Techno-Economic Feasibility Study to improve the salt industry of Commune Anse Rouge

~100 salt basins in near foreground, near Magazen, viewed from the south east.

conducted on behalf of the Article 29 Organization

by

Cox & Speller (Consulting Engineers, UK)

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ACRONYMS used in the report

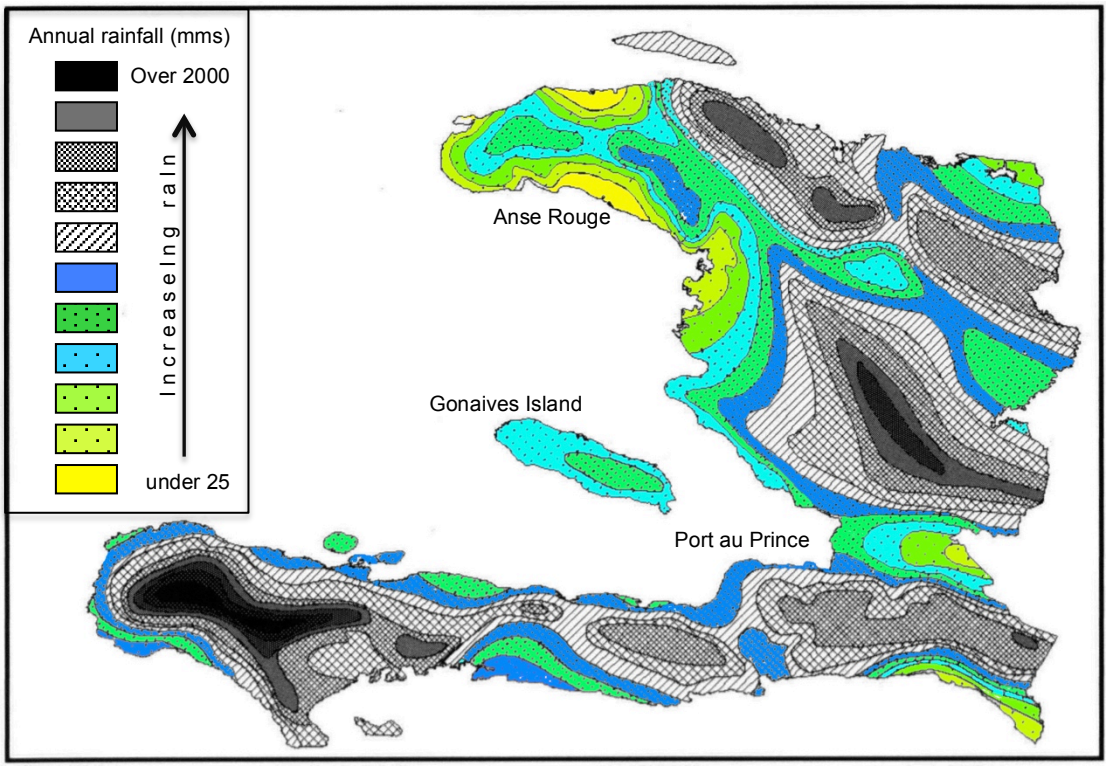
Accenture	Company name for a market research consultancy
ADP	Accenture Development Partnerships
AMURT	Amanda Marga Universal Relief Team
Baumé	Measure of the density/concentration of a brine
CuMs	Cubic Metres
DDA	Direction Départementale d'Agriculture
dwt	dead weight tonnage (maximum bulk cargo weight)
fob	Freight on board
GAIN	Global Alliance for Improved Nutrition
GIS	Geographic Information System
IDD	Iodine Deficiency Disorder
IOM	International Organization for Migration
MARNDR	Ministère de l'Agriculture des Ressources Naturelles et du Développement Rural [Ministry of Agriculture]
MI	Micronutrient Initiative
MSPP	Ministère de la Santé Publique et de la Population [Ministry of Health]
UND	University of Notre Dame
UNICEF	United Nations Children's Fund
USI	Universal Salt Iodisation (for a country or community)
WFP/PAM	World Food Programme / Programme Alimentaire Mondial

Contents

* *includes outline of scope of Design Study*

Introduction

About 70% of Haiti's salt is produced in Commune Anse Rouge[1] - one of the poorest[2] and most isolated regions of Haiti. Due to its arid climate, it is one of only two regions in Haiti that are chronically food insecure throughout the year and, without the income from salt, it would become even more impoverished.



Salt production at Commune Anse Rouge takes place in "salt basins" hand-dug below sea level (see cover and next page). The seawater that enters evaporates and forms salt crystals that are hand-harvested - a primitive labour-intensive and commercially uncompetitive process. The industry is threatened by cheaper better quality salt from near neighbours[3] and, if it does not modernise, the livelihoods of the already impoverished salt producing communities will suffer.

Another problem is the vulnerability of these salt basins to inundation from floods caused by rain falling on high hills some 20Kms inland. On several occasions these have destroyed dykes and necessitated expensive emergency rebuilding.

Modernisation could resolve both these problems, improve salt quality and increase output. However, unless new outlets for Haitian salt can be found, this might depress prices and reduce the net income. This issue was addressed by a market study commissioned[4] in January 2011, when road salt sales to the USA were identified as potentially a large income generator worth well over $2million/year[5].

Later, in April 2011, Cox & Speller[6] were asked to assess the technological feasibility of transforming several hundreds of existing salt basins into a modern saltworks that could satisfy all Haiti's domestic needs for iodised salt and also to make and export ≥200,000 tonnes/year. Our technical findings were positive - but we learnt that many salt basin owners initially may be reluctant join a cooperative.

Currently there are over 2,700 salt basins in Commune Anse Rouge with more than 1,400-recorded individual owners, more than 95% of whom live in or near Commune Anse Rouge[7]. Because of the inability of most villages within the coastal range and unirrigated plain to rely on agricultural crops, it is likely that 30-50% of the 40,000 population of Commune Anse Rouge is directly or indirectly dependent on salt production for their livelihoods.

The basins receive seawater by gravity by seepage and/or channels. This evaporates to less than 10% of its original volume and deposits a mixture of all salts of seawater in the salt basins – where they are 'harvested' as shown below.

Harvesting from a salt basin near Magazen

This procedure contrasts with the 'modern' method (actually, 1500 years old) of having the seawater flowing through, and evaporating from, a sequence of ponds. After 90% of the water has evaporated in this system, sodium chloride is deposited virtually free of the less soluble calcium salts (deposited earlier) or the more soluble magnesium salts (discharged with the residual brine).

Apart from making a better salt (>98% sodium chloride), this method can be 10 times more productive and, if technically feasible and viable commercially, it could substantially improve the livelihoods of the people of Anse Rouge.

For the field studies of 11-27 April 2011, Cox & Speller deployed two engineers, ***Dr John Cox****, a chemical engineer/ solar salt expert and* ***Simon Griffiths****, a civil engineer/roads and ports expert. We were accompanied in Commune Anse Rouge by a team that included: Local Bureau of Agriculture for Commune Anse Rouge:* ***Pascal Addison****, Agronomist, Oxfam America Livelihoods*

Coordinator and Article 29 Organisation Founder, ***Amber Lynn Munger****, Article 29 Organization Coordinator* ***Hebert Pierre*** *and two others.*

Whereas the Oxfam America team participated in all technical discussions in Haiti, the report was written and completed in the UK following discussions that included ***Peter Speller*** *(another chemical engineer with solar salt experience).*

Subsequently*, when it became apparent that it was unrealistic to expect all of the 1,400 salt basin owners to modernise without first seeing a small-scale pilot project demonstrating its advantages[8], the scope of the salt project altered. Whilst the ultimate objective remains to enable all the salt basins (in the Magazen area) to be modernised – eventually producing around 200,000 tonnes/year - the present proposal is more modest and realistic.*

The new perspective is to modernise as many salt basins as feasible (maybe 300) in a limited area and, initially, target for substitution the 15,000 tonnes/year imports recently[9] identified. What is now envisaged is a Pilot Project whose benefits should become evident within a three-year period - as an example for other owners to follow later by joining the cooperative created for the Pilot Project.

