Report:

UNIDO/CTCN: NAWASA Grenada

Improvement of water supply management through a GIS based monitoring and control system for water loss reduction in Grenada

Project Output 2: Review of GIS systems and recommendations for future development

Deliverable 2E: Best practices and lessons: procedures for data sharing and storage, workflows and quality checks procedures for the integration of surveyors data into the GIS, procedures and classification of repair and maintenance data, best standards for customer identification in GIS database

1. Introduction

The following report (v2 draft - 9th December 2019) was developed by the Wood/GISCAD team as a core deliverable of UNIDO/CTCN project entitled "Improvement of water supply management through a GIS based monitoring and control system for water loss reduction in Grenada". This project was delivered in collaboration with technical staff within the National Water and Sewerage Authority of Grenada (NAWASA).

Please note that this is the second draft version of the report, which includes several sections which will need to be updated, either following further discussion with staff at NAWASA and/or further technical work to be delivered in the next in-country visit to Grenada in January/February 2020.

The issue of the second version of this deliverable was agreed with Ramiro Salinas Revollo, UN project manager on 13/11/19 with a further and final third version of the report Is expected to be issued on/by 22st February 2020.

The scope of the report relates to the following objectives of Output 2 of the project:

- Best practices and lessons learned on: procedures for data sharing and storage, workflows and quality checks procedures for the integration of surveyors data into the GIS, procedures and classification of repair and maintenance data, best standards for customer identification in GIS database.

- On-the job training on the collection and management of GIS data – including finalised NAWASA procedures for future collection and management of GIS data
- Data processing workflows relating to collection and management tasks

The remainder of the document covers the following topics relevant to the future development of NAWASA GIS capability and the new GIS data model:

- Collection of survey data and integration of GIS into Operational & Maintenance activities, including:
  - Review of current working practices for data capture, management and data use by O&M functions;
  - Field testing of digital workflows for data capture
  - Development of workflows for update of the master GIS
- Integration of GIS into customer department procedures
- Ensuring secure IT backup of the information stored within the GIS data model

2. Collection of survey data and integration of GIS into Operational & Maintenance (O&M) activities

The following section focuses on workflows for the capture of new primary survey which will enhance the quality of the data held within the GIS and ultimately the future operational work of NAWASA. This focus on the capture of the location of primary assets including customer meters and pipelines. Testing of workflows for the capture of monthly customer meter readings are described in Section 3 of this report.

2.1 Review of current working practices

Survey data collection and data management

As outlined in project report 2A, NAWASA has worked in recent years to compile a single GIS dataset of clean water pipelines, key asset location and customer meter locations based upon available historical survey data, project records and engineering knowledge. This dataset is partially complete but still provides a useful starting point, it is important to acknowledge that the clean water datasets include a degree of data duplications and variability of attribute information.

This reflects different historical approaches to data collection and management within the organisation. This includes the management of asset information in individual project focused engineering drawings. These have typically remained in hardcopy form or CAD files held on NAWASA's server rather than being captured in a centralised GIS/database system.

Over recent years, NAWASA surveyors have adopted a variety of digital methods for capturing new survey data relating to Grenada's clean water infrastructure data. These methods include:

- Location of planned and newly installed pipeline assets – captured using Trimble GPS units
- Location of new/moved customer meter locations – captured using Trimble Juno handheld units

At present, selected elements of survey data collected by NAWASA staff are transferred into a GIS format, but this remains a largely manual exercise with data stored in project specific ESRI shapefiles.

