailability of the right tools
5. excavating entire collection sumps and vacuum valve units to remove solids, thereafter reinstalling them
6. regularly refitting opened lids,
7. regular oil check/oil top-up/oil change on vacuum pumps

Summarizing the operators' enabling environment to do the operation and maintenance and partly the monitoring and evaluation work:

1. **No** as-built drawing (*system layout*) is available in the pump station or the Technical Office
2. **No** as-tested documentation with the Technical Office of the Stampriet Village Council
3. **No** operation monitoring and recording/feedback/evaluation schedules exist
4. **No** adequate set of tools exists to perform maintenance duties
5. Occasionally casual labourers are hired through the VC to support the operator in excavating collection chambers for removing solids
6. Operators' safety clothing occasionally provided from Stampriet Village Council
7. **No** protective clothing against hazardous, contagious waste provided from the Village Council
8. **Very basic** education and training provided to just the operators with **no** follow up for performance management of both the vacuum sewer system technology or the operators

D. VILLAGE INSPECTION

The village inspection was carried out between Monday to Wednesday, 27/30.06.2011 to understand system constraints, human resource bottlenecks, and people's experience and to note the quality of work done and any mutual influences observed. General impression in Stampriet Proper: the operators have given up on 'proper'; many erven have 'made a plan' and have reconnected to their old soak ways or, like the private school, pump out their septic tanks into the river; in Soetdoring Laagte the operators expect major challenges once the toilet building project nears completion and these mini ablution blocks go online.

The findings:

1. Large parts of the western part of the system are not yet connected; however, **very little** sewage was sucked from the connected collection chambers
2. The eastern part (Proper) is connected and all vacuum lines in this part were open; however no measurable sewage was sucked from this part of the village; most collection sumps are flooded. This represents an **acute health hazard for the population especially for the school and hostel area.**
3. All main vacuum lines were open; an appropriately strong vacuum was only measured in a radius of ca 400 metres around the pump station.
4. **Vacuum leakages** and a lack of vacuum build-up were reported throughout the eastern part of the village; the location of all of the pipeing is unknown forcing the operators to dig at random.
5. **No test records** at hand in Stampriet to show previous tests carried out; i.e. trouble shooting becomes a challenge in itself
6. **No** appropriate tools were at hand to remove solids from blocked collection chambers

7. A number of collection chambers were **not** installed as per standards and best practices, e.g. their top flanges are not horizontally installed, many of them are eroded since the last rainy season, some level with the ground surface (infiltration of storm water and raw sewage is evident)
8. **No** flood proof or traffic load version of the valve chambers (type Z) is installed in Stampriet only the light duty standard chambers type G (*passenger load version*)
9. There are no solids traps installed across the village.
10. Children **frequently remove** the light weight covers of the collection chambers; at most of these chambers this is possible without any tools
11. The operators regularly complain about **broken/damaged inspection pipes.**
12. **No** site diary of the operators was available to demonstrate previous maintenance attempts (*important for system management*)
13. The Village Council's suction tanker was out of order and was **not** available to suck out collection chambers or to remove long standing puddles of raw sewage in the village.
14. **No** client education and awareness raising for the vacuum sewer system was done according to villagers
15. **No** client satisfaction surveys or feedback sessions were initiated and followed up; there is an indication of a generally poor willingness to pay for the sewage disposal service.

E. Vacuum Station

date: 27/06/2011

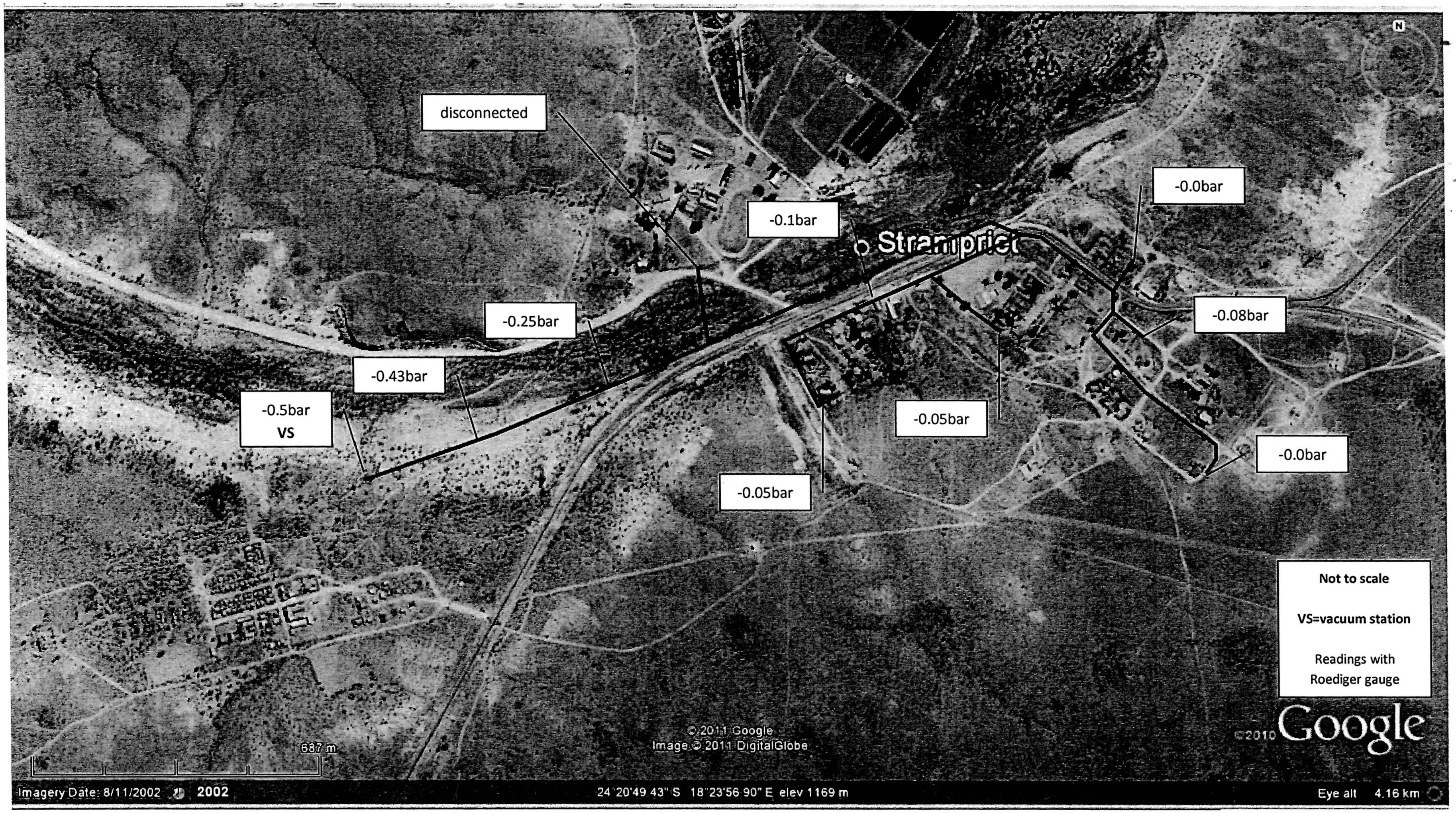
1. The vacuum reading on mechanical gauge was -0.48bar
2. The vacuum reading on integrated digital gauge was -0.58bar
3. Vacuum pump No# 2 urgently needs to be serviced, needs full oil top-up every 4-5 hours.
4. The other 2 vacuum pumps are running; vacuum pump No#1 does **not** cut off; No#3 cuts off at -0.6bar and kicks in at -0.56bar; however, the **vacuum can not be stabilized** which leads to extended running of vacuum pumps and energy wastage; the oil levels in vacuum pumps were adequate
5. Both discharge pumps seemed to work normally
6. Vacuum test equipment was readily available and used for the assessment
7. **No** power supply backup system is installed
8. **No** spare parts storage is available
9. **No system documentation is available at the pump station**; at least a quick reference guide should be made available to the operators for every day quick access when trouble shooting or doing basic maintenance
10. The vacuum station looked acceptably clean

F. Collection Chambers

1. The operators reported that **most collection chambers in Stampriet Proper are blocked**
2. Most vacuum control valves were **flooded** and submerged during this year's rainy season. The biggest challenge experienced on these controllers is the **fine calcrete dust** and the **high CCPP water** when flooded with raw sewage
3. 20 % of the village's collection chambers were randomly inspected and mostly found blocked with solids, in 'proper' the surrounding was flooded with raw sewage.
4. To test collection chamber effectiveness and efficiency it was agreed to first establish a management programme for the user/technology interface (*refer to "Topic 3.A" above*)

7. Trouble Shooting Observations Along Main Suction Lines

The map of the eastern part of Stampriet below shows the results of a first vacuum test walk to known suction points or vacuum test points (no as-built information available).



8. Key-Challenges Discussion

Four organisational challenge levels were identified during this preliminary assessment in Stampriet and similarly observed in Gibeon and Kalkrand:

1. **Policy and decision challenges** (*to determine to do something*). Decisions were made without sufficient consultation of and learning from the local population, without capacity threshold assessments (technical, managerial, operational), without in depth knowledge of the respective local site conditions (traffic ways, storm water drainage, power supply stability, managerial effectiveness, water demand management, O&M hardware needs etc.)
2. **Research and planning challenges** including (pre)feasibility studies (*to research and specify something*). What should have been picked up and integrated for decision taking on level 1: e.g. transport and traffic ways everywhere, lack of adequate storm water drainage, high CCPP potential in the water, lack of erosion protection throughout the villages; need for permanent guidance and site supervision of contractors, clear set of standards for installation, dust and infiltration sensitivity of chosen vacuum sewer technology especially light duty pedestrian version of valve units, lack of DIY-suitability and maintainability of technology on site, unknown water consumption customer profile.
3. **Installation challenges** related to workmanship and adherence to standards in general and protection of the technology and protruding components and proper recording and documentation in particular.
4. **Operation and maintenance challenges for clients/end users** related to user education, operation and maintenance capacity building, as-built information provision and awareness fostering, ability to pay for services, bearing the consequences of problematic planning and installations etc.

Level 1 needs all possible information in an iterative development process from level 2. Level 2 is the actual 'integration level' and needs constant info exchange with level 3 (guidance and supervision of contractors) and the future owners. Any unattended integration problems will surface in level 4. However, the crux of the matter is that level 4 implies a transfer of ownership to the next lower recursion level of organisation (Village Councils) again running through all four levels. In this, the villages are 'left alone'.

Four rather **technical challenge clusters** were identified during this preliminary assessment in Stampriet and similarly observed in Gibeon and Kalkrand:

1. **Vacuum loss on suction pipes** leading to **water logging** and **loss of system viability; erosion along vacuum lines** and collection chambers; **solvent weld fitting cracks** (material selection, integration and workmanship)
2. Vacuum control valve **sensitivity to fine calcrete dust and high CCPP water** (technology selection, design and manufacturing)
3. **System layout** and **lack of technology integration** into existing environment (planning, procurement); this sealed system either works or fails across an entire suction line, especially during floods or power failure
4. **Adequate protection of system components** (Village Council issue after signing certificate of completion and transfer of ownership else it remains a contractor issue)

Resource flows into Stampriet include little financial influx or reserves in and to Stampriet, poor or no information and experience exchange with other 'vacuum sewer villages' and nobody seems to be really interested to work there because of high unemployment and a very weak income generation potential.

Technology assessment challenges prior to installation into existing environment (*mostly related to financing and development agency*)

- The system tipping point in Stampriet is unknown with loss of system viability (*i.e. no self-starting ability for whole system as this is **primarily linked to debris entry, water logging of suction pipes, vacuum leakage.** The system is just not designed to cope with solid waste like rags/bones/stones/rocks/shoes etc.; i.e. important integration step is to establish a **user/technology interface management programme***)
- There are **restart problems after blockage/flooding** especially on the vacuum control valves and problems to maintain system viability.
- Although only partially online in Soetdoring Laagte and most of the time dysfunctional in Stampriet Proper, **discharge pump blockages** were reported because of rags/stones etc. due to missing solids traps on erven (*no debris/stone/rag/rock removal facility included in system, ideally waste should be separated at source*)
- **System component security and protection** must become a key-criterion for technology integration
- **Prohibitively high cost for accessories and spare parts** should be a criterion for technology selection and management strategy development

Planning/Layout/Procurement/Construction challenges include:

- **Technology not integrated and adapted to local conditions** and sanitation habits (*refer to rapid assessment above*) and there is **no user/technology interface management strategy in place**
- There is **no as-built and as-tested documentation** of the system in Stampriet available, this needs to be rectified
- Many vacuum pipes (*if on-line via opened division valves*) do not allow for an appropriate vacuum to build up; may have to do with either damaged/punctured PVC pipes, cracked fittings on inspection pipes or dysfunctional vacuum control valves or blocked interface valve units across the village which do not regenerate (*causes vacuum pumps to run permanently*)
- There is unhindered entry of storm water/sand/silt/stones/debris in some collection chambers due to collection chamber installation in depression or due to missing solid traps on erven (*needs rectifying soonest)*
- There is **no early warning system in place** to indicate potential failure (*observing the system*)
- There is **no online warning system** in place to indicate failure or abnormal changes of specific collection chambers or the system behaviour as a whole to the Village Council
- There are **too many unsecured protruding components** which can get damaged (*specifically above ground installations of vacuum test pipes and unsecured collection chambers*)
- There is **no system cut-off point installed** when system is "running dry" to prevent equipment overheating/energy wastage/wear and tear/high cost maintenance etc.)
- There was **no training and education provided** for system maintenance personnel (*implementing agencies could have made use of established education and training programs from Roediger/Bilfinger&Berger*)

Technical management challenges in Stampriet include:

- A general **lack of managerial effectiveness** of technical personnel, this needs addressing soonest
- There is **poor or no cost recovery on the system** (*system solvency at stake*)
- Appropriate education and skills development for operation and maintenance personnel was not called for/insisted upon during and after commissioning
- There are **no operation and maintenance, monitoring and evaluation and occupational health and safety policies**
- There are **no operation and maintenance, monitoring and evaluation records** available and benchmarking was not done to improve the system management
- There is **no appropriate workshop/storage** and **no appropriate tools** provided

9. WAY FORWARD (OPTIONS FOR REMEDY, RESULTS PLAN)

The results plan below, based on the results of the village inspection and the entire Performance Support Team assessment, shows what needs doing to **start the remedial action** on the vacuum sewer system in Stampriet and to enable for a re-evaluation after first remedial action. The results-plan is split into user/provider for quick reference. **This 'way forward' results plan points out options for remedy** and complements the on site developed 'Action Plan' further down under *Section 10.* The PST involvement to support this proposed results plan depends on sourcing of additional funding beyond ECAP and the commitments made during the action planning in Stampriet.