This report retains much of the original text written for Oxfam America for the 200,000 tonnes/year perspective - but alters passages where appropriate for the Pilot Project perspective. In accordance with normal professional practice, Cox & Speller has sole and total responsibility for all opinions and technical judgements.

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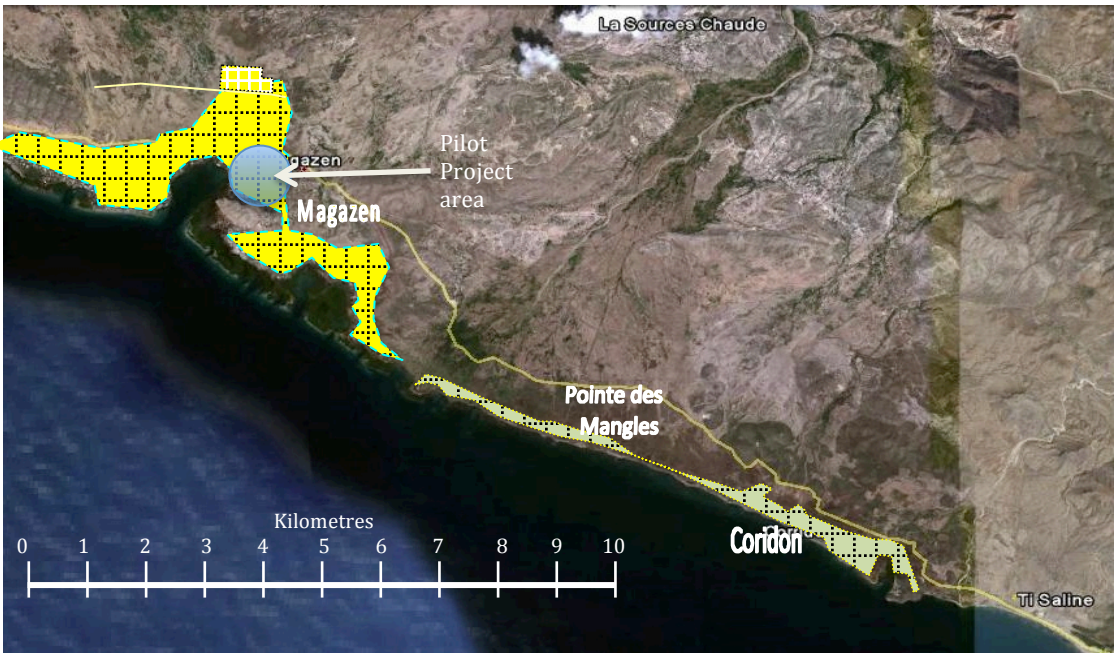
Project Area - showing the proposed Pilot Project area (light blue), the proposed fully modernised Magazen saltworks (hatched yellow) and the area of existing salt basins at Coridon (lighter yellow hatching), for which we have no immediate proposals.



1 EXECUTIVE SUMMARY

The study in April 2011 assessed critical technical issues relevant to saltworks design and found no fundamental obstacle to modernising saltworks at these locations or any flaw in previous assumptions. These critical technical issues are the topography, soils' characteristics and weather and, for exports, adjacent sea depths and availability of appropriate local building materials.

In every instance, the outcomes of the investigations in April 2011 met or surpassed the criteria Cox & Speller previously postulated as essential for the project to satisfy techno-economic feasibility.

In view of these findings, Cox & Speller recommended flood protection for the saltworks (wherever cost effective) and to protect local communities and, as and when community organisations are in place, modernisation of the salt basins and the provision of facilities for iodisation and exports.

This perspective was outlined to individuals at saltworks, in discussions in the community and at meetings in Magazen (>125) and Coridon (>35) and at various meetings with producer groups in the salt producing zones. Subsequent liaison[10] with the community confirmed significant support amongst the salt basin owners around Magazen for step-by-step modernisation, beginning with a Pilot Project for about 300 salt basins that, in due course, could be extended to include all the basins of the Magazen area,

The Pilot Project is now (November 2011) the main focus of our attention. A "Design Study" is needed to refine the cost estimates needed for any potential investor and complete the work of this Feasibility Study. Concurrently with the construction and operation of the Pilot Project, it is realistic to allow two years for the creation of the essential community-based local organisations.

Timing

The recommendations for earth moving and flood protection at Magazen are already sufficiently detailed that work could commence once the funding and institutional/organisational support becomes available. Flood protection plans for the Coridon area require further liaison and discussion[11].

The implementation of proposals for modernisation require the creation of appropriate local organisations to become the proprietors, to resolve issues relating to ownership, to explore investment opportunities and act for the local community on relevant issues as and when they arise.

Financing

The investment costs for a fully modernised saltworks and salt-exporting jetty (generating perhaps $2million/year) may cost up to $6million. This might be financed by a single private investment - but a preferable arrangement would be to begin with a "Pilot Project" to demonstrate the technical and commercial advantages on a small-scale and thereafter self-finance full-scale modernisation.

Flood protection (other than the dyke improvements included as part of saltworks modernisation) could be accomplished using development tools such as Cash For Work or other project related employment schemes and, if so, could involve the removal and transport of ~0.5million CuMs of excess earth currently piled around the salt basins to new flood barriers located in the near vicinity.

2 INVESTIGATIONS

These paragraphs summarise the findings from the investigations defined in the scope of work for the consultant in April 2011 (Appendix 1).

2.1 Depths survey

The purpose of this survey was to confirm that sea depths of >12 metres (required[12] by the 25,000 dwt ships needed for salt exports) existed offshore. It was conducted with a line and weight and confirmed that 12-15m depths exist just outside the lagoon, less than 250m offshore, close to shallow water that may well be suitable for a rock fill constructed jetty. This "area of interest" is shown on the satellite photographs appearing in Appendix 2.

This location is close to the edge of surveyed waters to far greater depths and more than adequate to confirm that a salt exporting jetty could be built at this location. However, an investor will require a detailed bathymetric survey to be conducted along this coastline (for, perhaps, about 1Km.) in order to inform the detailed design of the jetty at this location.

For the more modest Pilot Plant project, there will be no need for a jetty. If the perspective is to export bagged salt in (say) 10,000 dwt ships to the USA, no more than 8-10m depths are needed – and as these exist within the sheltered Magazen lagoon, the costs of the jetty will be very much reduced.

2.2 Topographical survey

The purpose of this survey was to establish how much of the unused and otherwise unusable land north of the road near Magazen could be used for a new modern saltworks. It confirmed that there are 120 hectares that could be added to existing salt basins to create a 600-hectare saltworks (Appendix 3).

No surveys were conducted elsewhere: as the existing salt basins are fed by gravity from the sea, they must be all close to and/or below sea level.

2.3 Geotechnical survey

The purpose of this survey was to establish the suitability of the ground to build a modern saltworks. It was conducted using a 'backhoe' to dig 18 holes in the Magazen saltworks area and sampling for clay, sand and silt (Appendix 4).

This confirmed that most of this site is underlain by impermeable clay that, moreover, was sufficiently abundant that it could be used to 'key in' to the base of flood barriers and thereby eliminate any need to purchase expensive plastic sheet rolls to prevent seepage losses. So these investigations more than confirmed the suitability of the site.

However, it should be noted that the Coridon area was not sampled and it is possible (although unlikely in view of our observations) that the composition of the Coridon soils differ markedly from those obtained in the Magazen area. If this were to be the case, it might be necessary to 'import' clay to the Coridon area from the Magazen area to seal any dykes constructed for new flood barriers.

2.4 Evaporation tests

The purpose of this investigation is to obtain a realistic estimate of the potential salt output from the area available for the new modernised saltworks.

Whilst we are confident that a lot more salt can be made than at present, in the absence of local weather records we have to obtain this data using test ponds.