Existing GIS mapping outputs for O&M support

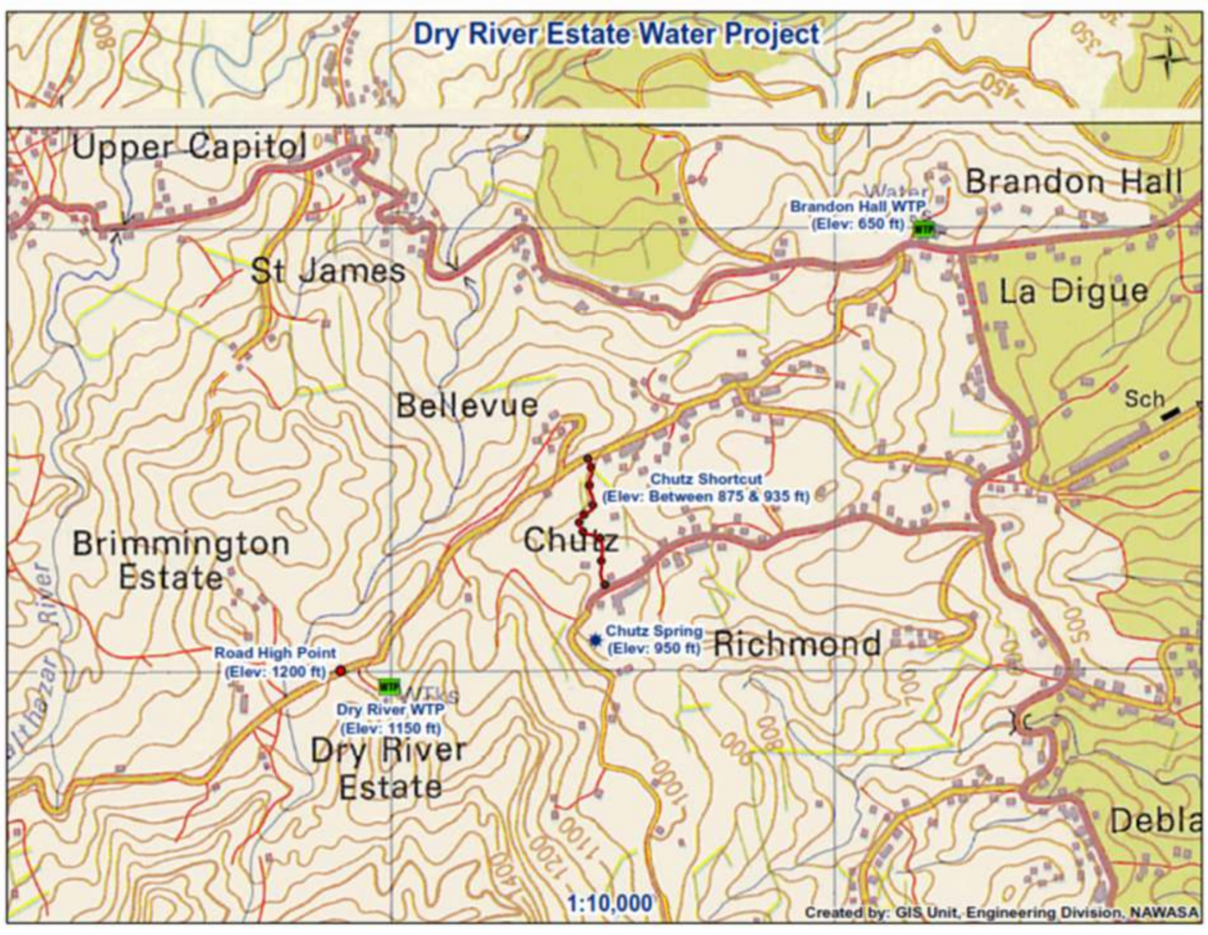
At present, NAWASA operates a small number of standalone QGIS desktop licences which are used to produce island wide map products detailing NAWASA's operational infrastructure across Grenada. Many of these map products are generated as A0 scale PDF products and/or printed to hardcopy maps. An example is presented below in Plate 2.1.

Plate 2.1 NAWAS Pipeline Network mapping product produced using QGIS - 2019

These products show existing assets overlaid on a standard Grenada basemap (scale 1:25,000) which shows terrain contours, roads and key land use areas (urban and forestry). The basemap included in these maps is relatively dated including topographical mapping originally produced by the UK Overseas Surveys Directorate (OSD) between 1977 and 1985. The current version of the map (edition 5 – 1988) remains the best mapping source currently available within the island.

Additional focused QGIS map products are also produced to support the planning of new infrastructure projects, such as the installation of new pipelines and/or upgrade of existing infrastructure assets. These maps typically show options or confirmed routes for new infrastructure alongside the location of existing infrastructure. These maps may show either the 1988 OSD map (high level planning) or increasingly current (2017-2019) high resolution satellite imagery and open source base mapping. A key data source used is the freely available online ESRI Global Imagery[1] and/or ESRI Streets web mapping services[2]. An example of a map product produced for a recent infrastructure development product is shown in Plate 2.2, with Plate 2.3 showing the installation of the new asset taking place during May 2019.