First results plan for the User, Stampriet Village Council supported by the PST where appropriate

Ref#	Results	Performance indicator	Responsibility (service provider)	Priority
VC-1	A joint decision is taken in Stampriet to adopt a **performance support team approach** for such time needed to integrate the vacuum sewer technology and especially the user/technology interface management programme	.......makes full use of the performance support team and cooperates on all levels of quality management by end of July 2011	**Stampriet Village Council**	1
VC-2	Appropriate *Operation and Maintenance [O&M], Monitoring and Evaluation [M&E]* and *Occupational Health and Safety [OHS]* **policies** are put in place to integrate and manage the Stampriet vacuum sewer system. This is done in conjunction with **Water Demand Management** (as specified in the Integrated Water Resources Management Plan for Namibia 2010)	system oriented O&M and M&E and OHS policies in place and applied for strategy and results development by end of September 2011	**Stampriet Village Council** with PST	1
VC-3	**Managerial effectiveness education and training** is provided to technical staff of Village Council	training sessions conducted and regularly followed up, staff enabled to manage O&M and M&E for the vacuum sewer system by end of September 2011	**Stampriet Village Council** with PST	2
VC-4	**Technical hands-on operation and maintenance education and training** is provided to technical staff, including on-site construction of easily cleanable solid traps along one branch of the system (done in Gibeon as part of the training) *refer also to Action Plan 10.II.3 below*	O&M staff successfully maintain the basic operations of the vacuum sewer system by end of September 2011	**Stampriet Village Council**, with support from PST	2
VC-5	**Technical management related results** are: marking out system components on site; measuring/recording power consumption on vacuum station; logging/recording discharges per day/week/month; recording frequency and volume of consumables and spare parts used; recording all breakdown and O&M activities to keep system running etc. to develop appropriate waste water tariffs and feedback on system effectiveness	key-data collected and processed to obtain basic information on power consumption, m^3 waste water processed, costs incurred, tariffs established by end of December 2011	**Stampriet Village Council** with PST	3

First results plan for the technology providers (planners, contractors, suppliers)

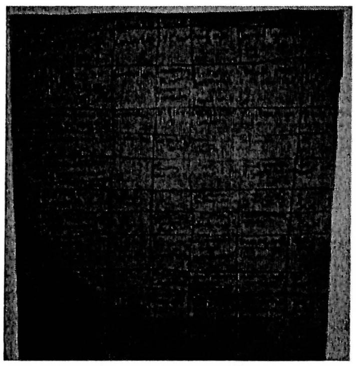
Ref#	Result	Performance indicator	Responsibility (provider)	Priority
P-1	**All as-built drawings, as-tested records and site supervision records** are provided to the Stampriet Village Council (site diaries of planners and contractors and updated drawings must be made accessible to the client)	as-built and as-tested documentation is used to identify system parts and constraints by end of July 2011	**Planners and Contractors** of the vacuum sewer system	1
P-2	**Vacuum system tests** on all suction lines (with blocked collection sumps) to determine **structural integrity** and functioning as per system own standards and international benchmarks is done	the vacuum system is structurally sound, a constant vacuum can be maintained in all suction lines, the vacuum pumps switch off if no water enters the system by end of August 2011	**Planners and Contractors** of the vacuum sewer system	1
P-3	All rocks and debris is removed from collection tank, suction lines, vacuum collection chambers in Stampriet	the entire system is free of blockages, collection sumps are self-cleaning by end of August 2011	**Planners and Contractors,** Stampriet Village Council	1
P-4	Additional installation support is provided for **easily cleanable solids traps on all premises** before waste water enters the collection chambers *refer also to Action Plan 10.II.3 below*	no unwanted solids enter the collection sumps, users are responsible and enabled to clean the solid traps by end of October 2011	**Planners and Contractors,** Stampriet Village Council, PST	2
P-5	Exchange/recycling/reuse of vacuum interface valves and vacuum control valves including capacity building for *Do-It-Yourself* maintenance in Stampriet is done and operators are enabled to maintain these basic system components in Stampriet	all vacuum interface valves and vacuum control valves are functioning and the technical staff is enabled to maintain these valves by end of October 2011	**Planners and Contractors** of the vacuum sewer system, **Stampriet Village Council**, PST	2
P-6	All vacuum collection chambers in Stampriet are flood protected, including vandal and children proof lids (could be made in ferro-cement technology or original Roediger lids) *refer also to Action Plan II.3 below*	only authorized persons can open the vacuum chamber lids by end of November 2011	**Planners and Contractors** of the vacuum sewer system, **Stampriet Village Council**, PST	2
P-7	The system is optimised for energy efficiency, an on-line warning system is installed to allow for timely communication of 'abnormal system behaviour' to the VC	the system operates at its energy efficiency target levels as designed for by end of November 2011	**Planners and Contractors** of the vacuum sewer system	3
P-8	A power supply back up system is decided upon and installed to maintain the 24/7 function of the vacuum sewer system in case	the system is 24/7 online by end of November 2011	**Planners and Contractors** of the vacuum sewer	4

	of power failure		system, **Stampriet Village Council**	
P-9	joint re-evaluation of the vacuum sewer system and its management for system viability, cost recovery targets, benchmarking etc.	a joint re-evaluation confirms reaching above performance indicators by end of January 2012	**MRLGHRD, Stampriet Village Council,** PST	4

10. Action Plan Vacuum System (elaborated on 29.06.2011)

The following action plan was elaborated on June, 29, 2011 in Stampriet. The participating team included members of the Village Council, Councillors and the ECAP/PST members. On 29.06.2011 the same participating team earlier collected key issues and prioritised those for the action planning (please refer to the main report for in depth coverage).

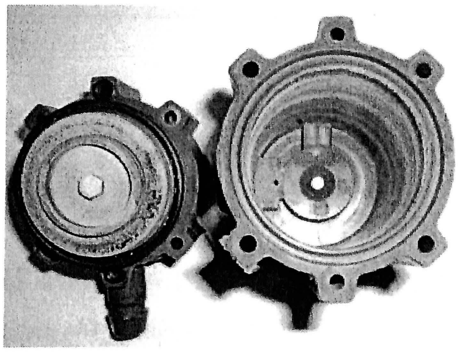
Activity	Responsible	Support	Resources	Milestone	By when?
II. **Vacuum Sewer System (second priority)**					
II.1 Clarify guarantee issues on workmanship, components and spare parts	VC	Ministry Councillors	Report, signed certificates	formal response from Ministry and Engineers	30.08.11
II.2 Submit tools list and costing (budget) to VC	Technical Team	VC	information on tools and availability	Budget	15.07.11
II.3 Technical Training for water and sanitation maintenance	VC	Councillors, Ministry, ECAP	ECAP (accom. and travel to Gibeon), Experience	Gibeon Training, Ministry Training	15.09.11



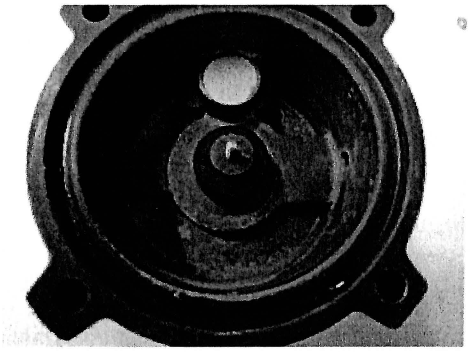
...the original action planning 'write-up'

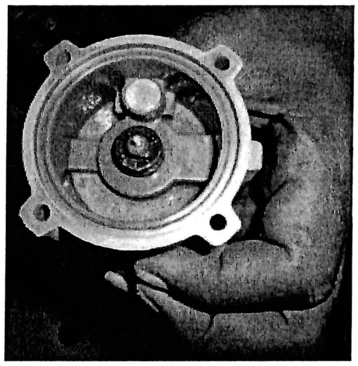
11. PHOTO DOCUMENTATION FROM PRELIMINARY ASSESSMENT

A. COMPONENT RELATED PHOTOS

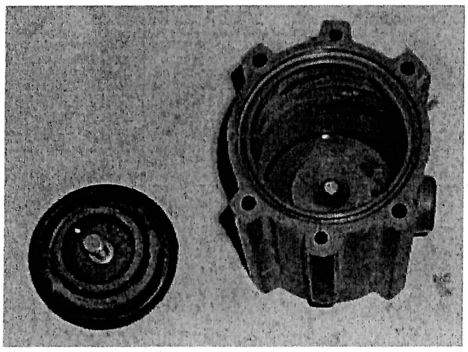


This vacuum control unit was completely filled with either storm water or raw sewage for a long time



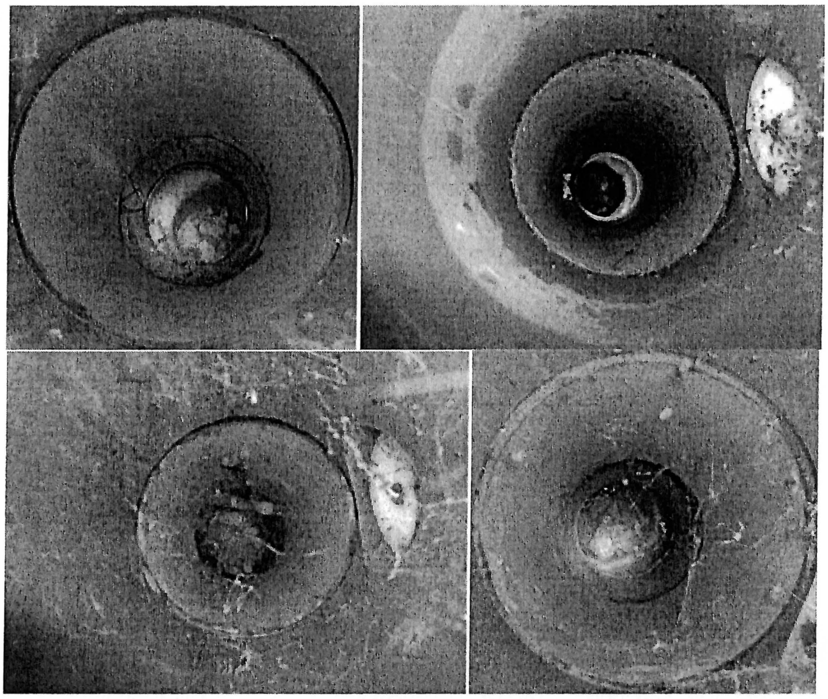


These two upper chambers of vacuum control units were exposed to dust and water (powdery deposits) their air filters were completely clogged, both units could not regenerate

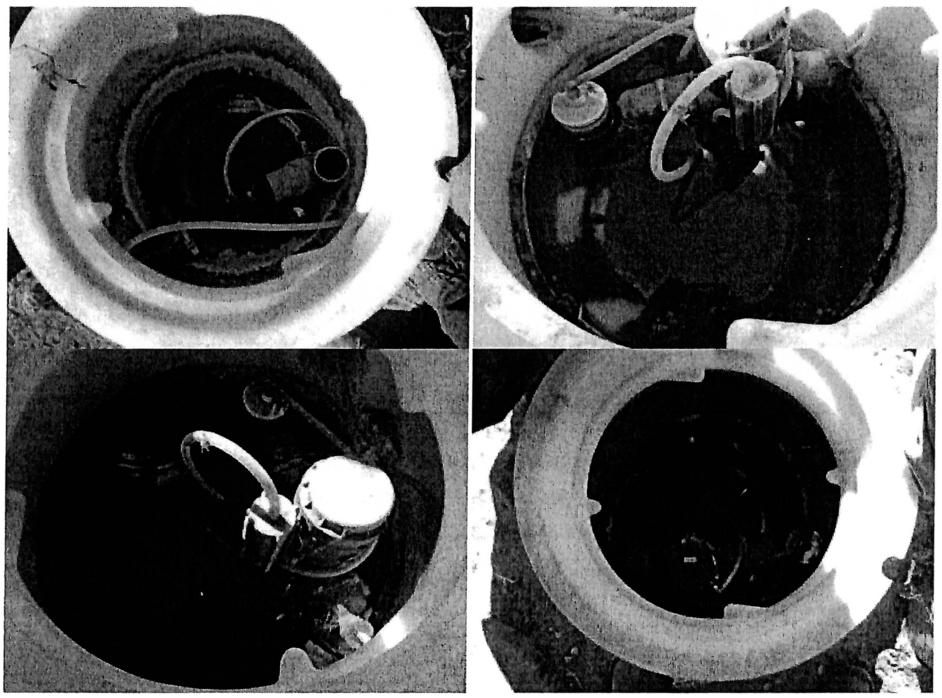


White calcrete dust in main vacuum chamber; the small switch did not seal properly and caused the interface valve to stay open permanently.

B. Collection Chamber/Valve Unit Related Photos

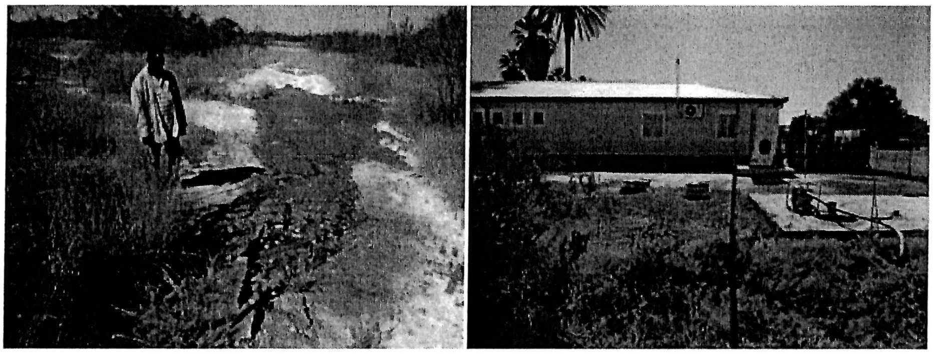


A common scenario in Stampriet: collection sumps filled with solid waste and rubble where the system is not yet on line. The operators do not have adequate tools to remove such solids; excavation is their current answer.

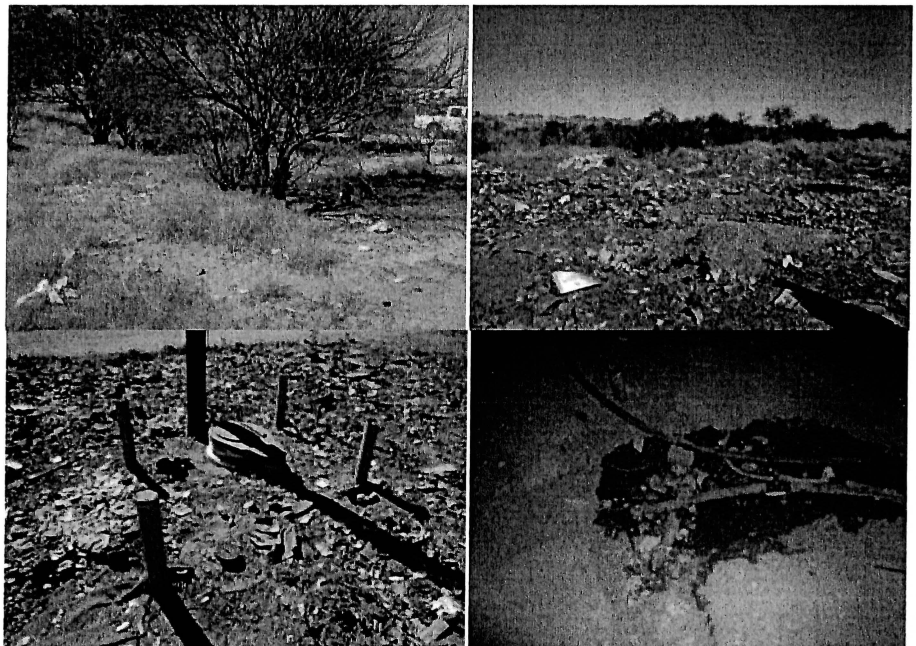


...another common scenario in Stampriet: long term flooded and dysfunctional valve units

C. Reconnection and General Sanitation Related Photos

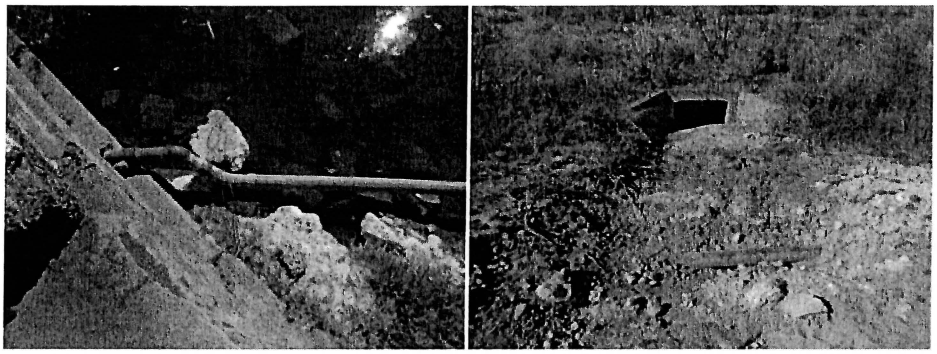


One example of reconnected sewage disposal is the private school which was disconnected from the vacuum sewers system due to insufficient vacuum. The school now pumps out the septic tank right into the river. The two collection chambers on the right hand side photo are disconnected.