These tests (Appendix 5), which are being supervised by the Bureau of Agriculture, need to continue over an extended period to obtain a truly realistic estimate of the potential output of the new saltworks (more than one season is advisable). Early results suggest that the potential output of the new saltworks may exceed 200,000 tonnes/year - but it will be some months yet before there are sufficient readings to make firm predictions.

2.5 Community Liaison[13]

During our investigations, the Bureau of Agriculture (Commune Anse Rouge) initiated meetings between producer associations, Article 29 and Oxfam and meetings were held at Magazen (>125) and Point de Mangles (>35) - where Dr John Cox and Amber Munger presented basic information about the research and answered questions. Additionally, numerous one-to-one discussions took place during the visits to the salt basins and nearby communities.

It became clear that the removal of excess earth and its for new flood barriers would be welcomed – not least because these also could protect the villages and houses. However, for the saltworks' modernisation, the costs are generally too high to justify protecting all but the most vulnerable locations (crystallisers, salt stockpiles and processing plant).

For a comprehensive flood protection scheme to be undertaken, it has to be justified by community benefits or as part of an irrigation system – saltworks' modernisation on its own cannot justify an all-encompassing flood protection scheme. In our (Cox & Speller) opinion, a comprehensive study of all aspects of flood protection should be undertaken in order that the community, salt basin owners and local farmers all may benefit.

Modernisation (of the saltworks) is critically dependent on societal issues and it is important to attempt to integrate any engineering and construction that is undertaken for the saltworks with other societal benefits.

3 RECOMMENDATIONS

Because the salt producing areas stretch from 20kms from east to west, it is appropriate to restrict the primary modernisation to the relatively compact area at and near Magazen, and provide it with a salt-exporting jetty. There is also some scope for limited improvements to the salt basins near Coridon - if desired and deemed appropriate by the stakeholders.

Although the basic science and technology is the same, the detailed design depends on the respective locations and will be described separately.

3.1 The Magazen area (includes the Pilot Plant area)

The available low-lying flat area (~600 Hectares) and proximity to deep water (>15m) make Magazen potentially suitable for a major salt exporting investment. Details of a possible integrated and modernised saltworks appeared as an Attachment to the report for Oxfam and its basic principles remain valid:

a) The position of the jetty is determined by the location of sea depths of at the appropriate depth and proximity to appropriate building materials.

b) The associated salt stockpiles and washing facilities should be nearby on shore to minimise the length and cost of conveying operations.

c) The crystallisers should be grouped around the washing and stockpiling facilities to minimise handling costs.

d) Several seawater intakes may be appropriate to minimise the pumping duties and costs – before pumping to the crystalliser ponds.

e) Additionally, washing facilities, a canteen and other personnel facilities, the engineering workshop and a power generator and a brine reservoir would be located near the new crystallisers.

Whilst several alternative layouts could satisfy these criteria (and, indeed, have been considered), the site chosen for the Pilot Project has pre-determined where the crystallisers are to be located and, effectively, where best to locate the stockpiles, processing and bagging units and the jetty.

3.2 The Pilot Project site

The area in which the Pilot Project is likely to be located is known locally as "Tet Bai" or "TetB". It was chosen by virtue of the high level of support already expressed by local salt basin owners. It also has other desirable features as the location for crystallisers and salt processing, notably:

a) It is less vulnerable to flooding than most other locations[14].
b) It is near relatively deep water (>8m) in a sheltered lagoon[15].
c) It is central to the majority of salt basins in the Magazen area.

The precise design of the Pilot Project will be determined by the proposed Design Study when, at the same time, realistic project costs will be estimated.

3.3 Coridon[16, 17, 18]

The usable low-lying flat area (~125 Hectares) that includes salt basins from Coridon to Pointe des Mangles could produce >25,000 tonnes/year. This is too small an output for a salt exporting investment – although it could supply the domestic market for salt in Haiti by road and by boat (as it does now).

The Coridon salt basins differ from those near Magazen in two important ways: (1) a smaller total area and (2) they are more widely dispersed. Whereas at Magazen there is merit in linking basins, the cost of doing so at Coridon would outweigh any benefits. Whilst there is scope for some improvements, local salt basin owners and workers have yet to indicate any wish to modernise and, until they do so, there is little point in devising any proposals.

3.4 Iodisation

Irrespective of progress towards full modernisation, it is feasible for salt producers to upgrade salt quality and supply the domestic market with iodised salt without necessarily proceeding to implement full modernisation. To iodise to international standards, three conditions have to be satisfied.

a) The salt quality may be improved by reducing the amount of solid and magnesium salt impurities. A small customised washing unit could do this short-term but will become redundant after the salt basins have been upgraded to become a modern saltworks,

b) A modernised saltworks must be able to iodise, dry and package the produced salt - as outlined below - and the salt workers have to be trained in the use of these facilities.

c) Institutional obstacles, such as the government's current preference for iodisation to be conducted centrally, must be addressed.

In respect to iodisation technology, Cox & Speller recently (March 2011) conducted a comprehensive review of progress in Ghana towards USI (Universal Salt Iodisation) and it is instructive to refer to this experience.

Knapsack spraying (Ghana March 2011) at Tradevco (right) and Elmina (left)

There are about 30-40 salt enterprises in Ghana, varying in output from as large as 100,000 tonnes/year down to less than 50 tonnes/year. The technology used varies from wholly manual knapsack spraying at small saltworks (above) to machine-controlled iodisation using a screw conveyor (below).

Machine operated iodisation at Nyanyano Cooperative, Ghana, March 2011

Whereas WFP/MI tend to promote and supply machines to willing salt enterprises and provide training, UNICEF/GAIN believe knapsacks also have a rôle to play. Either could be used at a modernised saltworks – the level of support offered by these agencies might determine the eventual choice.

Drying is the next stage of iodisation – if needed (the salt already may be dry enough). It then has to be packaged and dispatched. In Haiti, bearing in mind the importance of creating sustainable paid work, it is likely to be appropriate to dispense and pack measured amounts of iodised salt into airtight sachets, place these in retail-size packets and package the boxes for sale to Port au Prince and elsewhere in Haiti.

There is therefore no technological obstacle to iodising salt (even without full modernisation – though that is preferable). Cox & Speller understand that the major obstacle to iodising at Anse Rouge is an institutional preference to have it conducted near Port-au-Prince. Whilst this is doable technically, and the Pilot Project certainly could supply Port-au-Price with appropriate salt for iodisation,

centralisation incurs unnecessary transport costs and runs counter to experience of iodisation in other countries.

These options were outlined in Attachments to the earlier report to give producers an informed choice but, whatever is done, there will need to be an intensive programme of training in new production methods and iodisation to ensure that an acceptable quality iodised salt is produced (and sold).

3.5 Excess earth

The salt basins were created by digging out sand and clay to depths below sea level to allow seawater to flow by gravity into the basin. This excess earth was piled around the individual basins, as it would have been costly to pay for it to be carried to locations outside the salt basin area.

Typical salt basin and earth dykes near Pointe des Mangles (west of Coridon)

The deposited earth can reach heights of metres, making it difficult and arduous for workers to harvest and carry the salt away. Apart from the physical difficulty of walking through the basins, with or without salt, loose or in bags, and the excessive heights to which the salt has is lifted to drain after harvesting, and the loss of production due to the absence of wind within the basins, the major concern is the tough working conditions.

In short:

1) High dykes create wind barriers that reduce evaporation and thereby salt production (without air movement, no evaporation can occur and the salt ponds simply heat up without evaporation).
2) Whereas a pond with 300mm high dykes can rarely exceed 35-40°C, it is usual for a pond such as pictured above to exceed 65-70°C – which is why harvesting at this location has to take place during 3-7am.
3) The physical operations of harvesting and carrying the salt are made far more onerous by the presence of these mounds of earth.
4) The dykes require constant maintenance and whenever it rains or floods there is a risk of damage to the salt basins.