Plate 2.2 GIS map output produced to support the planning and development of new infrastructure asset



[1] https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9

2 https://www.arcgis.com/home/item.html?id=55ebf90799fa4a3fa57562700a68c405

Plate 2.3 O&M activity to install the new water main asset – May 2019

2.2 Developing and testing of new digital data capture processes

A key aim of the project will be to develop new workflows to assist in the future capture of digital information and the automated / semi-automated transfer of this data directly to the centralised GIS database created in the study. The following section outlines the development and testing of new digital workflows undertaken in this project, with final recommendations outlined in Section 4.

Objective

During the second project mission to Grenada, a series of evaluation and training exercises were undertaken to evaluate the performance of different combinations of mobile data capture equipment and data collection apps. This work was undertaken to evaluate the benefits of different technology to aid the future capture of the geographical location of existing NAWASA pipeline infrastructure and customer water meters; and using pre-prepared survey forms the recording of key information relating to the assets.

These evaluation tests were undertaken across three days (30th September – 2nd October) and involved the members of NAWASA (Damani Bruno and Annel Roberts) and the wider Wood/GISCAD (Neil Thurston, Sudesh Botha and Keyon Santlal) project team.

The primary aims of the mobile data capture training undertaken in late September and early October was to analyse the data collection accuracy and workflow of the software/hardware already used by NAWASA and potential alternative approaches using new hardware and software options. This included the evaluation of different standalone GPS equipment and assessing the pros/cons of selected software programs/apps for data collection. The key combinations of hardware and software considered are shown in Table 2.1.

Table 2.1 Hardware and software combinations evaluated

Software	Hardware	Estimated Accuracy	Solution overview	Cost model
Trimble Terraflex[3]	Trimble Catalyst, DA1 GPS, Mobile phone	30cm	Data collection using Trimble's Terraflex form solution on Smartphone linked to Trimble Catalyst, DA1, Mobile phone	Paid, Subscription Based
Trimble Terraflex	Trimble Juno 5D	4-8m	Data collection using Trimble's Terraflex form solution hosted on a Trimble Juna 5D	Paid, Subscription Based
Trimble Terraflex	Mobile Device	1-5m	Data collection using Trimble's Terraflex form solution hosted on an Android Smartphone	Paid, Subscription Based
SW Maps[4]	Mobile Device	1-4m	Android based data capture app hosted on an Android Smartphone	Free, Open Source
Qfield [5]	Mobile Device	1-4m	Android based data capture app hosted on an Android Smartphone	Free, Open Source
MS Excel	Mobile Device	1-4m	Capture of meter reading using MS Excel form hosted on t	Paid, Subscription Based
ArcPad	Trimble GeoXT/Zephyr GPS	3m	Existing NAWASA Asset but no longer supported. Evaluated for comparison purposes only.	No longer supported by ESRI

Pre-fieldwork preparation

The first stage of the evaluation process was the creation of a series of survey projects (one for customer meter location and pipeline) for the Qfield and SW Maps Android Apps. The Qfield form was established through the creation of a desktop QGIS project containing copies of master versions of existing pipelines, meter locations and other key assets (including hydrants).