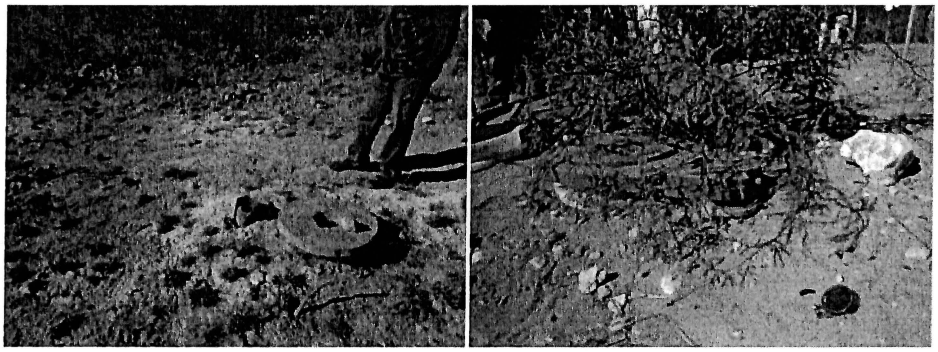


Top left: open defecation right next to the vacuum valve units in the middle of the village.
Top right and bottom left: solid waste everywhere; in a poor community like Stampriet these are the playgrounds and 'toys' for the young villagers. A welcome additional toy is an unprotected valve unit right in the village centre.
Bottom right: typical improvised water/waste water connection mix in a school backyard, both pipes are leaking.

D. The Need for Infrastructure Protection and Workmanship Improvement



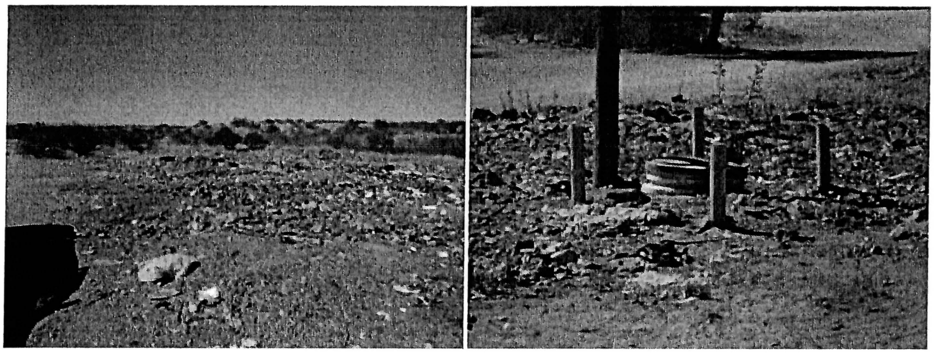
Two examples of erosion and consequences: the 'saw tooth' on the left photo was repaired several times. The suction line should not have been placed in a river bed where a small flooding event can erode all backfill material. The 2011 rainy season caused substantial flooding, exposing the suction line. In a suction event this pipe vibrates constantly and eventually breaks calling yet for another repair.
To the right: an eroded suction line next to a culvert exposed to sun light.



On the left: an unprotected vacuum test point in the river, an easy target for playing children.
On the right: an incomplete installation deteriorates.

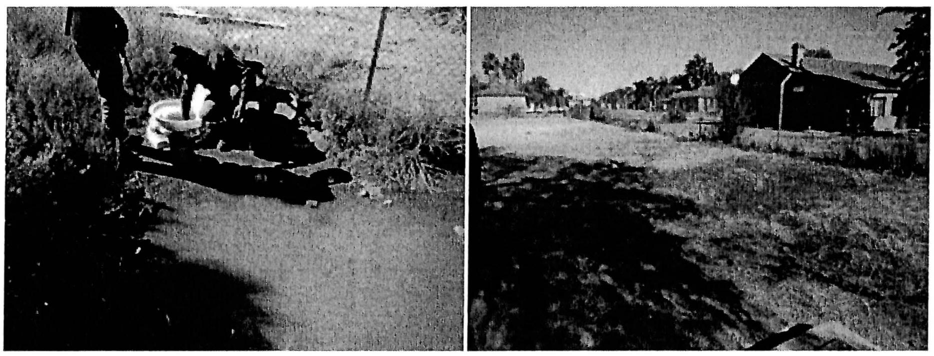
Planning, installation and workmanship challenges evident throughout the village; erosion is a key-challenge. The left hand side photo shows trench erosion in Stampriet Proper. The road on the right hand side photo in Soetdoring Laagte is higher than the surrounding erven. This 'dam building' caused the washed away soil to fill up an entire area around unprotected valve units with the consequence that these units were flooded and sand/silt entered the collection sump and valve chamber. Both units are dysfunctional.

E. Health Hazards and Pollution

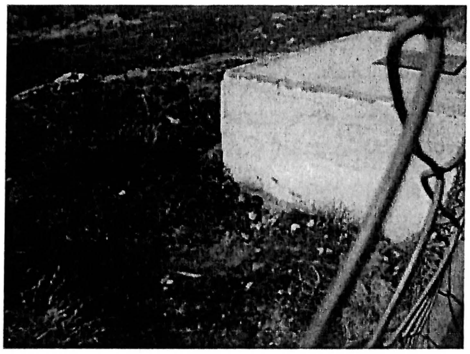


*...the urgent need for **sanitation improvement** is evident in Stampriet Soetdoring Laagte!*

*...most collection chambers are flooded in Stampriet Proper, **creating an odour nuisance, constant health hazard...***



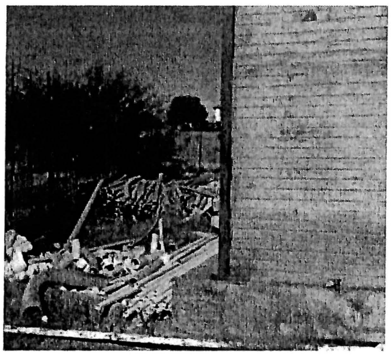
*Raw sewage floods the school grounds due to insufficient vacuum conditions, **presenting an acute health hazard for the learners and the staff***



*The school septic tank 'punctured' above ground to flood the environment with raw sewage outside the school premises **polluting surface- and ground water resources!***

F. Tools, Storage and Workplace Related Photos

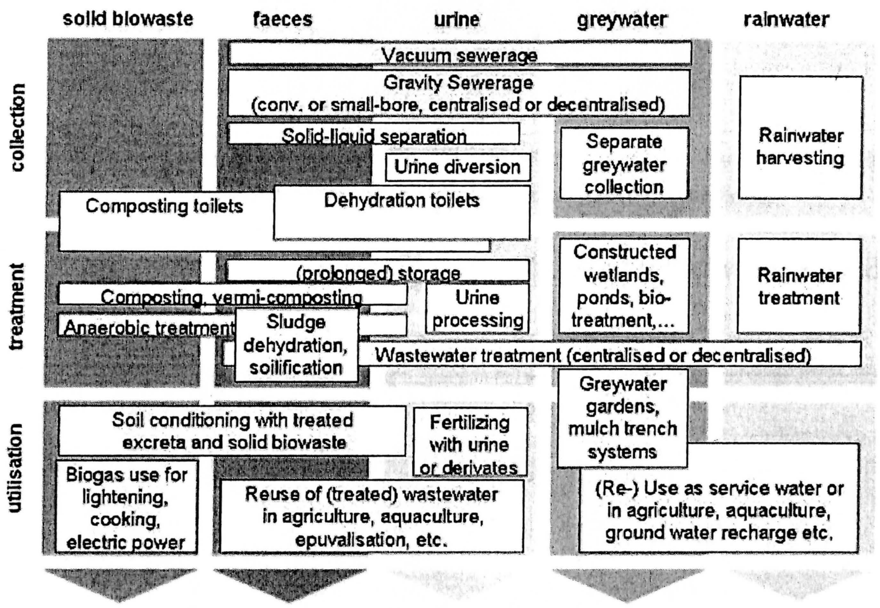
Stampriet does not own proper workshop, tools and storage facilities. The garages for the council vehicles are currently used to store building material for the toilet building project.



PVC pressure pipes are stored behind the garages in the sun.
The pipes in the back are already sun burnt; however, they are still used for repairs for water and vacuum system.

12. OPTIONS FOR ALTERNATIVE SANITATION PROVISION

Raw sewage is a mix of faeces, urine and grey water and is a valuable commodity if collected, transported and treated appropriately. The shorter the collection and treatment path the more economic and environmentally friendly is the technology. The GIZ diagram below illustrates the different options for collection, treatment and utilisation over the five reusable sanitation components.

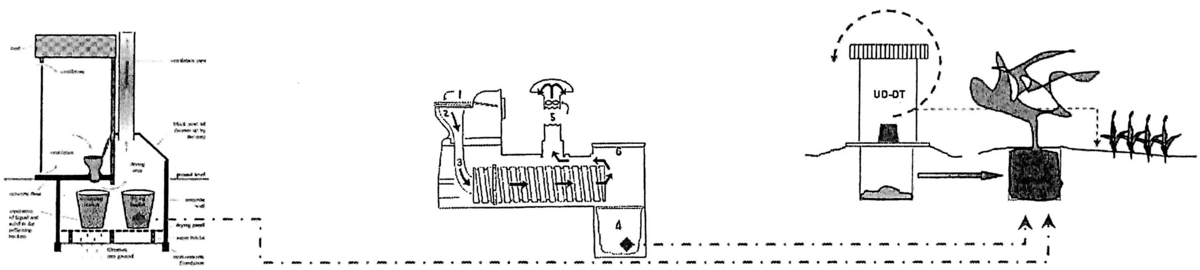


Source: GTZ/GIZ ecosan

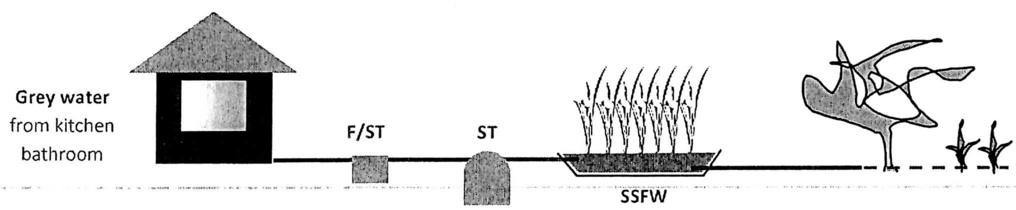
The Stampriet Village Council may look into alternative sanitation provision for those erven which up to date are not connected to the central vacuum sewer system. Three modular decentral alternatives out of a large number of possible combinations are sketched out below and are briefly described; they all include ***Water Demand Management Measures*** as specified in the *Integrated Water Resources Management Plan for Namibia 2010.*

A. DRY SANITATION AND GREY WATER TREATMENT ON-SITE

Single household: This alternative is the most robust and environmentally friendly solution to on-site sanitation. The toilets should ideally include urine diversion. Erven include shower/kitchen; collection and treatment through small fat/solids trap (F/ST), septic tank (ST), small horizontal subsurface flow grey water wetland (SSFW), shrub/tree garden, composting facility, backyard gardening.



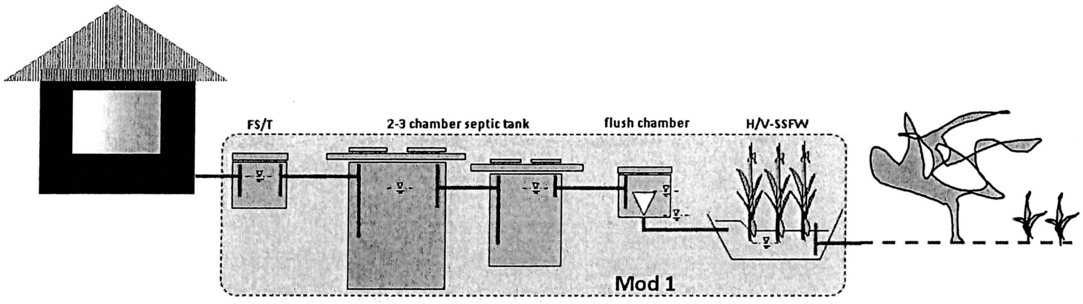
NAM Otji-Toilet or **RSA *ecosan* Dehydration Toilet** or **ZIM Urine Diversion Arbor Toilet** **...or**



B. Wet Sanitation with On-Site Treatment (on household level)

Single household: This alternative is the "luxury" version (*less affordable*) of alternative "A" above. The toilets are normal flush toilets; water consumption and maintenance is increased, the system has to treat faecal contaminated 'black water' and is more costly than alternative "A". Erven include bathroom/ kitchen etc; collection and treatment through small fat/solids trap (FS/T), standard PE rotomould tanks combined as 2-3 chamber ventilated septic tank (ST) for 3-5 days retention time, flush chamber for intermittent flushing, horizontal or vertical subsurface flow wetland (H/V-SSFW), shrub/tree garden, composting facility, backyard gardening.

Foreign product series: ready made PE septic tanks (*SABS approved*) can be obtained through South Africa from *CALCAMITE* in the sizes: 1100/1750/2500/5500 Litre. *CALCAMITE* also offers accessories related to underground irrigation of shrubs and trees.

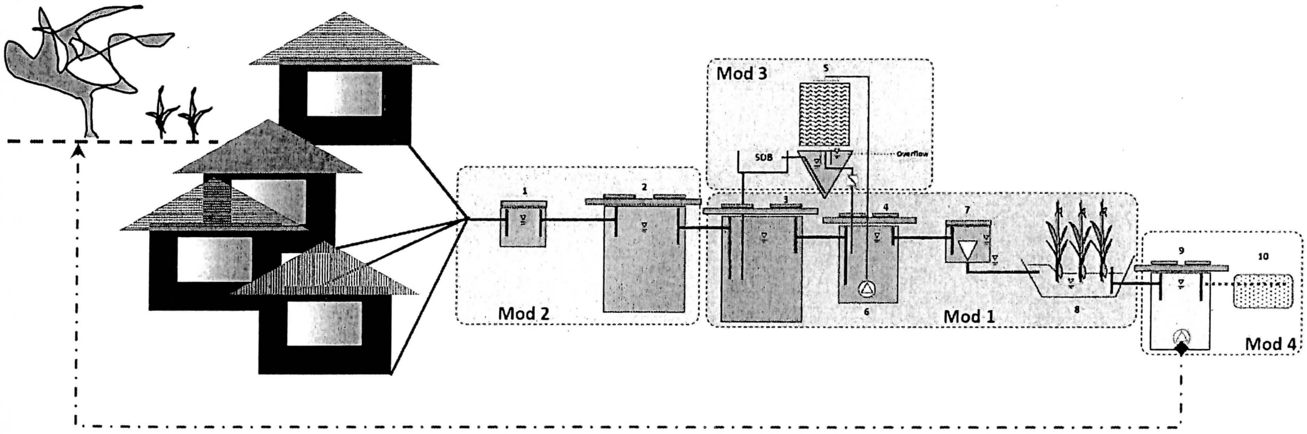


...the on-site collection and treatment components for wet sanitation

C. Wet Sanitation Clustering Several Households

Modular system for 4-20 or more households, extendable, can grow with demand:

- The basic system module (Mod 1) has the same components as in the previous alternative "B".
- An additional septic tank -standard PE rotomould tank (sizes from 1 000-10 000L)- is added in (Mod 2)
- When further demand is established (Mod 3), a trickling filter with circulation pump, sludge hopper and clarifier and a sludge drying bed are added. The horizontal or vertical subsurface flow wetland (H/V-SSFW) then serves as polishing wetland to achieve an optimal tertiary treatment ideal for reuse.
- (Mod 4) a final collector tank is added if the treated waste water is to be reused for irrigation purposes upstream. In such case an additional pump will have to be added. Recycled waste water (tertiary treatment) is a valuable commodity for urban gardening or village greening.