Removing excess earth will assist modernisation but for health and safety reasons is worthwhile even for unimproved salt basins. Moreover, this earth can be used usefully elsewhere – for flood protection barriers and irrigation. If Cash-for-Work or other funding could be obtained, there is enough earth for several thousand people to be employed removing earth for many years on community schemes – in addition to using it to assist saltworks' modernisation.

Scouring can cut through a highway

3.6 Flood barriers

Flooding is common in the rainy season and can inundate villages, cut roads and cause stress and loss to the local community. So besides issues for the saltworks (loss of production and repairing dykes), this is a major ongoing issue for the local communities.

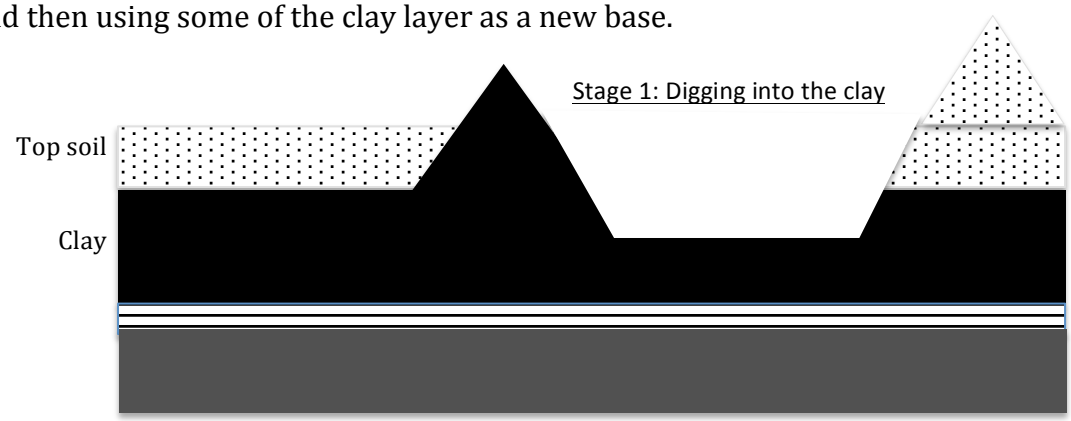
In April 2011 we viewed newly constructed flood defences near Coridon that, in our opinion, may prove unsuccessful as they lack reinforcements (clay core and rock armour) and also do not completely enclose the vulnerable area. We outline in the next pages what we think is needed for full and reliable flood protection for the modernised saltworks (or for community use or irrigation).

Design

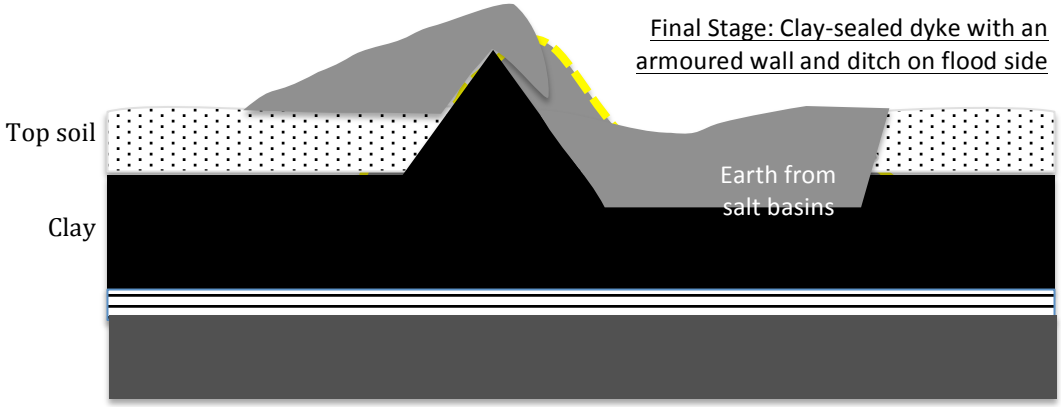
The design of all dykes and flood barriers, whether intended to retain the floodwaters for irrigation or simply to protect salt ponds or the community, has to cater for seepage (particularly important in a saltworks) and flood erosion. To minimise costs, clay is preferred to plastic sheeting at a saltworks and armouring with rock is used to prevent erosion.

The soils' testing (Appendix 4) revealed a clay underlying most of the site (typically as illustrated below). The construction of new flood barriers for the saltworks will utilise this local clay to seal potential leaks (where appropriate).

The next sketch represents the first stage of construction (note, for a new dyke) – removal of (say) a 2-3 metres wide strip of top soil (stacking it nearby) and then using some of the clay layer as a new base.



The work for this first stage is best done by machine: all remaining work could be manual – covering the whole dyke with earth (removed from the salt basins) and 'armouring' the faces with stones.



For existing dykes, armouring is straightforward (as above) but sealing may require the use of plastic inserts (which can be costly and time-consuming).

Perimeter dykes (for the saltworks)

Every saltworks needs perimeter dykes to prevent ingress of seawater (during a storm surge) or flood waters (during the rainy season). At Magazen, both need to be about 2m high. The latter also has to divert the floods coming from the inland hills to controlled escape routes to the sea. In all instances, the side of the barrier in contact with the sea or floodwater has to be 'armoured' – the other side need not be armoured and may be simply earth.

Some barriers may cross well-used access routes (for people, mopeds and cars). It is important, during the construction, to provide access up and over the flood barriers that is both convenient and attractive. Otherwise, people create 'unofficial' routes through the barriers rendering them ineffective.

After all the flood barriers have been built, there will be about ten times as much excess earth left over. If modernisation proceeds to utilise the unused land north of the highway, some could be used to build internal dykes.

Internal dykes

These will not contain fast flowing floodwaters and will not need to be armoured and, moreover, with the brine level almost the same on either side, there will be no need for a clay key. Also, as the brine is only 250-350mm deep, the dykes need not be higher than 1m – for many, 600mm is acceptable. Also, unless the earth is very sandy, it can be used for the sides with a 1:3 slope.

Brine storage

In a later phase of full modernisation, high dykes may be needed to store concentrated brine before the rains arrive, ready for the next production season. This construction could utilise a lot of the remaining excess earth as its walls will be of earth with an inner core of clay rising above 4 m high.

Short-term Employment

To maximise work opportunities, excess earth is to be removed from the salt basins by manual labour. Then, perhaps using machines, it should be taken to the line of the proposed flood barriers where, again using both manual labour and machines, the flood barriers would be built with local materials. Cash-for-Work or other appropriate schemes may be used to fund this phase of the work.

Aside from a few designated internal dykes (maybe <10% of the total), this earth removal should leave all the salt basins with dyke heights ≤300mm, this height being a necessary stage in the conversion to a modern saltworks.

The base for all new flood barriers must be clay, keyed to the existing clay strata and the flood side 'armoured' as illustrated earlier. Depending on location, they can be up to 2m high and in many sections might serve for vehicle access.

About 0.5 million Cubic Metres (CuMs) of earth is sufficient for all flood barriers in the saltworks, mostly not further than 50m away from where it is now. More than 4 million CuMs will be available for additional flood barriers for the local communities or for flood attenuation and irrigation. For these other uses, possibly more than 2 kilometres distant, trucking would be necessary.

4 PERSPECTIVE

Whereas the Cox & Speller study focused on the technical aspects of the saltworks' design, its implementation will depend on how those people most affected view the proposals and the response of organisations and institutions that are – or may become – involved.

This section is included to provide miscellaneous additional information that is likely to be of interest to people, organisations and institutions that may contemplate or consider becoming involved in the project.

4.1 Costs

The engineering and construction costs of the Pilot Plant are estimated at around $1million – but, to make this a success, perhaps as much again needs to be spent on project organisation, community liaison, capacity building (for the local community and local authorities) – and other 'soft' items.

If the Pilot Plant is successful and further investments take place, most of the significant items of expenditure for the Pilot Plant need not be replicated – notably, the engineering design, construction of a Works Office and associated facilities, creation of the Saltworks Enterprise – and many others.

This report is confined to engineering issues and the commercial outlook.