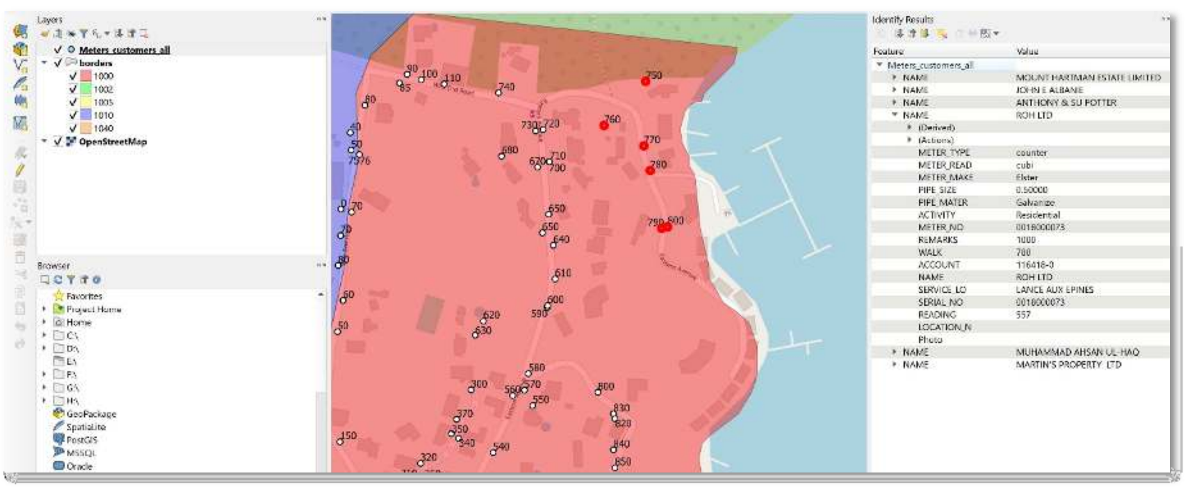
These projects were then published to a selection of different smartphones and tablets using either the QGIS sync plugin or direct copy of ESRI shapefiles for use with SW Map. An existing ArcPad form hosted on an

[3] https://terraflex.trimble.com/
[4] http://softwel.com.np/dw_manual
[5] https://qfield.org/

older NAWASA Trimble device was also used. Examples of the training provided to develop and deploy the forms are provided below in Plate 2.4 and 2.5.

Plate 2.4 Creating the sample Qfield, SW Maps survey forms in the office

Plate 2.5 Initial QGIS survey form design used during the field training exercises



Testing of the hardware and software options in the field

The following tasks were investigated in detail during the three days of field testing:

- Locating existing customer meters using information held on the hardcopy monthly meter round sheets and available GIS datasets;
- Recording information for existing customer meters – including logging meter functionality;

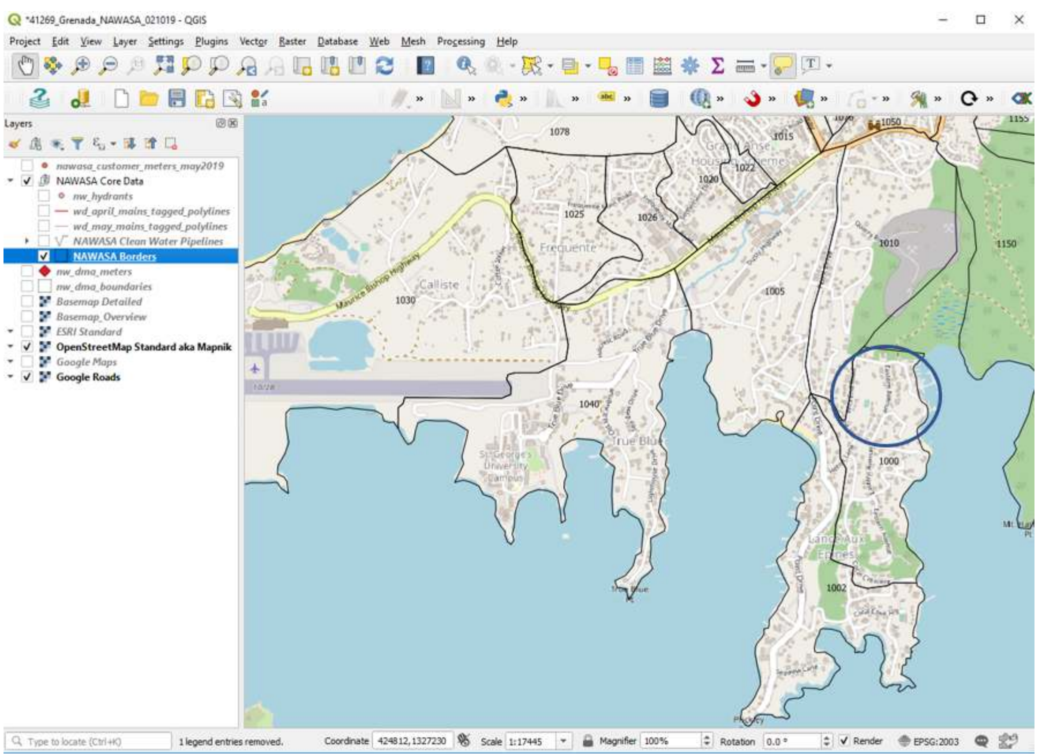
- Recording the location and attributes of existing customer meters which were not recorded on the existing GIS layers;
- Adding the location and attributes of pipeline features not currently recorded in the GIS. This work is key to the future delivery of NRW assessment but also the enhancement operational management of assets across Grenada; and
- Logging pipeline issues with comments for investigative visits from external departments.