...the clustered system components, growing with demand

STAMPRIET VACUUM SEWER SYSTEM

PRELIMINARY ASSESSMENT FROM 27-30/06/2011 FOR PERFORMANCE SUPPORT AND CAPACITY BUILDING

CONTENTS

1. BACKGROUND

A DRFN Associates/Stampriet Village Council Performance Support Team did a preliminary assessment to determine the **level and volume of performance support and capacity development needs** required for the Stampriet vacuum sewer system. The vacuum pumps of this system are constantly running, however, it was reported that the system does not meet its purpose. This preliminary assessment was carried out on 27.06 until 30.06 2011.

2. SCOPE AND LIMITATIONS

The limited scope of this preliminary assessment:

- **visual inspection** of the collection chambers and pipe network layout
- **visual inspection** of vacuum station and machinery (oil levels in vacuum pumps, unusual noises, loose parts, power on/off, general conditions etc.)
- observing existing **human resources capacity and constraints**
- observing the **managerial effectiveness capacity** of the technical staff entrusted with daily O&M
- observing existing **enablers** and **technology integration constraints**
- first **trouble shooting** through information gathering and information sharing
- based on a **rapid assessment** establishing **performance support needs** for vacuum sewer system.

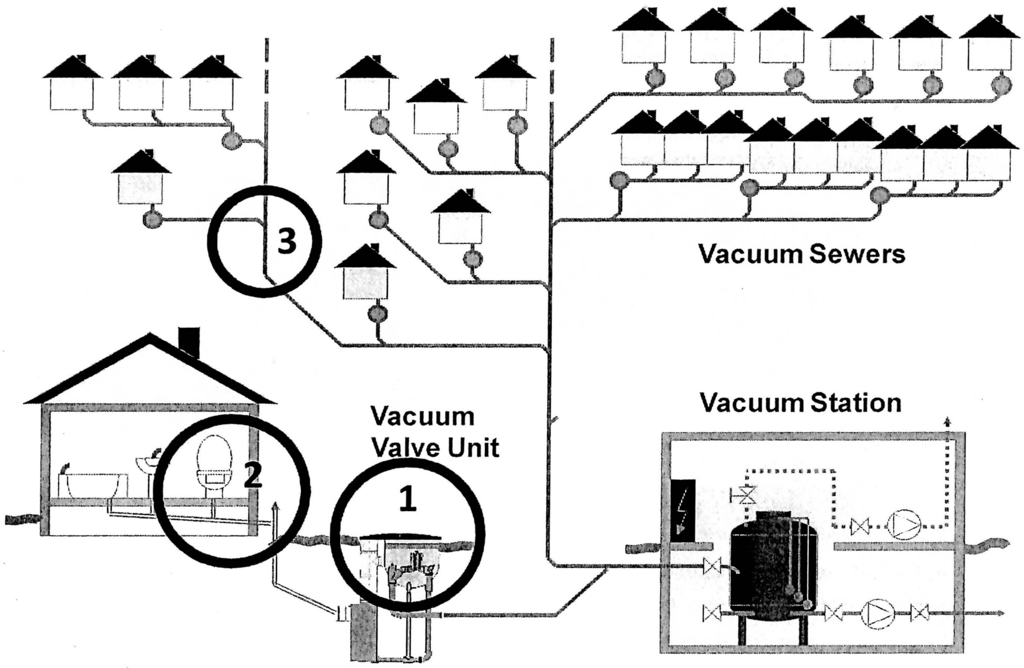
Excluded in this preliminary assessment:

- tracer studies and waste water flow measurements to understand response times and volumes transported for steering, maintenance planning and costing of services (*needs sophisticated equipment, data logging*)
- detailed vacuum tests at various vacuum test points in the village (*needs provision of as-built and as-tested information and preferably a digital vacuum gauge with data logger*)
- detailed machinery and equipment tests for proper functioning (*needs a variety of testing equipment*)
- setting performance standards (*needs management basics in place in Stampriet and benchmarking against successfully operating systems in Namibia and elsewhere*)
- observing and guiding operation and maintenance staff on emergency maintenance such as sucking out flooded valve chambers and collection sumps, exchanging and repairing dysfunctional interface valve units and vacuum control valves etc.

3. SUMMARY OF TECHNICAL OBSERVATIONS WITH SYSTEM OVERVIEW

During the preliminary assessment, the vacuum sewer system in Stampriet was not performing as it is supposed to do. The vacuum pumps were constantly running, building up a maximum vacuum of -0.6 bar at the pump station. The vacuum dropped to -0.25 bar around 400m upstream dropped further to -0.05 bar along the furthest vacuum test points in south-east Stampriet Proper. This drop of vacuum caused the collection chambers in this part of the village to flood like some collection chambers further upstream in Soetdoring Laagte. It was further observed that lack of an adequately strong vacuum caused the main suction lines to the east to become water logged and that constant emergency maintenance is needed to convey at least some sewage. Many collection chambers were blocked with excessive solids and the area around them was flooded. Vacuum tests on such blocked collection chambers showed that the vacuum was not sufficient to operate the vacuum control valves or the interface valves.

A. CRITICAL INTERFACES (USERS/TECHNOLOGY)

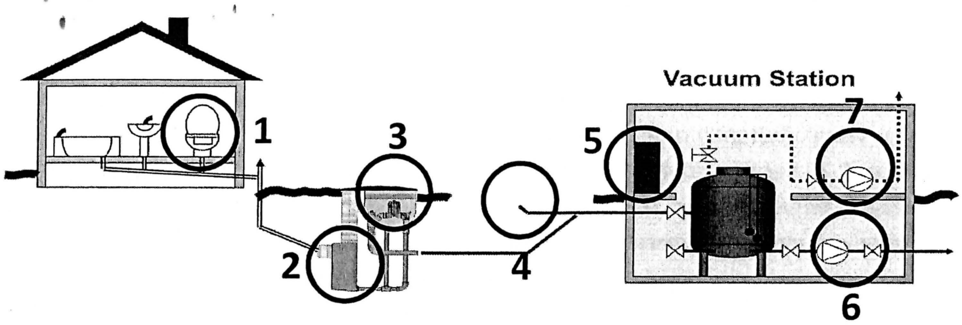


Critical interfaces between users and technology are marked with red circles

Three critical interfaces between users and technology need to be managed first. Only then can <u>system functioning</u> in Stampriet be tested.

- (circle 1) **security and protection of collection chambers and vacuum valve units** to avoid vandalism or "children just playing with lids or throwing stones and other solids down the collection sumps"
- (circle 2) **unwanted solids entry** into the system like shoes, rags, large bones, stones, news paper, plastic bags etc. at **household/user level** and
- (circle 3) **security and protection of protruding components** such as division valves and inspection pipes or **shallow and eroded vacuum pipes along sloped ground or in river bed** which can easily get damaged through traffic, fire, playing children, animals crossing etc.

B. Observed Interdependencies and Impacts/Burden of Major Components



Impacting Components in the System are marked with black circles

1	solids entry at household/user level(>40mm)
2	collection sump (av. 63mm pass into vacuum pipe)
3	interface valve (av. 35mm solids pass) and vacuum control valve (switch)
4	protruding components
5	central control unit (DB) in pump station; currently serves as "**indicator**" if observed timely and interpreted correctly
6	discharge pump(s) and non-return valves
7	vacuum pump(s)

Observed and disregarded interdependencies/cross impacts between components 1 to 7 from the above table

cross impact[1]	1	2	3	4	5	6	7
1	*none*[2]	sub-system blockage	sub-system blockage	system blockage[3]	*none*	system blockage	*none*
2	retains solids >63mm	sub-system blockage	flooding suffocating[4]	*none*	*none*[5]	system blockage[6]	*none*
3	retains solids >35mm	flooding and blockage	regeneration stops (flood)	*none*	*none*[7]	*none*	extended running[8]
4	"invitation to play"[9]	support blockage	support blockage	*none*	*none*[10]	support blockage	permanent running
5	*none*[11]	*none*	*none*	*none*	*none*[12]	*none*[13]	manages vac. pumps
6	*none*	*none*	*none*	*none*	ERROR message only	can run for too long	*none*
7	*none*	provide vacuum	provide vacuum	allow for vac. testing	supplies vacuum level	*none*	overheating wear & tear

The 'row-sum' represents the **impact strength on the whole system**; the 'column-sum' represents the **burden on a component** in the system (*is influenced by*). **Red cells** mark strong impacts, orange cells mark less strong impacts, **purple cells** mark disregarded impacts during planning and installation which are needed **to close feedback loops** (*disregarded impacts generally increase the burden on the whole system*) and **green** cells mark planned impacts. The system failure indicating colours (**red**, orange, **purple**) dominate in this cross impact analysis. Red arrows mark the interfaces user/technology.

[1] Cross impact refers to: components 1-7 in rows 1-7 **directly impact** on columns 1-7 which again represent components 1-7

[2] Ideally households/clients should receive appropriate instructions (poster, awareness sessions) about solids handling and disposal

[3] Either washed in solids or thrown in solids through damaged inspection pipes cause system blockage

[4] Flooding and suffocating of vacuum control valves did happen in underground version of vacuum chambers

[5] Ideally there should be a blockage-signal to the control unit (DB) and further to the Technical Office in the VC

[6] The solids still passing into the suction pipe of the collection sump obviously cause discharge pump blockage

[7] Ideally there should be a "no-regeneration" signal to the control unit (DB) and further to the Technical Office in the VC

[8] E.g. dust or sewage or storm water entry into the vacuum control valves prevents them from regenerating

[9] Open or damaged inspections pipes seem to attract children to play *(throwing stones and listen how they disappear)*

[10] Ideally there should be a "sudden vacuum drop"-signal to the control unit (DB) and further to the Technical Office in the VC

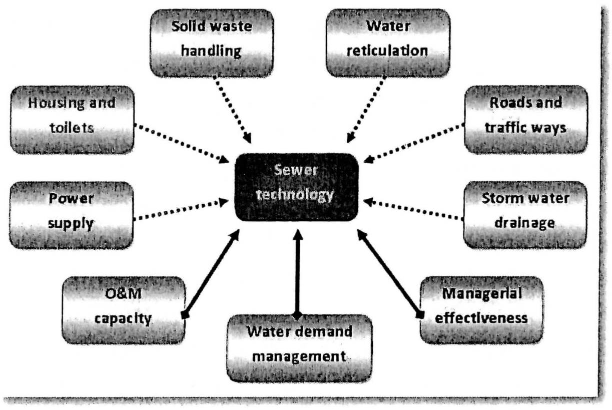
[11] Ideally households/users should receive appropriate feedback via the VC regarding "abnormal changes" and expected behaviour change

[12] Ideally the DB should also serve as an interface monitoring unit to report "abnormal changes" to the Technical Office in the VC

[13] There is no cut-off point installed to stop the pumps (only ERROR Message: 'pump is running too long')

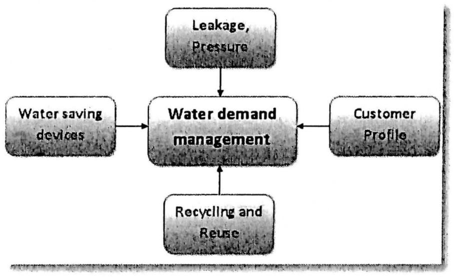
4. OBSERVED INTEGRATION CHALLENGES (WITH EXISTING TECHNOLOGIES)

Like previously in Kalkrand and Gibeon it was observed in Stampriet again that poor vacuum sewer technology performance primarily relates to the **lack of integration of the vacuum sewer technology into the <u>existing environment</u>** which in all three cases e.g. lacks appropriately designed and built road and traffic ways, storm water drainage etc. It is often observed that a lack of proper technology integration in an **environment needing substantial adaptation to accommodate a new technology** may eventually discredit an elsewhere proven and highly successful technology.



The simple MindMap above shows six *hardware* related -dotted arrows- and three *software* related **integration challenges** which are ideally taken into consideration **before** a system is installed and commissioned.

<u>Example 1</u>: Central to any planning effort should be **water demand management-** (*refer to detailed information and the Water Demand Management Strategy in the Integrated Water Resources Management Plan for Namibia, 2010*). The four key dependencies for **minimal WDM** may follow the planning card below. To master the 'first integration hurdle' the following four information blocks must be known and applied in the **technology selection** and subsequent preliminary design process:



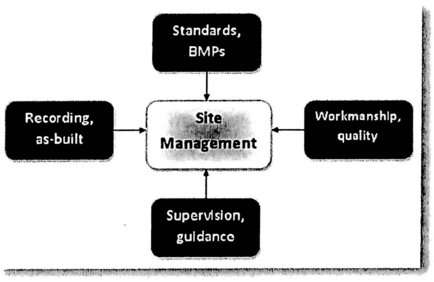
Four basic information blocks for technology selection and preliminary design

1. **Leakages** on the water reticulation network occurring throughout the village and **pressure management** of the network. If unknown like in Stampriet, a system may be under sized and the sewer technology may not perform satisfactorily, i.e. flooding with all negative health consequences will occur. (e.g. refer to PDHengineer.com, document No# C-4029)
2. The **water consumption customer profile** provides for water consumption distribution across a village and provides a good indication for sewer system sizing and layout. Again, if unknown like in Stampriet, a system may be under sized and the sewer technology will certainly not perform satisfactorily.
3. Understanding on-site collection and treatment options for **recycling and reuse** first to avoid bottlenecks in a sewer system and excessive material and energy use and future maintenance.
4. Integration of appropriate **water saving devices** like low flush toilets, low flow shower heads etc. to optimise sewer technology operation, maintenance and to save on villagers' budget (water, electricity, sewage disposal).

Example 2: Rural villages in Namibia have very basic or poor infrastructure in terms of their roads and water reticulation and drainage networks, and have poor sanitation facilities in general. Such villages have little income generating activities and have to battle hard to receive enough revenue to pay for water and electricity and very basic maintenance of other infrastructure. Unemployment and poverty levels are high in rural villages in Namibia with an overall unemployment rate above 50%. Deciding for the light duty, non flood protected vacuum valve units in such villages may soon after commissioning bring a negative image for the chosen vacuum sewer technology if road and traffic ways and storm water drainage are not built as per best design standards or if they are completely **missing** like in Kalkrand, Gibeon and Stampriet. To initially limit capital costs in an area where people can drive and water can flow everywhere **will certainly increase the recurrent costs and maintenance requirements** for such a technology. People will certainly drive over insufficiently secured and unprotected infrastructure and storm water will certainly infiltrate. Where there is **no storm water drainage system installed,** a moderate rainfall will end up forming large puddles in depressions or even forming small dams where the unprotected tracks were built higher than the surrounding erven levels. This will soon annul potential benefits and frustrate the users. In all three assessed villages 'dam building' and erosion is a key challenge which does not allow the installed technology and components to provide the full benefits to the user (benefits e.g. low ecological foot print, energy efficiency, water use efficiency, health&safety for the people etc.). In fact, the user has to cope with **flooded infrastructure** and related **health hazards**. The commendable effort to improve sanitation for the respective villages has become not credible not because of vacuum sewer technology failure in the first place but because of a **lack of appropriate technology selection, lack of technology integration, lack of adequate component selection** (the technology allows for component selection to accommodate integration) and **lack of adequate infrastructure protection** often paired with **poor site management** and **poor workmanship**.