Developments at Magazen after the Pilot Plant is operational

The design concept for the Pilot Plant is to link the 90% of the salt basins that will continue as evaporation ponds and to pump to the 10% that have to be elevated in order to serve as crystallisers.

Provided that the Pilot Plant successfully demonstrates the superiority of the modernised techniques and more salt basin owners decide to join, a similar arrangement will be implemented, with more and more crystalliser ponds being created (in the TetB area) to use the saturated brine then available. The ultimate design will centralise the crystallisers around the Pilot Plant crystallisers and be adjacent to the location for the future jetty, in the sheltered lagoon.

Our estimates imply that the fully completed Magazen saltworks and jetty may cost ~$6 million and, hopefully, might be self-financed by the Pilot Plant.

Coridon

This is not part of the Pilot Plant proposal. Iodisation at this location (see Section 3.3) could begin if institutional restrictions on local iodisation are lifted – but no modernisation will be suggested until local salt basin owners indicate a desire to do so.

If iodisation were to be undertaken prior to modernisation, it will require facilities to wash the current quality of salt as well as to iodise, dry and package it. Based on costs for similar plants of this size in other countries, and without taking account of the very substantial assistance potentially available from agencies such as UNICEF and WFP, this investment might cost up to $½ million.

If the investment is postponed until the salt basins have been modernised, there will be no need for the customised washing plant and the investment may cost up to $¼ million – some of which might be funded by UNICEF or WFP.

4.2 Timing

The Pilot Project is scheduled to take up to 3 years – but, if the owners of contiguous salt basin owners wish, it may be feasible for them to join within this three-year period. The primary constraint on implementation is the speed with which owners become fully committed[19] and establish institutions to promote the work.

Preliminary soundings of potential investors and salt buyers suggest that their support will be forthcoming once the necessary organisations are in place.

4.3 The AMURT 'factory'

Discussions took place in April with representatives of AMURT in respect to their unfinished 'factory' (then lying idle), followed by a site visit. At that time it was agreed that it was feasible, from a technical perspective, to include this area in the ultimate new integrated saltworks including all the unused flat land north of the highway running from Magazen to Anse Rouge.

Several modifications to the existing facilities would be essential to make it suitable for integration into the proposed modern saltworks:

(1) reduce the number of ponds to ~37, by removing redundant dykes,

(2) standardise the pond sizes to ~120m x ~100m,

(3) raise internal dyke heights to ~600mm and widen some as appropriate,

(4) provide Archimedes' screw-type pumps for inflows and outflows.

There is no technical impediment why this area could not eventually be included in the envisaged fully modernised saltworks - which would include all the low-lying flat land north of the highway. At that stage, this entire extra 120 hectares (Appendix Three) would be enclosed by flood barriers with clay cores and the considerable costs of so doing could be recovered from the extra output from this extra area.

By contrast, integration with the Pilot Project would be problematic. Its smaller area (33 hectares) has a disproportionately long perimeter (3Kms) and it would be relatively costly to provide it with full flood protection. Whilst we did give this possibility serious consideration, we now understand that AMURT do not want their area incorporated into the Pilot Project and, as this will be better from a commercial standpoint, we see no reason to pursue this matter further.

4.4 Next Steps

The report for Oxfam America focused on the technology and concluded that modernisation of the Magazen salt basins could be commercially viable. The difficulty with full-scale modernisation (still a desirable goal) is that every single individual salt basin owner needs to be convinced that it is worthwhile joining the envisaged Cooperative Enterprise. This is why we envisage making progress in stages, beginning with salt basin owners already willing to cooperate and then persuading the others to join having seen the example of the Pilot Project.

Our proposals impinge on various organisations and institutions and will affect many – maybe everyone – in the community. In order to progress, it will be necessary to pursue several parallel leads:

a) Financing

Potential institutional partners, sources of funding and investors need to be approached and some sort of strategy devised in respect to financing and long-term planning.

- Possible financing and/or institutional partners to include WFP/PAM, UNICEF, GAIN, BID, IOM, Micronutrient Initiative, and others.
- Financing to include the same mix as above but may rely more heavily on international financing institutions (especially for public infrastructure improvements such as the jetty and potable water lines). Additionally, private sector partners from the salt industry and corporate sponsors may also be engaged.

b) Organising the Salt Producers

A local Haitian Organization is needed to work with the salt producing communities for the following objectives:

- Forming an association or associations that can effectively advocate for salt producing communities to local government (and NGOs if necessary)
- Enabling the communities to absorb the information about the different options that exist for them regarding salt production and the risks and benefits to salt production and the individual producer
- Assessing willingness of the producers to modernize collectively at key checkpoints in the process (Year One, Year Two)[20]
- Helping to frame or facilitate participatory processes and relations between local government and the producer groups

c) Employment opportunities

Identify opportunities for maximising employment during the Pilot Project, expansion and rehabilitation phases, including but not limited to Cash-For-Work[21].

d) The national highway (post Pilot Project)

Rehabilitation/construction of bridges and placement of any other minor infrastructure that will result in temporarily altering the national highway

- Approval from the Ministries of Planning and Commerce must be received to move forward.[22] This recently took place for similar purposes in 2008 when the bridge that currently crosses over a canal along the national highway was constructed (and financed by IOM).[23]
- While an engineer from outside of Anse Rouge may be necessary to design the bridge, local labour and transport trucks should be used to construct the bridge. The existing bridge was constructed using local work crews and project managers and these should be relied on to execute the project in order to maximise livelihood benefits in the region.
- Construction of the bridge should take no more than two months and should start as soon as the rainy season has ended.

e) Flood barrier design

The institutions responsible for the recently constructed flood barriers at Coridon and Pointe des Mangles need to be contacted to discuss and agree on the enhancements that are needed. It is important to engage the local representatives of the communities who the barriers and dykes are meant to protect and WFP to ensure alignment with their project priorities and that the local organisation responsible for constructing the recent barriers and dykes (a) receives approval for enhancing their previous work and (b) assesses whether they can execute at least this portion of the project.

f) Design Study

The next stage, possibly after the cash-for-work activities are started, is to commission a comprehensive Design Study for the salt exporting and iodisation investments to specify in detail what is to be built. [This would have a similar, but far more detailed, scope of work to this current Feasibility Study and, typically, will cost ~5% of the investment – about $300,000 if our budget estimate of $6 million is correct.]

g) National strategy for salt

A multi-stakeholder entity (salt producers from Commune Anse Rouge, salt producers from other regions, local and regional government) championed by government and charged with determining appropriate strategies for national salt production must be formed to determine best uses for the Magazen and Coridon areas. This entity also should be tasked with addressing issues of salt production for iodisation, as an important part of the salt value chain.

Capacity building for local authorities so that appropriate scale-ups are possible in other regions (such as Gonaives or the north) in order to address local iodisation in the more remote localities.

4.5 Irrigation

The new saltworks will block the path to the sea for seasonal rivers and, with appropriately designed flood barrier dykes, could assist irrigation[24].

The design of an irrigation system is outside the scope of a Design Study for the new saltworks but, ideally, should take place concurrently. In principle, as any flood barrier keyed into the underlying clay (as recommended herein) will retain water flowing from the hills, the location and height of these dykes simply has to be chosen to ensure that the retained water is available for irrigation.

The precise details need to be discussed with the relevant institutions and authorities so that, when the detailed design of the saltworks is undertaken, the desirable heights for the weirs that retain the floodwaters are already known.