The work undertaken in Day 1 focused more on the practical use of the available GPS and data capture equipment for capture of meter locations and testing and refinement of the initial data entry form. The work undertaken on Day's 2 and 3 focused more on using the equipment to help capture the location and characteristics of customer meters and pipeline infrastructure. This included the capture of new features not currently held in the NAWASA GIS datasets and several operational issues identified during the field walking exercise. Examples are provided in the remainder of this section.

Day 1 Field Testing - Wilts End Road - Lance aux Epines

On Day 1 (29/9/19), the team evaluated the ability of different hardware (GPS/tablets) and software tools to enable the capture of customer meter locations and to undertake meter readings. This evaluation was undertaken for various properties along Wilts End Road, Lance aux Epines located in meter survey round area - 1000, as shown in Plate 2.6. This initial work focused on assessing the practical use of different GPS units connected to different smartphone and tablet devices.

Plate 2.6 Day 2 fieldwork location map



An example is shown in Plate 2.7, which highlights the high <1m (79cm) accuracy which can be achieved using a pole mounted Trimble Catalyst / DA1 GPS antenna

Plate 2.7 Trimble catalyst / DA1 GPS Antenna tested in the field – 29/9/19

The general level of GPS accuracy achieved with a standard smart phone and/or standard Trimble units was typically in the range 1-4m.

This testing conduced on Day 1 also demonstrated that the Qfield mobile application could be successfully used to capture meter readings using the sample data and form created for the testing process. Several improvements were noted (including adding a field to tag if the meter location should be captured using a high accurate GPS unit). These improvements were reflected in a revised form design used on Day 2 and 3.

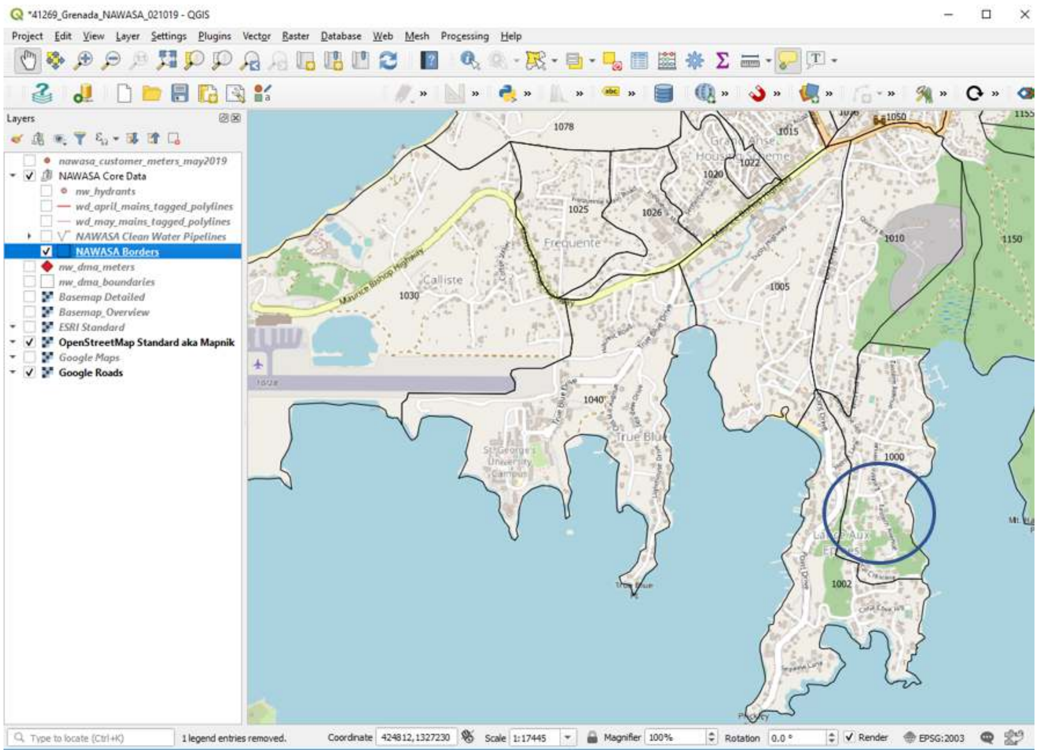
During Day 1, it was noted that one new meter had been recently been installed (Plate 2.8) and that it was not listed on the survey round sheets created from the NorthStar customer management system. This new meter was associated with a private residence and the details of the new meter were successfully captured using Qfield. This was a good illustration and testing of the process for capturing the detailed location of new meter installs - ideally at the time of installation.