Example 3: Ideally a **capacity threshold assessment** should be done before deciding on any sewer technology. Such an assessment provides the decision makers and eventually the planners and contractors with vital information to build **operation and management capacity** in the respective villages concurrently while installing the most appropriate system. Essentials coming from such an assessment relate to **O&M manuals design** (not one shoe fits all), procurement of **adequate storage/workshop facilities** and **tools** to perform maintenance tasks, developing the necessary **skills and attitudes** of the operation and maintenance team, procuring the best mix for a **spare parts inventory**. If this assessment is not done and villagers are not prepared accordingly, routine maintenance is neglected and emergency maintenance will have to kick in, increasing costs with all known consequences.

Example 4: A new sewer technology needs a **decent briefing and constant follow-through with regards to planning, procurement, construction and site supervision**. The planning card below shows the **minimal** information blocks needed.



1. The current **standards** and **best management practices** [BMPs] must be known by all parties (decision makers, planners, contractors, users). If unknown like in Stampriet, the work quite often has to be remedied or the job has to be done twice, increasing capital and recurrent costs. E.g. inspection/vacuum test points should be installed at maximum every 100 meters on suction lines and not only a handful across the village most of them sealed and buried, else water logged suction pipes and a flooded village remain a challenge.
2. **Workmanship and quality** need to be pre-defined. If not, the parties are forced into litigation.
3. **Guidance and supervision** must enable the contractors/workforce to meet the standards and BMPs.
4. **As-built and as-tested records** need to be kept and provided to the users. If not, operation and maintenance becomes a major challenge in itself.

5. Observed Sustainability Challenges (Rapid Assessment)

The following is a rapid assessment of the vacuum sewer technology (design/procurement/construction/operation) in its environment (*client perspective*) with the aid of **20 sustainability imperatives** over four domains of human interference and benefit (*refer to Integrated Water Resources Management Plan for Namibia, Strategy and Action Plan and Integrated Framework for Institutional and Human Resources Capacity Building, 2010*). This rapid assessment fuzzyfies and smoothens the sustainability related observations and information obtained during the preliminary assessment to provide a 'barometer' glimpse. In this rapid assessment, the assessment variety is reduced with **imperative variety** being confined to: 'thumb up' = recognizable; 'thumb down' = not or poorly recognizable. Both indications are without the degree to which the respective imperative is met to provide for a first fuzzy but holistic overview and to show where improvements/adaptations could ideally be made through performance support and capacity building. The table below shows the four domains in columns and twenty sustainability imperatives in rows, assessed in 1|0 variety as in general yes/no. Again, such a rapid assessment does not go into details where some of them surely may matter. Instead it provides a first overview to better understand the direction of remedial efforts. The yellow highlighted fields **ought to be integrated** to allow for continued resource flows, use and benefits of the technology. Regarding the white field: here the focus must be on water and sanitation oriented client education and **integration into the social and cultural environment of the client** not the manufacturer/planner/supplier (a client focus is needed).

	ECOL [Ecology]	ECON [Economy]	SOC [Society]	TECH [Technology]
1.	innovative use of resources (*)	affordability	health&safety	'do it yourself'-suitability
2.	waste minimization	manageability	security and protection	extendibility of structures and processes
3.	energy use efficiency	value creation	integration in social and cultural environment	durability of materials and processes
4.	water use efficiency	cost recovery	attractiveness and acceptance	maintainability and serviceability
5.	land use efficiency	profitability	well being of people	adaptability to changing environment

The **blue icons** assess the vacuum sewer technology as it is experienced in a well managed 1st world environment (EC); the **red icons** assess the **integration/adaptation** of the said technology into the villagers' environment in Stampriet. I.e. what can the technology do for people in an **EC village (blue[14])?** ...and what did the planners/providers/contractors/operators do to support and/or enhance the inherent capabilities of the technology in the **system Stampriet (red)?** This system "Stampriet" includes {technology, people/users, internal constraints, boundary conditions, external influences/influxes of resources into Stampriet} and is **highly interconnected.** A more in depth study is recommended to understand this system "Stampriet" to provide management support also for other installations in Namibia (Kalkrand, Gibeon, Henties Bay, Ondangwa, Gobabis and in future for Outapi etc.).

(*)Addendum to the table above following cybernetic principles (*F. Vester; S. Beer et al.*): ***Innovative use of resources*** (*systemic use of resources*) is the first of the twenty sustainability imperatives and relates to natural, financial, human, information resources and their flow over time. It includes a subset of cybernetic principles which are: ***the principle of self regulation*** through negative feedback; ***the principle of multiple use*** such as serving a number of purposes/functions at the same time; ***the principle of recycling*** requiring the re-integration of processes, services or products; ***the principle of symbiosis*** or the exploitation of differences, mutual coupling and exchange; ***the principle of biological design*** through feedback planning and integration.

[14] The technology may not be the most 'user friendly' in the EC, it comes with a 'price tag': dependency on the manufacturer/supplier and 24/7 O&M, this has cost and tariff implications; e.g. for a 15mm connection the waste water basic is around N$250/m, the discharge tariff around N$ 35/m^3, this exludes the installation of the system for which users have to contribute per square metre property additional N$ 40.

A. Notes to thumbs up or down icons in sustainability domain and imperatives table (*Sustainability-Barometer*)

The rosé[15] highlighted cells indicate sustainability imperative ***deficiencies*** *of technology and integration, based on observations made during this preliminary assessment* *<u>and</u>* *feedback received from an EC village -similar in size as Kalkrand- on 12 years of 24/7 technology use. Both villages use the same technology.*

Mind: The purpose of a system is what it does, and a system does what it is established for! Only if all sustainability imperatives[16] -which are highly interconnected- <u>are met at the same time</u> system viability[17] may be given for that point in time.

imperative	technology capability (feedback)	integration of technology (Stampriet)
ECOL 1. innovative use of resources	e.g. vacuum control valve **stabilizes and regenerates through negative feedback** and **multipurpose use of processes** (e.g. suction support and timed -5 sec- regeneration while mixing air/water for self cleaning and transport)	**System stagnation** (water logging), system has no regenerating and self-starting capability, needs constant emergency management. Critical feedback loops are not installed or not observed in time, not interpreted correctly and communicated; dust and water entry in vacuum control valves causes system break down
ECOL 2. waste minimisation	specific technology is designed for **waste separation at source** based on **strict EC waste minimization standards**, (e.g. also complete recycling and reuse of components and eventually the waste water itself)	**waste separation at source and client education was not picked up**, current lack of integration allows for solid waste disposal into collection sumps or toilet pans blocking parts of or the entire system
ECOL 3. energy use efficiency	**energy use efficiency is a design feature of the technology** (e.g. only sporadic discharge pumping and vacuum 'top-up' is needed to maintain the purpose of the system)	**energy wastage** because system tipping point is unknown and no early warning and cut-off point installed (e.g. the **vacuum pumps run unproductively for days** without anybody noticing it; no early warning system/algedonic signal installed or observed and interpreted)
ECOL 4. water use efficiency	**water use efficiency is designed into the technology as a basic EC requirement,** (it is a prerequisite in the EC for EC designed and manufactured technologies), using minimal additional water to maintain and clean the system; the system is in principle **self-cleaning** if fed with the right consistency and quality of waste water (e.g. air/water mix)	**no water demand management measures observed and installed** in Stampriet households (e.g. customer profile, leakage management, low flush toilets, waste separation at source etc.). For details refer to customer profile: *water consumption pattern* in main report
ECOL 5. land use efficiency	land use efficiency is designed into the technology requiring only a **small foot print** (e.g. small (de)centralised vacuum stations, narrow and shallow trenches for vacuum pipes etc.)	**no land use efficiency** picked up in Stampriet, the dysfunctional system occupies 20-50 times the land surface it is built on due to constant overflow of collection sumps and flooding

[15] In b/w print this may be light grey in both right hand side columns (capability and integration)

[16] The four domain/twenty imperatives table used in this preliminary assessment only captures the most obvious connection points, i.e. it follows the *Pareto principle* of 20% specific imperatives bringing the 80% result. **These imperatives have <u>to be met all at the same time</u>.**

[17] System viability is defined as a system's ability to survive, i.e. **to maintain its own independent existence because of its unique purpose and identity.** The system can only do that if a sustainable flow of resources (human, financial, natural, information) is achieved at any point in time, i.e. sustainability relates to resource distribution and resource flows and system adaptation to maintain resource flows.

ECON 1. affordability	affordability for various sizes of communities through modular structure is a sales strategy behind the technology (e.g. manufacturer claims up to 25% more cost efficient than some gravity fed systems if installed with appropriate toilet/sanitation technology). **However, waste water tariffs may be prohibitively high due to the 24/7[18] need for highly qualified O&M[19] staff and expensive spare parts**	The system is partly functional only in the immediate surrounding of the pump station, the cost situation needs to be established once the client/technology interface is properly managed, only then can affordability be determined. The current state of the system and the lack of quality service provided to clients indicate that the system in its current state is **not affordable**.
ECON 2. manageability	**not as easily manageable as gravity fed systems** e.g. due to many moving parts and substantial pneumatic/electronic controls, 24/7 maintenance stand-by needed, **(dependency on manufacturer/service providers!)**	**poorly manageable technology in its current state of integration** e.g. because no training and education to Stampriet O&M workers provided, no regular follow-through and follow-up and rectifying of system malfunctioning from planners and installers given, no client education provided to people of Stampriet, no appropriate toilet technology and solids traps installed, no power supply back-up installed.
ECON 3. value creation	value creation could **generally be possible in high income countries** with well educated and skilled work force, 24/7 O&M, short distances to suppliers and providers, risk distribution amongst stakeholders	**no value creation** for Stampriet if the system is dysfunctional most of the time and can not be used AND if technology integration is poorly managed AND if peoples' ability to pay is severely stressed AND if raw sewage flooding provides a **health hazard**
ECON 4. cost recovery	cost recovery **generally possible in high income countries,** willingness to pay and managerial effectiveness is generally given, users are bound through contracts which they have to honour	The system is only partially functional, the cost situation needs to be established once the client/technology interface is properly managed, only then can cost recovery be determined. The current state of the system and the overall poor ability to pay indicates that the system in its current state is **not recovering its costs**.
ECON 5. profitability	profitability **generally possible in high income countries,** willingness to pay and managerial effectiveness is generally given (refer also to EC policy landscape on environmental protection and investment)	The system is only partially functioning; the cost situation needs to be established once the client/technology interface is properly managed. The services provided with the technology are currently **not profitable** due to the overall poor ability to pay.
SOC 1. health&safety	health&safety requirements for population are **generally met through sealed system;** the wider population has generally no contact to waste water	**no health&safety for Stampriet population given** as collection chambers are flooded and large puddles and streams of raw sewage along village roads and on premises **expose people to health risks!!**
SOC 2. security& protection	security&protection of technology **generally given through small technology footprint and sealed system,** vacuum stations in EC have to follow strict standards for security&protection of technology and people	**no protection of technology** given if people can open lids freely, dump solid waste into collection chambers or into toilet pans, protruding components are not secured, the vacuum station is only marginally secured, no cross ventilation installed

[18] 24/7 is an abbreviation for 24 hours per day for 7 days a week, no break possible

[19] O&M = operation and maintenance

SOC 3. cultural integration	developed for EC cultural, technical and social environment, **can not serve as comparison** for Africa where different integration strategies have to be developed and applied	**very poor integration** into peoples' social and cultural environment in Stampriet e.g. due to **lack of customer education and lack of feedback mechanisms either installed or followed** (*who is supposed to learn from whom*?)
SOC 4. attractiveness	**generally good attractiveness and acceptance** due to small technology footprint and little to be seen above ground other than small tidy lids and a small vacuum station with a biological air filter	**very poor attractiveness and acceptance** if technology often is dysfunctional and allows for raw sewage puddle and stream building around collection chambers (**health risk, odour nuisance in the village, attraction of flies, rodents and snakes etc.**)
SOC 5. well being of people	**generally supports good quality of life** due to sealed and rapid response technology, clean set-up, small footprint; prerequisite=skilled 24/7 O&M and regular preventive maintenance and good management	**does not support people's quality of life** due to frequent breakdowns, odour nuisance, exposure to **health risks** via puddles of raw sewage, long lasting blockages or system failure altogether etc.
TECH 1. do-it-yourself suitability	**limited "do-it-yourself" suitability,** reduced to diaphragm exchange on interface valve units and minor repairs e.g. NOT to overhaul vacuum control valves (**dependency on supplier and service providers!**)	**not "do-it-yourself" suitable** if work force is left untrained, and no workshop and no repair manuals are provided other than standard Roediger documentation kept in some offices but not on site (**maximum dependency on supplier and contractors, this drains the villagers' budget and eventually fails the technology**)
TECH 2. extendibility of structures and processes	extendibility of pipe network within limits of vacuum station capacity, modular set-up to **increase capacity by up to 20%** for existing system	there are **serious doubts about process extendibility** (e.g. sufficiently strong vacuum) if new sections to be connected to a **currently dysfunctional system**
TECH 3. durability of materials and processes	durability of materials given if installed as per prescribed EC standards; however, **process durability may not be given, requires 24/7 on-call maintenance personnel AND highly trained workforce AND substantial spare parts inventory**	**NO process durability given, the system is too instable** (power failure, discharge pump blockage, debris entry, whole system blockage, flooding of valve chambers, permanent running of vacuum pumps with no usable vacuum building up, wear&tear of system, poor maintenance capacity etc.) **NO material durability given** if solvent weld fittings are reported cracking
TECH 4. maintainability and serviceability	**limited maintainability and serviceability** due to **dependency on suppliers and service providers AND highly trained work force AND high level of 24/7 O&M**	**currently NO maintainability and serviceability given** due to untrained workforce, no solids traps installed, access roads washed away, **maximum dependency on supplier/ contractor**
TECH 5. adaptability to changing environment	adaptability to changing environment is not critical as long as the waste water quality does not change (**strict standards in EC about waste water quality, disposal and testing frequency**)	there are **serious doubts about adaptability to changing environments** e.g. to any disposed fluids and solids. In rural Namibia there are no quality testing standards for waste water disposal applied and followed. The technology calls for BMPs and adaptation of the larger environment first to become fully functional (e.g. roads, storm water drains, solid waste management etc.)