APPENDICES

Appendix 1 Objectives of the Study

The essentials of the objectives for the Oxfam America study were as follows:

- The principal task has been to assess the technological feasibility of transforming existing salt basins into modernised saltworks (1) to satisfy Haiti's requirements for iodised salt and also (2) to make and export ≥200,000 tonnes/year.
- This was formalised in the Contract[25] as "Develop a plan for a commercially viable investment in salt production that will: (a) maximise economic and social benefits to the local community; (b) enable production of high quality local salt for iodisation in quantities sufficient to meet Haiti's national demand; and (c) enable export of Haitian produced solar sea salt" …. and continues, "Within the above over-arching objectives, analyse the opportunities that exist to maximize gainful employment and utilise local resources".
- This required basic engineering data[26] about the proposed site in Commune Anse Rouge so that Cox & Speller could design the new saltworks in sufficient detail to make budget cost estimations to assist informed investment decisions. Obtaining this basic engineering data accounted for most of the field investigations.
- A further requirement from Oxfam America (OA) requested that special attention should be paid to the need to develop the project in phases (that could be stand-alone investments), so that OA "may proceed in the near term with cash-for-work projects" …. to improve salt production for the region and provide immediate employment for host communities[27].
- The consultants were asked to "note any opportunities for maximising secondary benefits to the community, including improved agricultural potential" in adjacent regions, the potential for hydro and solar power and potable water to support the facilities and infrastructure improvements (such as a jetty and better roads)[28].
- The Consulting Engineers are very aware of associated environment issues and in particular the need to protect the mangrove forests surrounding the salt works and the need to maximise agricultural use of rainwaters.

All these questions were answered either specifically in the report to Oxfam America or in memoranda[29] forwarded to or received by Amber Lynn Munger.

In essence, the terms of reference for this update (for the Article 29 Organization) are identical to that specified for Oxfam America in April 2011 - save for the perspective of beginning the work with a Pilot Plant project of ~300 basins and incrementally adding extra salt basins as and when additional owners decide to join the envisaged producers' cooperative that would have ultimate responsibility for the project.

A significant number of salt basin owners in the area known locally as "Tet Bai" or TetB" (along the north east coastline of the lagoon) already have expressed support for this perspective and, for this reason (amongst others), the plans for the Pilot Project have focussed on this area (over page).

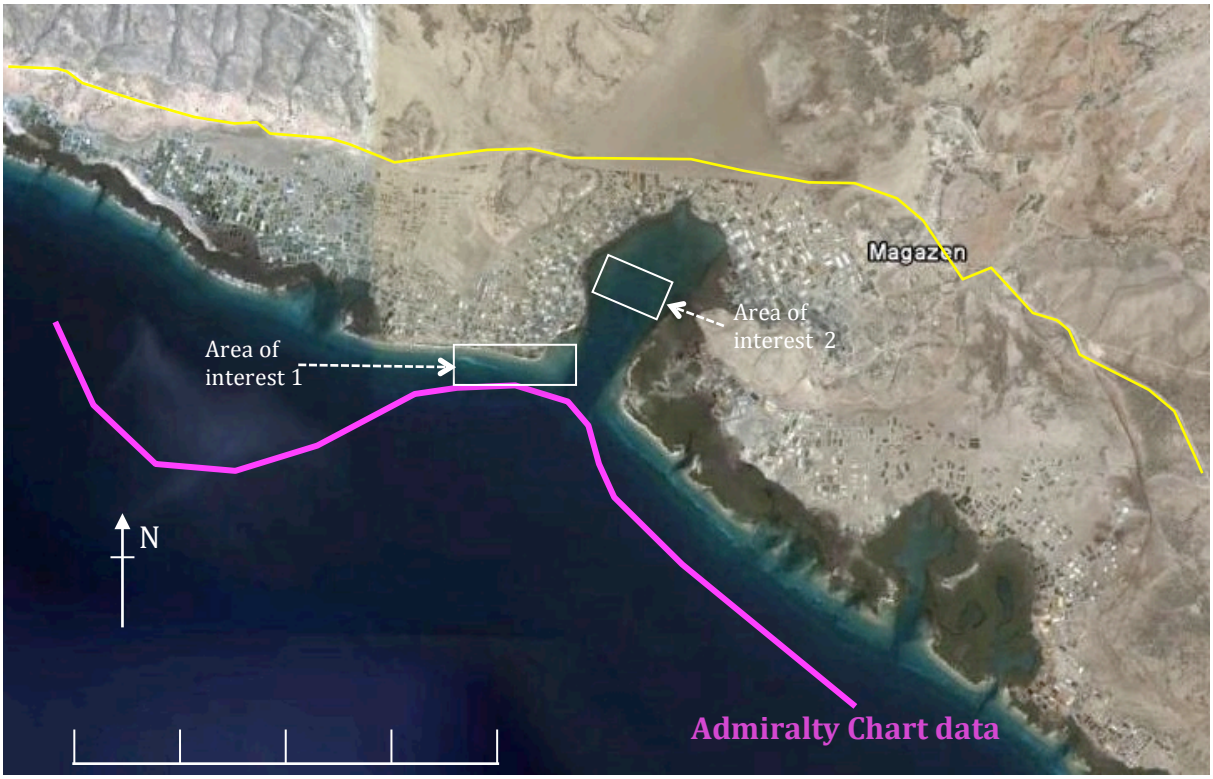
This Google Earth satellite photograph shows the area envisaged for the Pilot Project.

- Within A-B-C-D-E-A, roughly 10% of the used area will be elevated crystalliser ponds – all other salt basins will be evaporation ponds linked for sequential operation. Salt basins outside the Pilot Project will be left alone/untouched and circumnavigated.
- From A to B there needs to be a 2m high sea wall and perimeter access road, utilising as many as available of the dykes of participating salt basins.
- From B to C there needs to be a 2m high flood barrier and perimeter access road that utilises as many as available of the dykes of participating salt basins.
- From C, D, E to A, there should be provision to divert rainwater from the hillsides.
- The area near and adjacent to A will be quarried to provide rock for the roads and a future rock-fill jetty at F. The quarry base will be used for saltworks' facilities (office, workshop, personnel facilities, salt stockpile, bagging and processing, etc.).

The proposed Design Study has to specify all of the above in detail.

Appendix 2 Location of deep water for jetty

The purple line superimposed on this Google Earth satellite view is the 20m-depth contour that appears on the relevant Admiralty Chart - the shallowest useable depth recorded nearby. The two photographs show "areas of interest" and adjacent salt basins in close-up.



Area 1 has shallow water near in shore and deeper water within 250m of the coastline. The line-and-weight depths survey conducted during the field studies confirmed the existence of 15m sea depths within this area of interest. This should be sufficient for bulk salt exports 25,000dwt ships using a 12m (low tide) berth.

A bathymetric survey, acceptable to the Haiti coastal authorities as a navigation chart, will be needed to decide on a precise jetty location.

Marine Summary

Inspection indicated that during the **normal** sea state:

- The tidal range is in the order of 300mm to 500mm.
- The beach slopes/gradients are shallow suggesting nominal wave action
- No evidence of significant wave action was noted or reported – waves such as those photographed (above right) being described as "choppy"!
- No evidence of significant beach erosion/deposition was noted or reported

Winds are reported to vary seasonally from the South East and the North East, the former being an onshore wind and the latter an offshore wind. During the Autumn/rainy season (low pressure) with on shore winds it was reported that waves break over the back of the beach and inundate the coastal plain. But, as this is in the hurricane 'season', there is no obligation to design for ship movements during this period.

During the boat survey, inspection of the shallower seabed indicated shelving rock or possibly dead coral with limited sand or silt overburden. Equally the water was clear enough to see to depths of circa 8m. This confirms limited littoral drift.

Due to the availability of suitable material, a solid jetty construction using locally won hearting material, reverse stone filters and wave armour rock is recommended. A concrete bank seat would be provided seaward to support a floating pontoon berthing face. The solid jetty would be "T" shaped to allow a vessel to be "tied" during loading.

Suitable rock is available nearby. In the isolated hills within the coastal plain there are originally sedimentary rocks of various types and with various degrees of metamorphism containing occasional lenses of igneous rock. Within a few hundred metres of the jetty location, there is a large isolated hill of mixed metamorphic rocks.

For a complete design specification for the jetty, the designers will ask for extra data, notably: (a) Wave data (Rose), (b) Wind data (Rose), (c) Current data, (d) Littoral draft data/scour, (e) Significant, extreme and design wave, (f) An accurate bathometric survey that is approved by the Haiti Coastguard/Pilot (for an official navigation chart), (g) Similar official berthing lighting and warning buoys to define the channel.