Plate 2.8 Capturing the location of a newly installed customer meter - 29/9/19

Field Testing Day 2 - Mt Hartman Drive, Eastern Avenue and Secret Harbour - Lance aux Epines

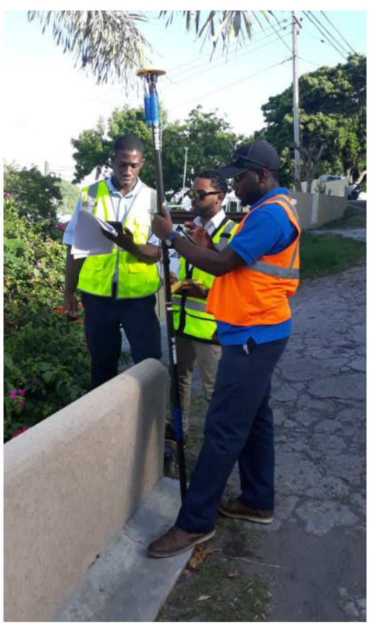
On day 2 (30/9/19), the fieldwork team returned to Lance Epines and continued to test the different hardware and software combinations in Meter Round Area 1000 in the general area of Mt Hartman Drive, Eastern Avenue and Secret harbour (Plate 2.9).

Plate 2.9 Day 2 fieldwork location map



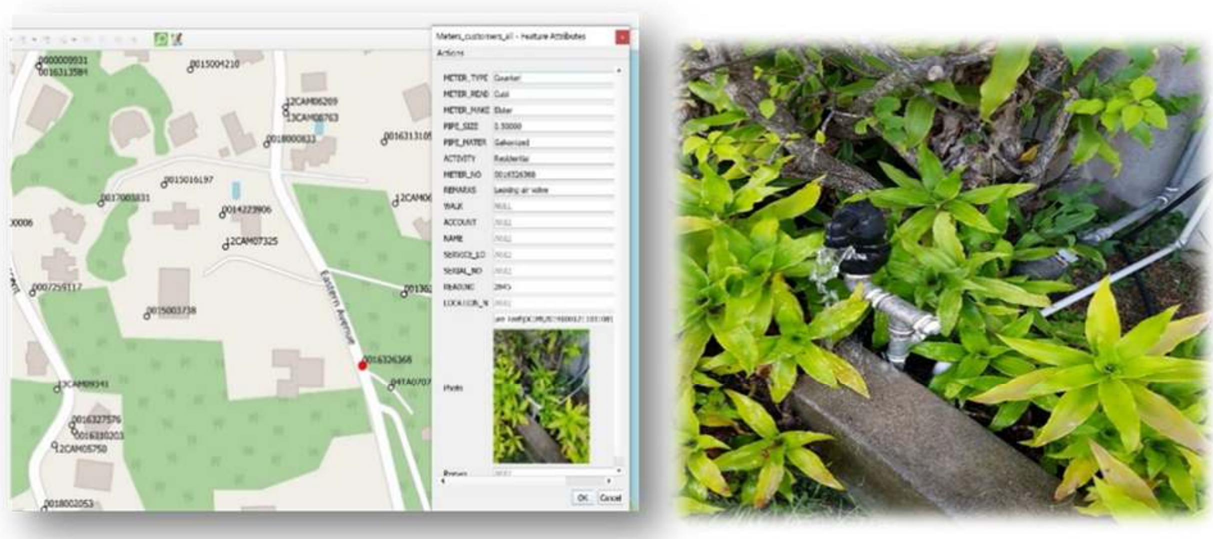
This work continued to test the ability of both Qfield and SW Maps to aid the capture of both meter locations and characteristics, see Plate 2.10.