6. Additional Observations Made

A. Planning | Layout | Installation

System dimensioning and vacuum station layout and planning was done by **Roediger**/Bilfinger&Berger in Germany, so was most of the component planning/manufacturing for the system. Site layout and pipe network planning was done by **WML Consulting Engineers**, Windhoek, Namibia. Component/Consumables/Spares provision is done through **VACSEW Maintenance**, Windhoek, Namibia. The contractor was named as **Strydom Construction** Namibia. **There is no as-built and as-tested information available to the Stampriet Village Council.**

B. System Management

Summarizing the equipment available and in use to support continuous operation and maintenance:

1. **No air filter/cleaner installed**, odour nuisance in vicinity of pump station (*depending on wind direction*)
2. **No power supply backup system installed**
3. **The suction tanker is currently 'out of order'**
4. **No lockable and appropriately equipped workshop available** (only one small table under a tree)
5. **No appropriate tools and machinery available**
6. One store room at village council available, however, the facility is filled up with building materials

Summarizing the system management process:

1. **Basic skilled** management personnel in Technical Office, only **basic skills** available on site
2. **No** operation and maintenance, monitoring and evaluation and occupational health and safety policies in place from the Technical Office of the Stampriet Village Council
3. **No** monitoring and evaluation [M&E] records exist
4. **No** usable maintenance records are kept on site or in Technical Office of the Stampriet Village Council (only oil top-up records are kept at the pump station)
5. **Very poor** education and skills training to maintenance personnel provided
6. **No** operation and maintenance related assignments are discussed, supervised, followed through and followed up
7. **Basic** trouble shooting knowledge and trouble shooting strategy, the system layout and as planned documentation does not support any usable strategy (*refer also to disregarded impacts above*)
8. **No** cost figures are readily available, such figures need to be established after successful user/technology interface management
9. **No** cost recovery targets are set and followed up
10. System solvency is **unknown**
11. System profitability target is **unknown**
12. System productivity target is **unknown**
13. System performance is **unknown** (*ratio of what is done to what should be done*)
14. System latency is **unknown** (*development potential for HR and technology integration*)
15. Attraction of the best suitable people does **not** happen, two drivers are entrusted with day-to-day operation and maintenance
16. **No** responsibilities for system O&M documented
17. **No** accountability pathways and feedback signals formalised
18. **No** early warning system in place

C. System Operation

There are currently only operators of the vacuum sewer system in Stampriet; they are employed as drivers with the Stampriet Village Council. They are entrusted with *ad hoc* on-site jobs related to operation and maintenance [O&M] of the vacuum sewer system. Their involvement is 8/5 instead of 24/7.

Such *ad-hoc* jobs include but are not limited to:

1. exchanging and cleaning vacuum interface valves,
2. exchanging vacuum controllers; however, on hand over not all vacuum valve units were equipped with vacuum control valves and on many of the installed control valves the seal is broken.
3. sucking out flooded valve chambers, however, a suction lance needs to be bought first
4. rarely removing solids from sumps due to unavailability of the right tools
5. excavating entire collection sumps and vacuum valve units to remove solids, thereafter reinstalling them
6. regularly refitting opened lids,
7. regular oil check/oil top-up/oil change on vacuum pumps

Summarizing the operators' enabling environment to do the operation and maintenance and partly the monitoring and evaluation work:

1. **No** as-built drawing (*system layout*) is available in the pump station or the Technical Office
2. **No** as-tested documentation with the Technical Office of the Stampriet Village Council
3. **No** operation monitoring and recording/feedback/evaluation schedules exist
4. **No** adequate set of tools exists to perform maintenance duties
5. Occasionally casual labourers are hired through the VC to support the operator in excavating collection chambers for removing solids
6. Operators' safety clothing occasionally provided from Stampriet Village Council
7. **No** protective clothing against hazardous, contagious waste provided from the Village Council
8. **Very basic** education and training provided to just the operators with **no** follow up for performance management of both the vacuum sewer system technology or the operators

D. Village Inspection

The village inspection was carried out between Monday to Wednesday, 27/30.06.2011 to understand system constraints, human resource bottlenecks, and people's experience and to note the quality of work done and any mutual influences observed. General impression in Stampriet Proper: the operators have given up on 'proper'; many erven have 'made a plan' and have reconnected to their old soak ways or, like the private school, pump out their septic tanks into the river; in Soetdoring Laagte the operators expect major challenges once the toilet building project nears completion and these mini ablution blocks go online.

The findings:

1. Large parts of the western part of the system are not yet connected; however, **very little** sewage was sucked from the connected collection chambers
2. The eastern part (Proper) is connected and all vacuum lines in this part were open; however no measurable sewage was sucked from this part of the village; most collection sumps are flooded. This represents an **acute health hazard for the population especially for the school and hostel area.**
3. All main vacuum lines were open; an appropriately strong vacuum was only measured in a radius of ca 400 metres around the pump station.
4. **Vacuum leakages** and a lack of vacuum build-up were reported throughout the eastern part of the village; the location of all of the pipeing is unknown forcing the operators to dig at random.
5. **No test records** at hand in Stampriet to show previous tests carried out; i.e. trouble shooting becomes a challenge in itself
6. **No** appropriate tools were at hand to remove solids from blocked collection chambers

7. A number of collection chambers were **not** installed as per standards and best practices, e.g. their top flanges are not horizontally installed, many of them are eroded since the last rainy season, some level with the ground surface (infiltration of storm water and raw sewage is evident)
8. **No** flood proof or traffic load version of the valve chambers (type Z) is installed in Stampriet only the light duty standard chambers type G (*passenger load version*)
9. There are no solids traps installed across the village.
10. Children **frequently remove** the light weight covers of the collection chambers; at most of these chambers this is possible without any tools
11. The operators regularly complain about **broken/damaged inspection pipes.**
12. **No** site diary of the operators was available to demonstrate previous maintenance attempts (*important for system management*)
13. The Village Council's suction tanker was out of order and was **not** available to suck out collection chambers or to remove long standing puddles of raw sewage in the village.
14. **No** client education and awareness raising for the vacuum sewer system was done according to villagers
15. **No** client satisfaction surveys or feedback sessions were initiated and followed up; there is an indication of a generally poor willingness to pay for the sewage disposal service.

E. Vacuum Station

date: 27/06/2011

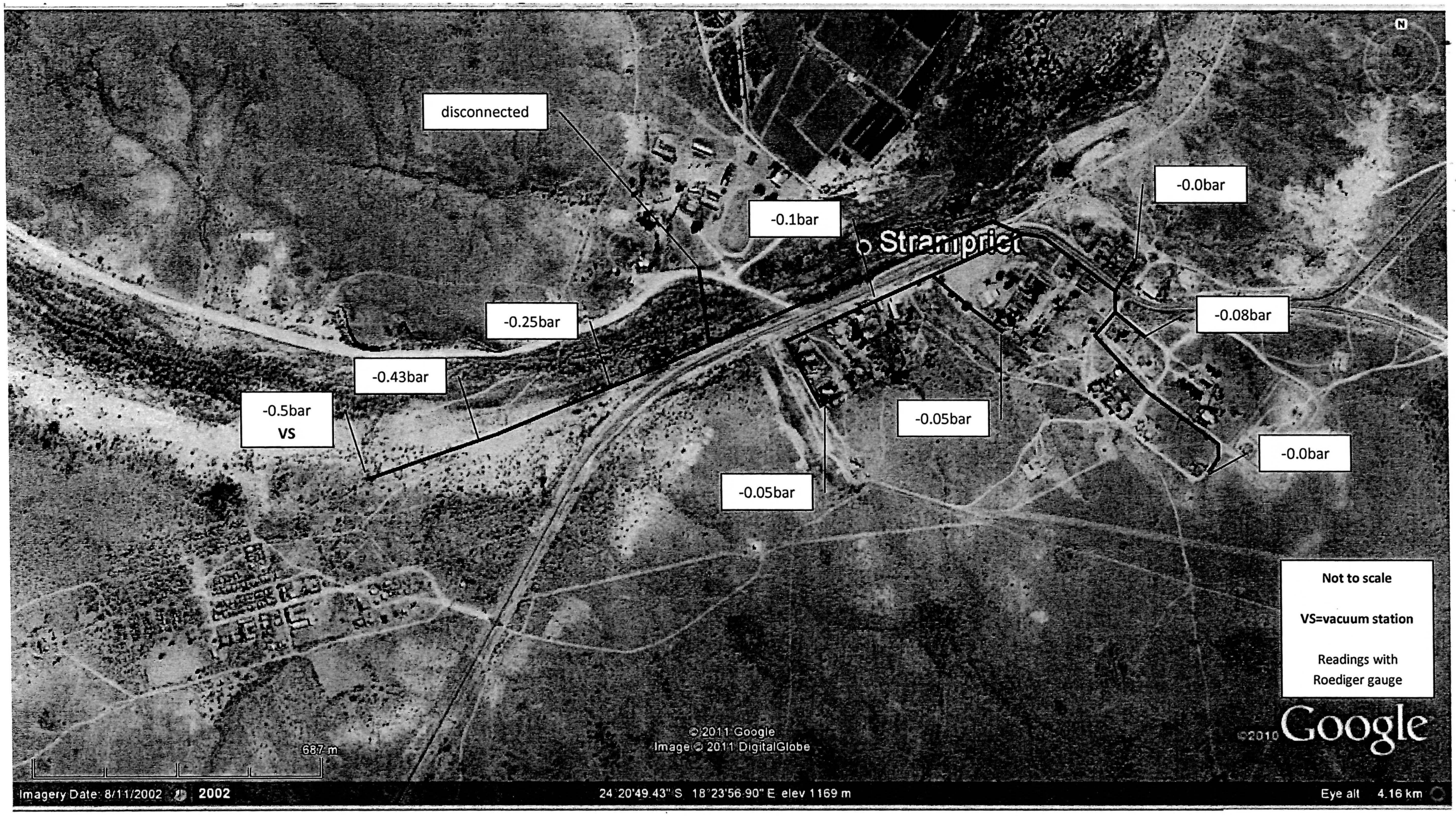
1. The vacuum reading on mechanical gauge was -0.48bar
2. The vacuum reading on integrated digital gauge was -0.58bar
3. Vacuum pump No# 2 urgently needs to be serviced, needs full oil top-up every 4-5 hours.
4. The other 2 vacuum pumps are running; vacuum pump No#1 does **not** cut off; No#3 cuts off at -0.6bar and kicks in at -0.56bar; however, the **vacuum can not be stabilized** which leads to extended running of vacuum pumps and energy wastage; the oil levels in vacuum pumps were adequate
5. Both discharge pumps seemed to work normally
6. Vacuum test equipment was readily available and used for the assessment
7. **No** power supply backup system is installed
8. **No** spare parts storage is available
9. **No system documentation is available at the pump station**; at least a quick reference guide should be made available to the operators for every day quick access when trouble shooting or doing basic maintenance
10. The vacuum station looked acceptably clean

F. Collection Chambers

1. The operators reported that **most collection chambers in Stampriet Proper are blocked**
2. Most vacuum control valves were **flooded** and submerged during this year's rainy season. The biggest challenge experienced on these controllers is the **fine calcrete dust** and the **high CCPP water** when flooded with raw sewage
3. 20 % of the village's collection chambers were randomly inspected and mostly found blocked with solids, in 'proper' the surrounding was flooded with raw sewage.
4. To test collection chamber effectiveness and efficiency it was agreed to first establish a management programme for the user/technology interface (*refer to "Topic 3.A" above*)

7. TROUBLE SHOOTING OBSERVATIONS ALONG MAIN SUCTION LINES

The map of the eastern part of Stampriet below shows the results of a first vacuum test walk to known suction points or vacuum test points (no as-built information available).



8. Key-Challenges Discussion

Four organisational challenge levels were identified during this preliminary assessment in Stampriet and similarly observed in Gibeon and Kalkrand:

1. **Policy and decision challenges** (*to determine to do something*). Decisions were made without sufficient consultation of and learning from the local population, without capacity threshold assessments (technical, managerial, operational), without in depth knowledge of the respective local site conditions (traffic ways, storm water drainage, power supply stability, managerial effectiveness, water demand management, O&M hardware needs etc.)
2. **Research and planning challenges** including (pre)feasibility studies (*to research and specify something*). What should have been picked up and <u>integrated</u> for decision taking on level 1: e.g. transport and traffic ways everywhere, lack of adequate storm water drainage, high CCPP potential in the water, lack of erosion protection throughout the villages; need for permanent guidance and site supervision of contractors, clear set of standards for installation, dust and infiltration sensitivity of chosen vacuum sewer technology especially light duty pedestrian version of valve units, lack of DIY-suitability and maintainability of technology on site, unknown water consumption customer profile.
3. **Installation challenges** related to workmanship and adherence to standards in general and protection of the technology and protruding components and proper recording and documentation in particular.
4. **Operation and maintenance challenges for clients/end users** related to user education, operation and maintenance capacity building, as-built information provision and awareness fostering, ability to pay for services, bearing the consequences of problematic planning and installations etc.

Level 1 needs all possible information in an iterative development process from level 2. Level 2 is the actual 'integration level' and needs constant info exchange with level 3 (guidance and supervision of contractors) and the future owners. Any unattended integration problems will surface in level 4. However, the crux of the matter is that level 4 implies a transfer of ownership to the next lower recursion level of organisation (Village Councils) again running through all four levels. In this, the villages are 'left alone'.

Four rather **technical challenge clusters** were identified during this preliminary assessment in Stampriet and similarly observed in Gibeon and Kalkrand:

1. **Vacuum loss on suction pipes** leading to **water logging** and **loss of system viability; erosion along vacuum lines** and collection chambers; **solvent weld fitting cracks** (material selection, integration and workmanship)
2. Vacuum control valve **sensitivity to fine calcrete dust and high CCPP water** (technology selection, design and manufacturing)
3. **System layout** and **lack of technology integration** into existing environment (planning, procurement); this sealed system either works or fails across an entire suction line, especially during floods or power failure
4. **Adequate protection of system components** (Village Council issue after signing certificate of completion and transfer of ownership else it remains a contractor issue)

Resource flows into Stampriet include little financial influx or reserves in and to Stampriet, poor or no information and experience exchange with other 'vacuum sewer villages' and nobody seems to be really interested to work there because of high unemployment and a very weak income generation potential.

Technology assessment challenges prior to installation into existing environment (*mostly related to financing and development agency*)

- The system tipping point in Stampriet is unknown with loss of system viability (*i.e. no self-starting ability for whole system as this is* ***primarily linked to debris entry, water logging of suction pipes, vacuum leakage****. The system is just not designed to cope with solid waste like rags/bones/stones/rocks/shoes etc.; i.e. important integration step is to establish a* ***user/technology interface management programme***)
- There are **restart problems after blockage/flooding** especially on the vacuum control valves and problems to maintain system viability.
- Although only partially online in Soetdoring Laagte and most of the time dysfunctional in Stampriet Proper, **discharge pump blockages** were reported because of rags/stones etc. due to missing solids traps on erven (*no debris/stone/rag/rock removal facility included in system, ideally waste should be separated at source*)
- **System component security and protection** must become a key-criterion for technology integration
- **Prohibitively high cost for accessories and spare parts** should be a criterion for technology selection and management strategy development

Planning/Layout/Procurement/Construction challenges include:

- **Technology not integrated and adapted to local conditions** and sanitation habits (*refer to rapid assessment above*) and there is **no user/technology interface management strategy in place**
- There is **no as-built and as-tested documentation** of the system in Stampriet available, this needs to be rectified
- Many vacuum pipes (*if on-line via opened division valves*) do not allow for an appropriate vacuum to build up; may have to do with either damaged/punctured PVC pipes, cracked fittings on inspection pipes or dysfunctional vacuum control valves or blocked interface valve units across the village which do not regenerate (*causes vacuum pumps to run permanently*)
- There is unhindered entry of storm water/sand/silt/stones/debris in some collection chambers due to collection chamber installation in depression or due to missing solid traps on erven (*needs rectifying soonest)*
- There is **no early warning system in place** to indicate potential failure (*observing the system*)
- There is **no online warning system** in place to indicate failure or abnormal changes of specific collection chambers or the system behaviour as a whole to the Village Council
- There are **too many unsecured protruding components** which can get damaged (*specifically above ground installations of vacuum test pipes and unsecured collection chambers*)
- There is **no system cut-off point installed** when system is "running dry" to prevent equipment overheating/energy wastage/wear and tear/high cost maintenance etc.)
- There was **no training and education provided** for system maintenance personnel (*implementing agencies could have made use of established education and training programs from Roediger/Bilfinger&Berger*)

Technical management challenges in Stampriet include:

- A general **lack of managerial effectiveness** of technical personnel, this needs addressing soonest
- There is **poor or no cost recovery on the system** (*system solvency at stake*)
- Appropriate education and skills development for operation and maintenance personnel was not called for/insisted upon during and after commissioning
- There are **no operation and maintenance, monitoring and evaluation and occupational health and safety policies**
- There are **no operation and maintenance, monitoring and evaluation records** available and benchmarking was not done to improve the system management
- There is **no appropriate workshop/storage** and **no appropriate tools** provided

9. WAY FORWARD (OPTIONS FOR REMEDY, RESULTS PLAN)

The results plan below, based on the results of the village inspection and the entire Performance Support Team assessment, shows what needs doing to **start the remedial action** on the vacuum sewer system in Stampriet and to enable for a re-evaluation after first remedial action. The results-plan is split into user/provider for quick reference. **This 'way forward' results plan points out options for remedy** and complements the on site developed 'Action Plan' further down under *Section 10.* The PST involvement to support this proposed results plan depends on sourcing of additional funding beyond ECAP and the commitments made during the action planning in Stampriet.