For the Pilot Project, nothing more complicated than a rock fill jetty (to depths of ~6m) need be built. If additional depth is needed (for larger shipments), the jetty could be supplemented by a floating extension (as the lagoon is relatively sheltered).

Appendix 3: Topographical Survey

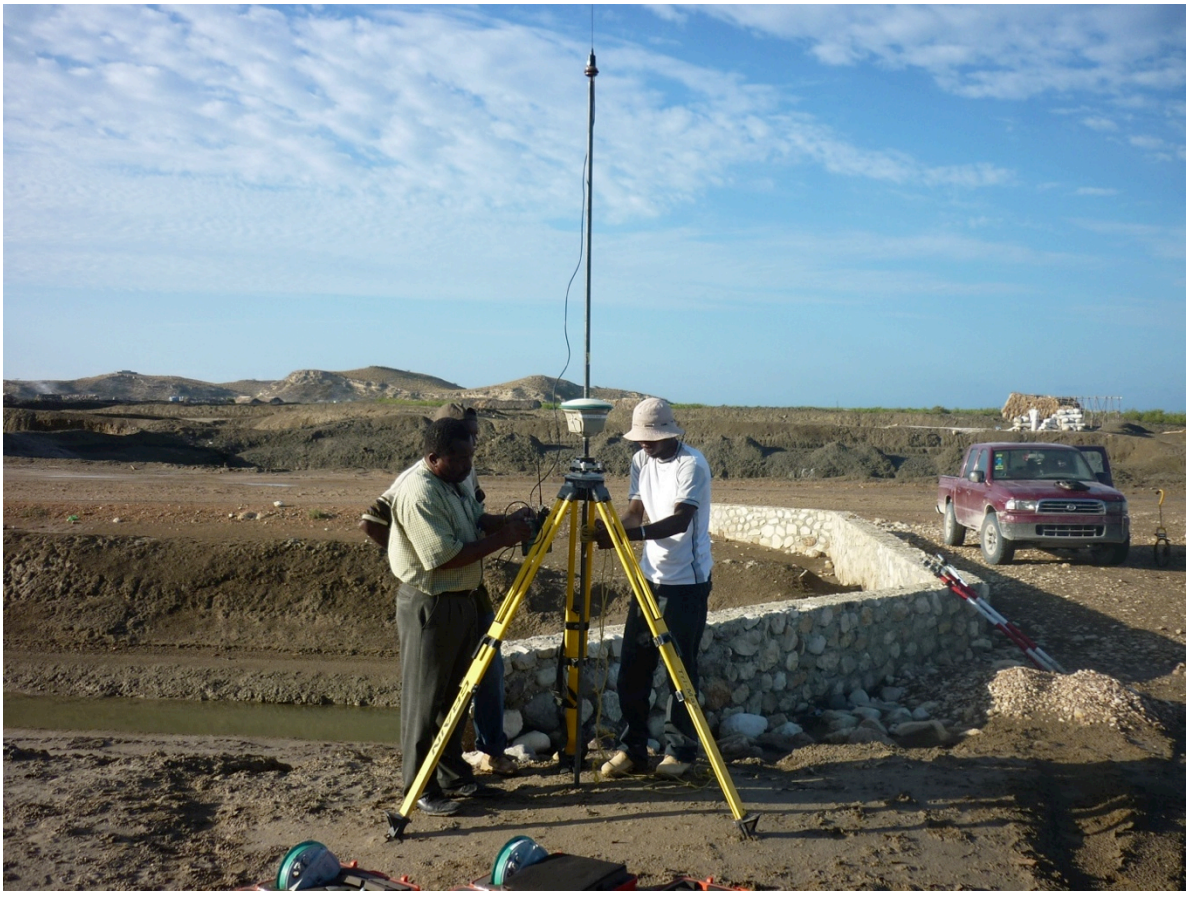
Whereas the levels of the existing salt basins can be inferred as at or just below sea level, no such assumptions can be made for the large unused area north of the national road. The topographical study was commissioned specifically to determine how much was close enough to sea level to enable it to be incorporated in the new modernised saltworks.

135° panoramic view of unused land north of highway

- photographed from top of small hill at north of site

The survey revealed that there are some 120 hectares within 1-2m of sea level that can be readily utilised by the new saltworks and that the slope trend is such that it will be essential to provide one extra (north-south) dyke to ensure that the brine flows throughout the area without needing extra pumps.

This data is available (from Oxfam) in electronic format and may be used for the 'cut and fill' calculations required to optimise the depth profile when the design of the saltworks comes to be specified in detail.



Appendix 4 Geotechnical survey

In the higher-level platform/gentle hills the dominant strata seems to be weakly cemented conglomerate with occasional areas of increased metamorphism (intrusions). This is the material that the rainfall runoff erodes and is evident on the surface of the roadways. The cobble-sized fraction is mainly rounded indicating a fluvial or marine source. This (well mixed with the matrix material) could be used for hearting to the bunds (together with impermeable clay) and the jetty and for surfacing the bunds to form roadways.

In the isolated hills within the coastal plain there are a series of metamorphic, originally sedimentary, rocks of various types and with various degrees of metamorphism. Lenses of igneous rock were noted very occasionally. There seems to be sandstone, limestone and conglomerate metamorphic rocks. With careful choice these could be used for constructing the armour layers and reverse filters on the bunds/dykes and for the Jetty.

The above materials are evident for the whole East West length of the site. The 18 trial holes on the coastal plain, dug by a back hoe (listed on the next page), show variation in the underlying shallow strata east and west of the central lagoon. West of the central lagoon the general sequence is:

Windblown sandy silty surface layer - Brown SILTS with clay - Brown CLAYS with silt (clay content increasing with depth) - Brown CLAYS - Grey CLAYS (possibly organic - in one location mangrove was found underlying grey clays).

The clays varied between soft and firm and would be suitable as impermeable barriers within the core of dykes and bunds and for the floors of any basins. The clays would need protection using the locally won materials from the higher-level platform /gentle hills noted above.

East of the central lagoon the strata are more variable and significant clays were only found in the central eastern area - and these clays had a sand content and were relatively soft. The area immediately east is underlain by very wet, almost liquid, sandy stony strata, overlain by loamy silts with nominal clay content. The area adjacent to the Eastern beach is underlain by sandy materials with shell fragments and nominal clay content overlain by loamy silts with nominal clay content.

Notwithstanding this, these materials could be utilised to form core protection in dyke/bund construction - but it is expected that clay would be required from the centre of the Eastern area and/or West of the central lagoon to supplement this material for impermeable linings and cores to dykes/bunds. If the eastern clays were used, a further geotechnical assessment would be recommended.