Plate 2.10 Further testing of the hardware and software combinations - 30/9/19



During the field visit, the team also observed successfully logged information on a leak of an air valve at one residence using the Qfield mobile application (Plate 2.11). This was then updated with comments and an associating image to the main dataset on the QGIS desktop software and was referred to the relevant department for repairs.

Plate 2.11 Recording the location of leaking air valve requiring additional maintenance action - 30/9/19



The app was also used to capture several new metre location features which were not present in the original GIS meter layer.

Field Testing Day 3 - True Blue (Hillcrest Drive and Dusty Highway) and Lance aux Epines

The training and evaluation work undertaken on Day 3 focused on using the available survey equipment to help the capture of pipeline locations. This work was undertaken in three main locations along Hillcrest Drive in True Blue; Dusty Highway and one of the unnamed roads running parallel to the Lance aux Epines Main Road. The general fieldwork area for Day 3 was located across NAWASA meter round areas 1005 and 1040, as indicated on Plate 2.12

Plate 2.12 Location map of survey areas investigated on Day 3

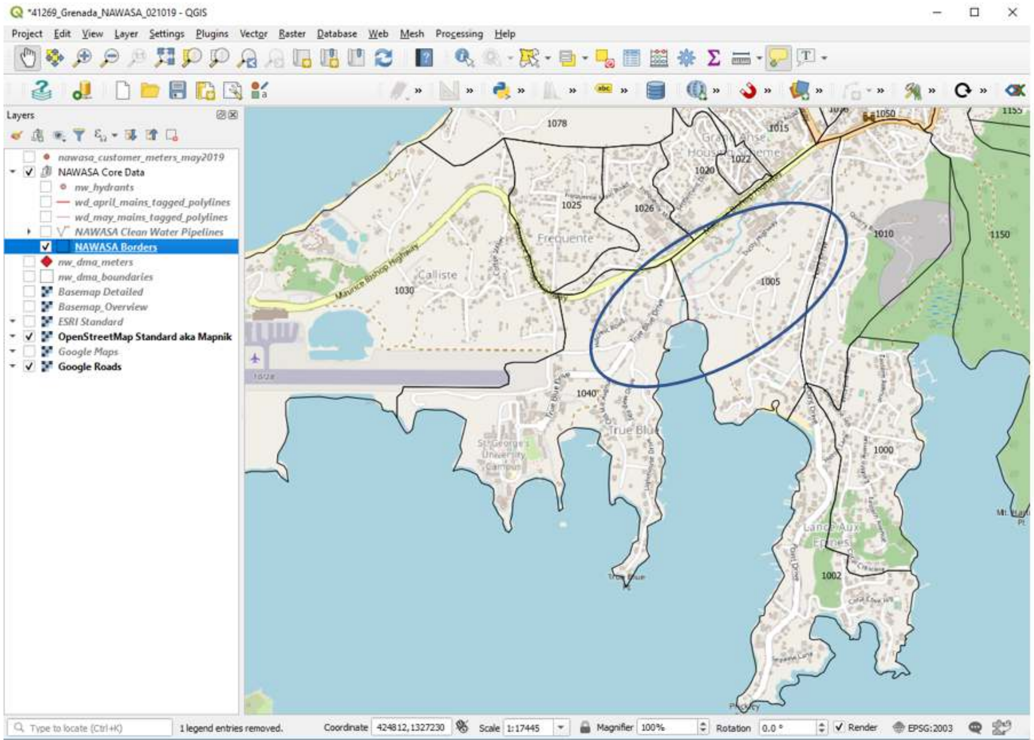


Plate 2.13 Field walking of Hillcrest Drive, True Blue to evaluate the connectivity of pipeline system

Field walking to establish the location of primary water main – north of the Maurice Bishop Memorial Highway – near junction of Hillcrest Drive (True Blue DMA)

Field walking to establish the flow direction and pipeline connectivity for residential water delivery - Hillcrest Drive (True Blue DMA)

As shown in Plate 2.13, the field walking on Day 3 highlighted the specific difficulties of locating and ultimately capturing pipeline assets – especially where hidden under dense vegetation and/or buried underground.