First results plan for the User, Stampriet Village Council supported by the PST where appropriate

Ref#	Results	Performance indicator	Responsibility (service provider)	Priority
VC-1	A joint decision is taken in Stampriet to adopt a **performance support team approach** for such time needed to integrate the vacuum sewer technology and especially the user/technology interface management programme	.......makes full use of the performance support team and cooperates on all levels of quality management by end of July 2011	**Stampriet Village Council**	1
VC-2	Appropriate *Operation and Maintenance [O&M], Monitoring and Evaluation [M&E]* and *Occupational Health and Safety [OHS]* **policies** are put in place to integrate and manage the Stampriet vacuum sewer system. This is done in conjunction with **Water Demand Management** (as specified in the Integrated Water Resources Management Plan for Namibia 2010)	system oriented O&M and M&E and OHS policies in place and applied for strategy and results development by end of September 2011	**Stampriet Village Council** with PST	1
VC-3	**Managerial effectiveness education and training** is provided to technical staff of Village Council	training sessions conducted and regularly followed up, staff enabled to manage O&M and M&E for the vacuum sewer system by end of September 2011	**Stampriet Village Council** with PST	2
VC-4	**Technical hands-on operation and maintenance education and training** is provided to technical staff, including on-site construction of easily cleanable solid traps along one branch of the system (done in Gibeon as part of the training) *refer also to Action Plan 10.II.3 below*	O&M staff successfully maintain the basic operations of the vacuum sewer system by end of September 2011	**Stampriet Village Council**, with support from PST	2
VC-5	**Technical management related results** are: marking out system components on site; measuring/recording power consumption on vacuum station; logging/recording discharges per day/week/month; recording frequency and volume of consumables and spare parts used; recording all breakdown and O&M activities to keep system running etc. to develop appropriate waste water tariffs and feedback on system effectiveness	key-data collected and processed to obtain basic information on power consumption, m^3 waste water processed, costs incurred, tariffs established by end of December 2011	**Stampriet Village Council** with PST	3

First results plan for the technology providers (planners, contractors, suppliers)

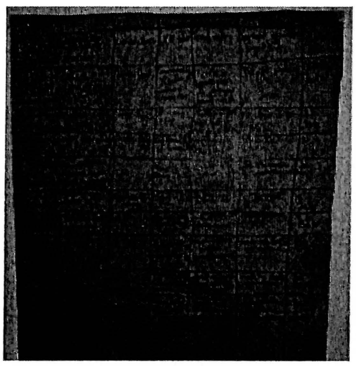
Ref#	Result	Performance indicator	Responsibility (provider)	Priority
P-1	**All as-built drawings, as-tested records and site supervision records** are provided to the Stampriet Village Council (site diaries of planners and contractors and updated drawings must be made accessible to the client)	as-built and as-tested documentation is used to identify system parts and constraints by end of July 2011	**Planners and Contractors** of the vacuum sewer system	1
P-2	**Vacuum system tests** on all suction lines (with blocked collection sumps) to determine **structural integrity** and functioning as per system own standards and international benchmarks is done	the vacuum system is structurally sound, a constant vacuum can be maintained in all suction lines, the vacuum pumps switch off if no water enters the system by end of August 2011	**Planners and Contractors** of the vacuum sewer system	1
P-3	All rocks and debris is removed from collection tank, suction lines, vacuum collection chambers in Stampriet	the entire system is free of blockages, collection sumps are self-cleaning by end of August 2011	**Planners and Contractors,** Stampriet Village Council	1
P-4	Additional installation support is provided for **easily cleanable solids traps on all premises** before waste water enters the collection chambers *refer also to Action Plan 10.II.3 below*	no unwanted solids enter the collection sumps, users are responsible and enabled to clean the solid traps by end of October 2011	**Planners and Contractors,** Stampriet Village Council, PST	2
P-5	Exchange/recycling/reuse of vacuum interface valves and vacuum control valves including capacity building for *Do-It-Yourself* maintenance in Stampriet is done and operators are enabled to maintain these basic system components in Stampriet	all vacuum interface valves and vacuum control valves are functioning and the technical staff is enabled to maintain these valves by end of October 2011	**Planners and Contractors** of the vacuum sewer system, **Stampriet Village Council**, PST	2
P-6	All vacuum collection chambers in Stampriet are flood protected, including vandal and children proof lids (could be made in ferro-cement technology or original Roediger lids) *refer also to Action Plan II.3 below*	only authorized persons can open the vacuum chamber lids by end of November 2011	**Planners and Contractors** of the vacuum sewer system, **Stampriet Village Council**, PST	2
P-7	The system is optimised for energy efficiency, an on-line warning system is installed to allow for timely communication of 'abnormal system behaviour' to the VC	the system operates at its energy efficiency target levels as designed for by end of November 2011	**Planners and Contractors** of the vacuum sewer system	3
P-8	A power supply back up system is decided upon and installed to maintain the 24/7 function of the vacuum sewer system in case	the system is 24/7 online by end of November 2011	**Planners and Contractors** of the vacuum sewer	4

	of power failure		system, **Stampriet Village Council**	
P-9	joint re-evaluation of the vacuum sewer system and its management for system viability, cost recovery targets, benchmarking etc.	a joint re-evaluation confirms reaching above performance indicators by end of January 2012	**MRLGHRD, Stampriet Village Council,** PST	4

10. Action Plan Vacuum System (elaborated on 29.06.2011)

The following action plan was elaborated on June, 29, 2011 in Stampriet. The participating team included members of the Village Council, Councillors and the ECAP/PST members. On 29.06.2011 the same participating team earlier collected key issues and prioritised those for the action planning (please refer to the main report for in depth coverage).

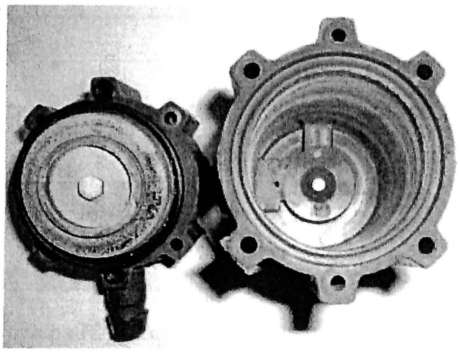
Activity	Responsible	Support	Resources	Milestone	By when?
II. **Vacuum Sewer System (second priority)**					
II.1 Clarify guarantee issues on workmanship, components and spare parts	VC	Ministry Councillors	Report, signed certificates	formal response from Ministry and Engineers	30.08.11
II.2 Submit tools list and costing (budget) to VC	Technical Team	VC	information on tools and availability	Budget	15.07.11
II.3 Technical Training for water and sanitation maintenance	VC	Councillors, Ministry, ECAP	ECAP (accom. and travel to Gibeon), Experience	Gibeon Training, Ministry Training	15.09.11



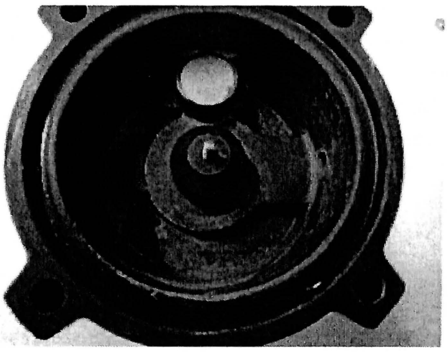
...the original action planning 'write-up'

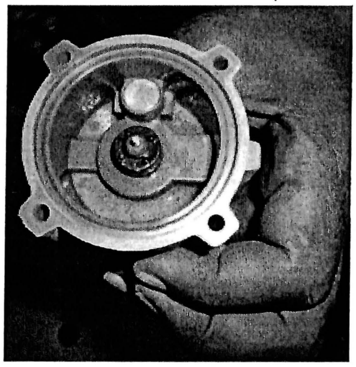
11. Photo Documentation from Preliminary Assessment

A. Component Related Photos

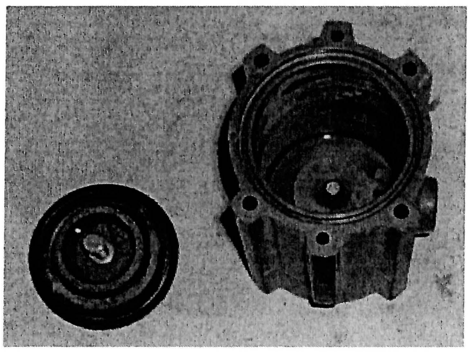


This vacuum control unit was completely filled with either storm water or raw sewage for a long time



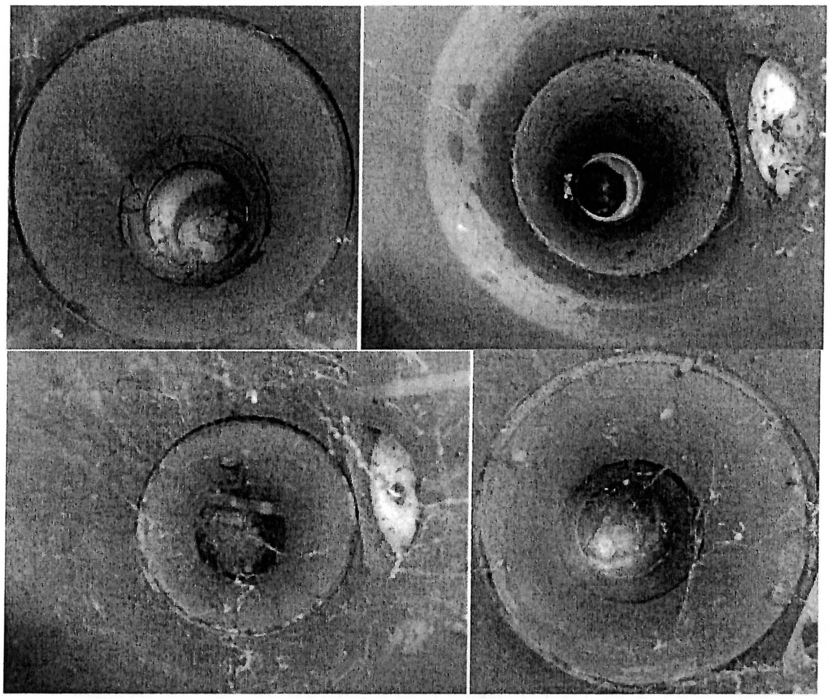


These two upper chambers of vacuum control units were exposed to dust and water (powdery deposits) their air filters were completely clogged, both units could not regenerate

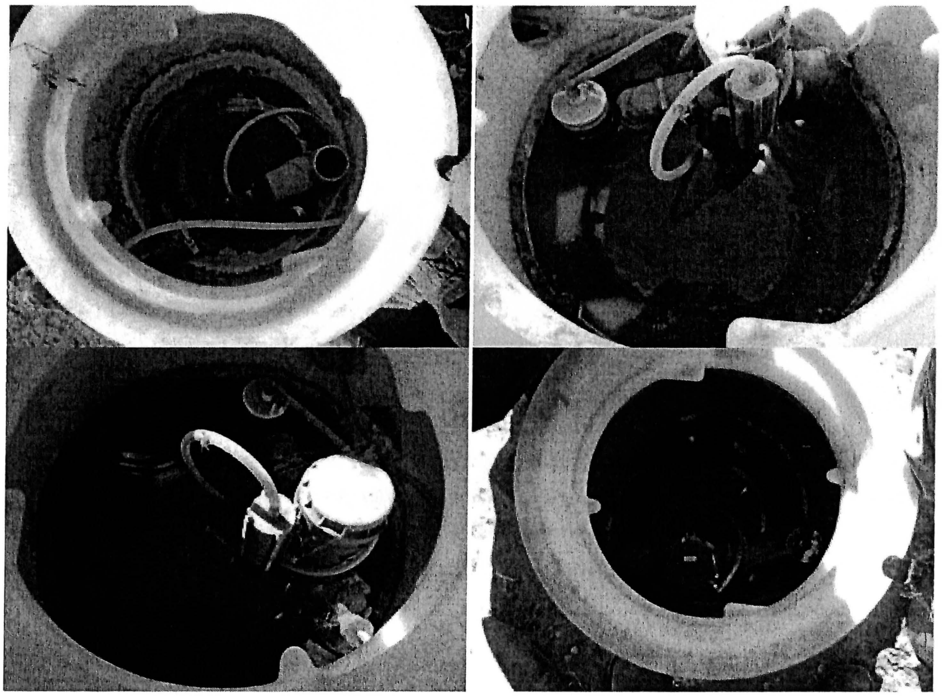


White calcrete dust in main vacuum chamber; the small switch did not seal properly and caused the interface valve to stay open permanently.

B. Collection Chamber/Valve Unit Related Photos

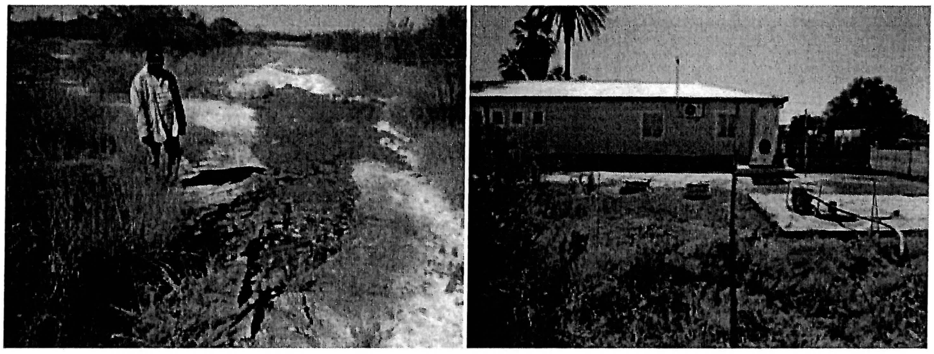


A common scenario in Stampriet: collection sumps filled with solid waste and rubble where the system is not yet on line. The operators do not have adequate tools to remove such solids; excavation is their current answer.



...another common scenario in Stampriet: long term flooded and dysfunctional valve units

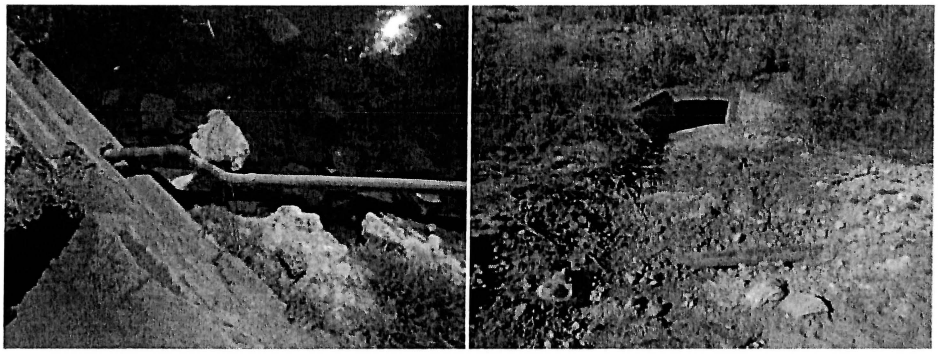
C. Reconnection and General Sanitation Related Photos



One example of reconnected sewage disposal is the private school which was disconnected from the vacuum sewers system due to insufficient vacuum. The school now pumps out the septic tank right into the river. The two collection chambers on the right hand side photo are disconnected.