Hole	Location	Observations
1	Western extremity of the salt basins	0-300mm of top soil, sandy loam / 300mm to 2000mm CLAY / Coral bedrock at 1m through clay
2	50m to east of Hole 1	0-300mm of top soil, sandy loam / 300mm to 2000m brown CLAY / Coral bedrock at 2m / Seawater seepage on CLAT bedrock horizon
3	By Mayor's pond	0-300mm of top soil, sandy loam / 300-1500mm loamy sand with increasing clay content with depth/ 1500-2500 1m grey CLAY with mangrove remnants / underlain by DEAD MANGROVE
4	South of highway near to outlet for floods	0-300mm of top soil, sandy loam / Immediately cemented stony CONGLOMERATE, probably run from hills just to north of road / Hole ended at 600mm
5	~50m south of Hole 4	0-300mm of top soil, sandy loam / 300-1300mm brown CLAY / 1300-1500 black CLAY / 1.5m bedrock / Seawater seepage at 1.5m on CLAY bedrock horizon
6	~500m north of Hole 4 where floods reported to exit plain	0-300mm of top soil, sandy loam / 300-800mm brown silty CLAY. Clay content increasing with depth / 800-1200mm darker brown CLAY / At 1500mm CLAY becoming soft / By 3000mm getting very soft and wet / 3.4m water strike
7	West extremity of the northern extension	0-300mm of top soil, clay/silt (mainly silt) / 300-1.5m SILT with clay (increasing with depth) / 1.5m CLAY with silt / water strike (lens) on silt/clay horizon
8	~500m east of Hole 7 and 250m more north	300mm of SILT with clay, 300-1500mm SILT with clay getting softer and wetter with depth / very wet at 1500mm / 1500-3500mm(end hole) CLAY
9	Further north east and near to a small hill	0-1.1m of SILT with clay getting softer and wetter with depth / 1.1-2.2m CLAY with silt / water strike at CLAY/SILT horizon / 2.2m top of soft grey CLAY / water strike on Clay/grey clay Clay horizon
10	Close to NW corner of AMURT construction	0-1m SILT with clay / 1m water strike / 1-1.3m soft SILT with increasing clay / 1.3m substantial water strike / 1.3-2m soft SILT with significant clay / 2-3m soft blue-grey clay and mangrove remnants / 3m stiffer blue-grey clay, more mangrove remnants
11	Close to SE corner of AMURT construction	0-300mm of top soil, sandy loam / 300mm SILT with clay content increasing with depth / 2000mm CLAY / water strike at SILT/CLAY horizon
12	South from Magazen to easterly salt basins	0-0.5m top soil, sandy loam / 500-1000mm CLAY with sand and silt clay / CLAY becoming soft at 1m / 1.3m major water strike, standing water at 1.4m / 1300mm to end hole light coloured wet (flowing) conglomerate of sandy/stony/silt
13	1.2Kms east of Hole 12	800mm silt overburden / 800-1400mm yellow conglomerate comprising pebbles and sand in silt/CLAY matrix / saline water strike at 1.4 metres
14	1.2 Kms south east of Hole 13	0-1100mm SILT / 1100-2200mm sandy CLAY quartz fragments / Water strike at 2.1m, 2.3m finish
15	1.1 Kms south east of Hole 14	0-1200mm SILT / 1200-1300mm Soft sandy silty CLAY becoming soft grey clay / 1.3m soft organic CLAY / Water strike on 1.3m horizon silty clay and grey CLAY
16	1Km south of Hole 15	0-800mm SILT / 800-1500mm sandy/silty CLAY, high silt fraction / 1500-2200mm, grey CLAY with sand / 1.8m water strike (probably indicates increased clay content / 2.2-2.7m black SAND, 2.7m sand with organic odour / 2.7m water strike
17	50m east of Hole 16	0-1.4m SILT / 1.4-2.2m grey CLAY with a small amount of sand / 2.2-2.4m SAND with clay / 2.2-2.7m water ingress through sand with clay, 2.4m SAND
18	Near beach	0-800mm of SILT / water strike at 900mm / 900-1700mm SAND with silt and clay / 1.7-2.2m SAND with shells / 2.2-3m SAND with whole clam shells

Approximate positions of numbered dug holes

Appendix 5 Evaporation tests' log sheet

Day	Date	Pond			Other relevant information
	dd/mm	Depth (mm)	°Bé	°C	(e.g. on weather, before and after pond refilled, etc.)
examples	20/4	550	5.1	35	Before pond refilled
Monday					
Thursday					
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Appendix 6 References

1 TechnoServe Value Chain Research, 2011

2 Supporting Rural Health in Haiti - An Assessment of the Health System of Commune Anse Rouge, Remie Stubbs-Dame, May 5, 2010

3 There are large established solar saltworks in Turks and Caicos, Bahamas and Bonaire and – a more recent investment - the Dominican Republic. The total imports identified by the recent TechnoServe report (Ref. 7 below) were 15,000 tons/year.

4 "Haiti Livelihoods: Salt Market Assessment" – ADP (commissioned by Oxfam).

5 ADP identified several other potential market outlets but this was the largest and on its own considered sufficient to justify proceeding with this TechnoEconomic study.

6 See www.cox-and-speller.com - the pages on SALT.

7 AMURT-Haiti Project Report, January 2008, GIS study of salt basins

8 Diagnostic Report for Oxfam America Visit Conducted July 19-21, 2011 Anse Rouge Exploratory Visit Report, production cooperatives Haiti (pcH)

9 The Haitian Salt Industry: An Analysis and Strategic Growth Plan: TechnoServe September 2011

10 Diagnostic Report for Oxfam America Visit Conducted July 19-21, 2011 Anse Rouge Exploratory Visit Report, production cooperatives Haiti (pcH)

11 The salt basins at Coridon are widely dispersed and it would not be cost-effective to provide flood protection for them. On the other hand, the villages along this stretch of the coastline suffer from regular inundation and flood protection here is more justified for the protection of the community than the salt basins.

12 "Haiti Livelihoods: Salt Market Assessment" – ADP (commissioned by Oxfam).

13 Since superseded by other interventions – notably by Diagnostic Report for Oxfam America Visit Conducted July 19-21, 2011 Anse Rouge Exploratory Visit Report, production cooperatives Haiti (pcH)

14 It is bounded on the south and east by hills, so only the 700m northern boundary, which already has 2m high earthen dykes, has to be upgraded (Appendix 1). There is also need for a western perimeter sea wall, also utilizing existing dykes of potential participating salt basins. Both also should serve as access roads to the built works.

15 The rock fill jetty could use rock quarried from the adjacent hill side and the base of the quarry could be used for appropriate buildings and works facilities (Appendix 1)

16 Improvement of Micronutrient Nutrition, September 2009, WFP/MI

17 A Summary of an evaluation of a project supported by the Micronutrient Initiative "Assistance to Food Insecure People in Crisis Situation – Salt Iodization Activities" Haiti, August 2010

18 Proposal to resolve Haiti's IDD problems by iodizing salt produced in Anse Rouge commune. Dr. John Cox (Cox & Speller) August 2010

[19] It is not essential to have 100% consensus from the existing basins' landowners. If the owners of a minority of the basins wish to continue with the present methods, their basins could be bypassed and still allow a modern saltworks to be built.

[20] One year after initial organising begins, it needs to be known (for the saltworks' design and organisational matters) how many producers are interested in pooling their lands together for a new system and where these lands are located. It is assumed that the Magazen area are likely to support modernisation, as producers in this area have already started to convert to the new method on their own, and the owners of the unused land in the area are proponents of modernisation.

[21] Cox & Speller are available for an initial supervisory role but the work should be executed and managed by a Haitian Contractor.

[22] The process that the project manager must follow to construct the bridge is to (1) get sign off from the Mayor's Office; (2) get sign off from regional government that the purpose of the project is in alignment with government priorities; (3) have an engineer design the specifications for the bridge; (4) have the engineer visit the site with an engineer from the Ministry of Planning; (5) have the plans approved by the Ministry of Planning; (6) in conjunction with the Mayor's Office, plan for the construction in such a way as to appropriately divert existing traffic.

[23] Although the weight-bearing load of the bridge far surpasses what could possibly be needed at that location, the bridge is insufficient for the volumes of water that will pass once appropriate diversion dykes are constructed. So it has to be widened – unless the scope of engineering is widened to include irrigation schemes that, as a by-product, would reduce the rate of flow of flood waters at this point.

[24] Pre-feasibility Report on a salt-exporting opportunity to be located in Commune Anse Rouge, Dr. John Cox (Cox & Speller) & Amber Lynn Munger (Article 29 organization, June 2010.

[25] Services Agreement between Oxfam America and Cox & Speller, Exhibit A, Responsibilities.

[26] ibid

[27] Services Agreement between Oxfam America and Cox & Speller, Exhibit A, description of Research, Research Topics

[28] ibid

[29] Pre-feasibility Report on a salt-exporting opportunity to be located in Commune Anse Rouge, Dr. John Cox (Cox & Speller) & Amber Lynn Munger (Article 29 Organization, June 2010.

"Water and Electricity", Letter to Amber Lynn Munger from John Cox, July 2010