Top left: open defecation right next to the vacuum valve units in the middle of the village.
Top right and bottom left: solid waste everywhere; in a poor community like Stampriet these are the playgrounds and 'toys' for the young villagers. A welcome additional toy is an unprotected valve unit right in the village centre.
Bottom right: typical improvised water/waste water connection mix in a school backyard, both pipes are leaking.

D. The Need for Infrastructure Protection and Workmanship Improvement

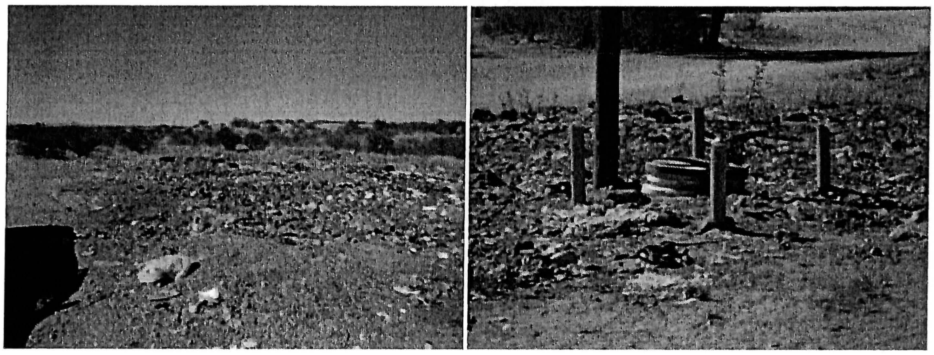


Two examples of erosion and consequences: the 'saw tooth' on the left photo was repaired several times. The suction line should not have been placed in a river bed where a small flooding event can erode all backfill material. The 2011 rainy season caused substantial flooding, exposing the suction line. In a suction event this pipe vibrates constantly and eventually breaks calling yet for another repair.
To the right: an eroded suction line next to a culvert exposed to sun light.

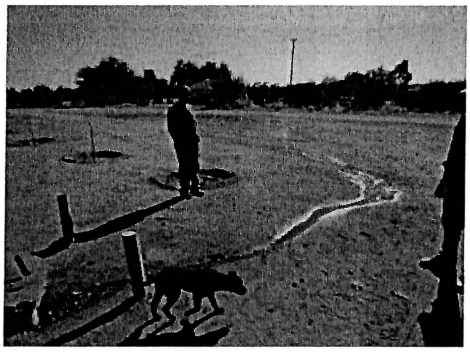
On the left: an unprotected vacuum test point in the river, an easy target for playing children.
On the right: an incomplete installation deteriorates.

Planning, installation and workmanship challenges evident throughout the village; erosion is a key-challenge. The left hand side photo shows trench erosion in Stampriet Proper. The road on the right hand side photo in Soetdoring Laagte is higher than the surrounding erven. This 'dam building' caused the washed away soil to fill up an entire area around unprotected valve units with the consequence that these units were flooded and sand/silt entered the collection sump and valve chamber. Both units are dysfunctional.

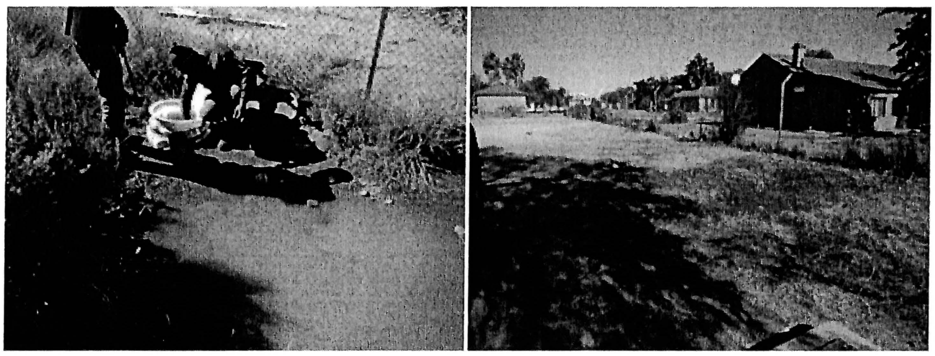
E. Health Hazards and Pollution



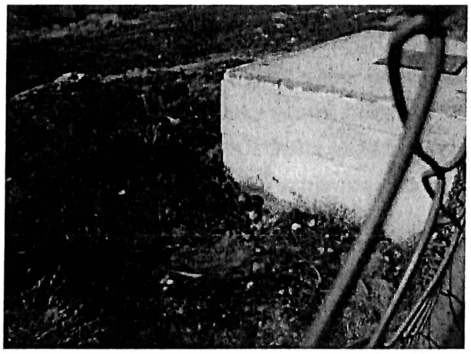
*...the urgent need for **sanitation improvement** is evident in Stampriet Soetdoring Laagte!*



*...most collection chambers are flooded in Stampriet Proper, **creating an odour nuisance, constant health hazard...***



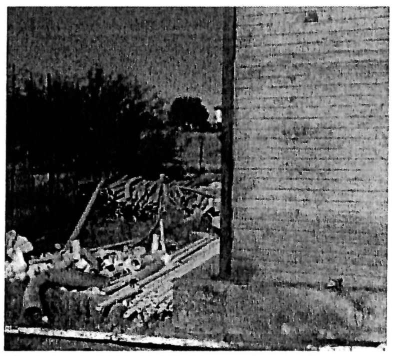
*Raw sewage floods the school grounds due to insufficient vacuum conditions, **presenting an acute health hazard for the learners and the staff***



The school septic tank 'punctured' above ground to flood the environment with raw sewage outside the school premises ***polluting surface- and ground water resources!***

F. Tools, Storage and Workplace Related Photos

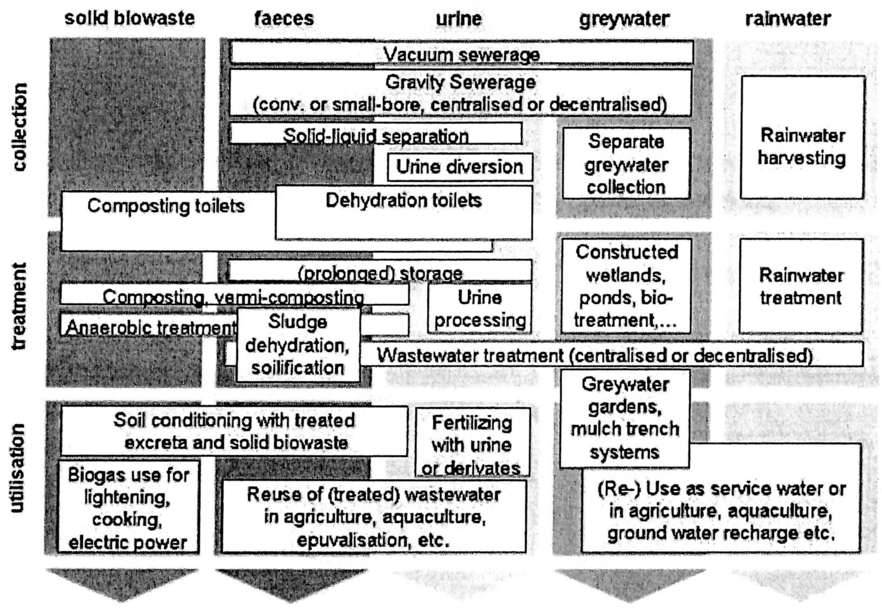
Stampriet does not own proper workshop, tools and storage facilities. The garages for the council vehicles are currently used to store building material for the toilet building project.



PVC pressure pipes are stored behind the garages in the sun.
The pipes in the back are already sun burnt; however, they are still used for repairs for water and vacuum system.

12. Options for Alternative Sanitation Provision

Raw sewage is a mix of faeces, urine and grey water and is a valuable commodity if collected, transported and treated appropriately. The shorter the collection and treatment path the more economic and environmentally friendly is the technology. The GIZ diagram below illustrates the different options for collection, treatment and utilisation over the five reusable sanitation components.

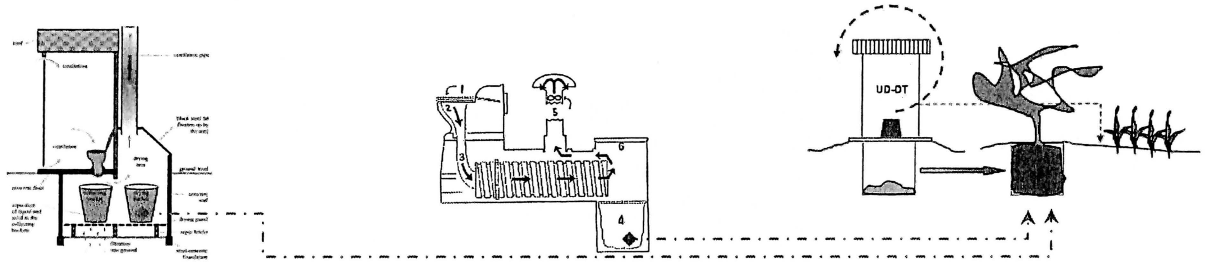


Source: GTZ/GIZ ecosan

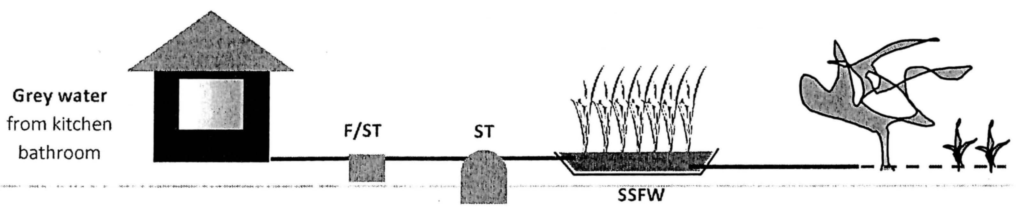
The Stampriet Village Council may look into alternative sanitation provision for those erven which up to date are not connected to the central vacuum sewer system. Three modular decentral alternatives out of a large number of possible combinations are sketched out below and are briefly described; they all include ***Water Demand Management Measures*** as specified in the *Integrated Water Resources Management Plan for Namibia 2010.*

A. Dry Sanitation and Grey Water Treatment On-Site

Single household: This alternative is the most robust and environmentally friendly solution to on-site sanitation. The toilets should ideally include urine diversion. Erven include shower/kitchen; collection and treatment through small fat/solids trap (F/ST), septic tank (ST), small horizontal subsurface flow grey water wetland (SSFW), shrub/tree garden, composting facility, backyard gardening.



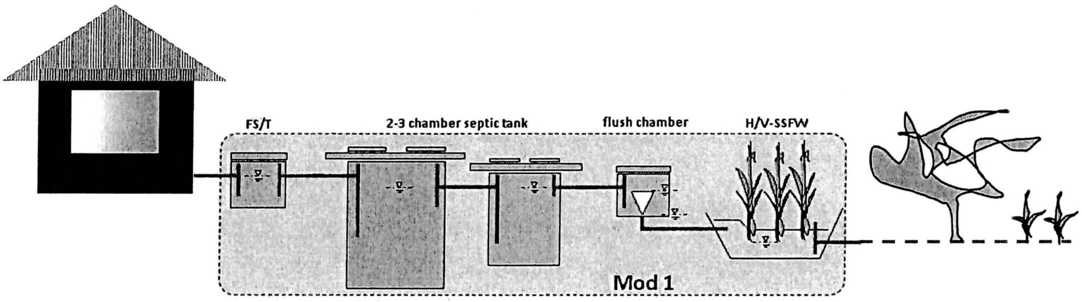
NAM Otji-Toilet or **RSA *ecosan* Dehydration Toilet** or **ZIM Urine Diversion Arbor Toilet** ...or



B. Wet Sanitation with On-Site Treatment (on household level)

Single household: This alternative is the "luxury" version (*less affordable*) of alternative "A" above. The toilets are normal flush toilets; water consumption and maintenance is increased, the system has to treat faecal contaminated 'black water' and is more costly than alternative "A". Erven include bathroom/ kitchen etc; collection and treatment through small fat/solids trap (FS/T), standard PE rotomould tanks combined as 2-3 chamber ventilated septic tank (ST) for 3-5 days retention time, flush chamber for intermittent flushing, horizontal or vertical subsurface flow wetland (H/V-SSFW), shrub/tree garden, composting facility, backyard gardening.

Foreign product series: ready made PE septic tanks (*SABS approved*) can be obtained through South Africa from *CALCAMITE* in the sizes: 1100/1750/2500/5500 Litre. *CALCAMITE* also offers accessories related to underground irrigation of shrubs and trees.

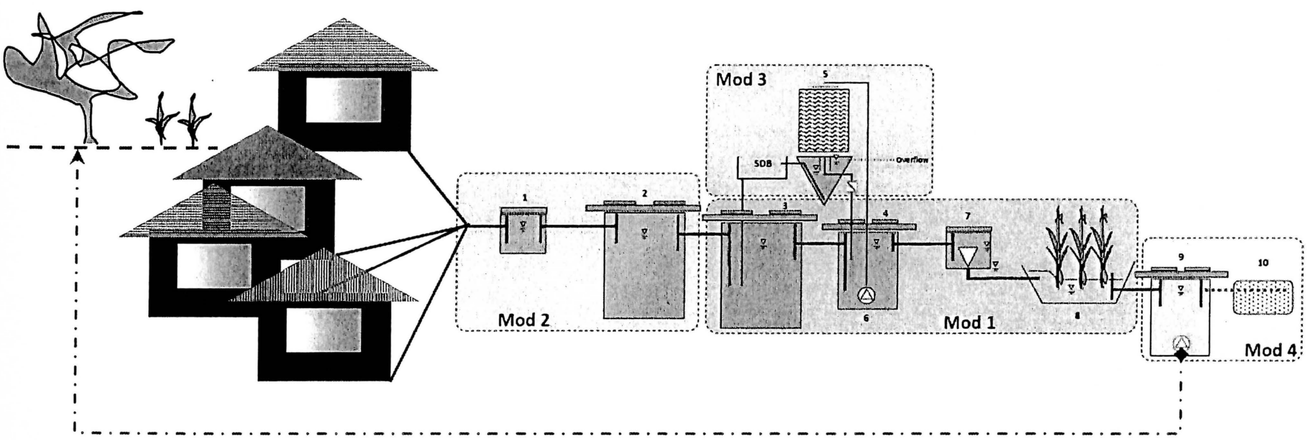


...the on-site collection and treatment components for wet sanitation

C. Wet Sanitation Clustering Several Households

Modular system for 4-20 or more households, extendable, can grow with demand:

- The basic system module (Mod 1) has the same components as in the previous alternative "B".
- An additional septic tank -standard PE rotomould tank (sizes from 1 000-10 000L)- is added in (Mod 2)
- When further demand is established (Mod 3), a trickling filter with circulation pump, sludge hopper and clarifier and a sludge drying bed are added. The horizontal or vertical subsurface flow wetland (H/V-SSFW) then serves as polishing wetland to achieve an optimal tertiary treatment ideal for reuse.
- (Mod 4) a final collector tank is added if the treated waste water is to be reused for irrigation purposes upstream. In such case an additional pump will have to be added. Recycled waste water (tertiary treatment) is a valuable commodity for urban gardening or village greening.



...the clustered system components, growing with demand