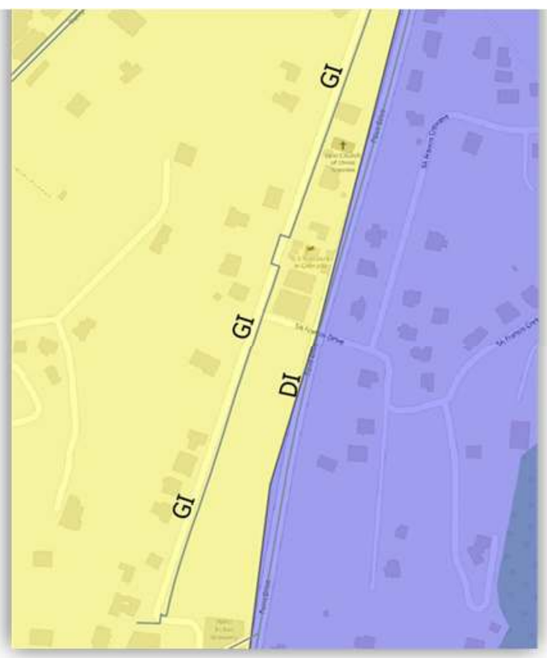
Even with these constraints, the field testing the potential to use of smartphones and tablet devices alongside Qfield to enable the capture of visible or 'interpreted' pipeline locations. These locations (although still subject to uncertainly) will be beneficial for the pilot NRW assessment which are being created in these areas. The provisional locations will also provide a basis for future update when the pipeline require upgrades or maintenance.

The final survey area investigated on Day 3 was an unnamed residential road running parallel to the Lance aux Epines Road. This road was selected as it had over 20 residential customer meters (as mapped on GIS) but no related mapped service pipeline feature in the GIS.

The road was walked to investigate the ability of the available survey equipment to capture the location and attribute features of pipelines which were not previously recorded in NAWASA's GIS systems.

This requirement was successfully achieved with the capture of a new pipeline routes by both manual digitising in Qfield but also data captured using the route tracking capability of the SW Maps app (Plate 2.14). This final approach was used to capture the route of pipeline which was visible in the right-hand verge of the residential road surveyed. This information has subsequently added to NAWASA GIS system with the enhanced pipeline information used in the pilot DMA assessment.

Plate 2.14 Capture of pipeline route in meter round 1005 using Qfield and SW Maps Android apps



During the field walking in this area, one of the NAWASA engineers also noticed a connection where a second un-metered connection had been added. The information was updated in the attributes of the existing form for the customer. This information was also used to send a direct email to the relevant department for further investigation.

Transfer of survey data into the new GIS model

The fieldwork testing and training undertaken in the study has also examined the different methods of transferring information collected in the field from individual tablet/smartphone devices to desktop QGIS and ultimately the master GIS database. The work conducted to-date has highlighted the following recommended steps for controlled setup, capture and transfer of data to NAWASA master systems.

- Setup of a QGIS project containing the required survey layer;
- Creation of a Qfield data package, which makes a copy of the QGIS project and accompanying data;
- Copy the QField package to the target device;
- Collection of the required data in the field;
- Copy of the new GIS data from the device to a working folder
- Check of the newly captured data by a GIS analyst
- Creation of time stamp backup version of the current master layer;
- Integration of the new data into a copy of the current master GIS dataset. This includes running the Vector – Check validity tool to identify potential geometry errors.
- Final update of the master QGIS layer on the master PostgreSQL database.

The following section outlines how the GIS data collected by NAWASA is currently used to help operational and maintenance procedures under taken by the organisation. The section also examines how increase the accessibility and quality of digital data held in a GIS will aid future operational and investment decisions undertaken by the organisation.

2.3 Using the GIS for future operation and maintenance (O&M) operations

The development of the enhanced GIS capability will in the long term provide NAWASA with various additional operation and maintenance (O&M) benefits. Some examples include:

- Enable O&M staff the ability to review existing infrastructure/customer data while in the field;
- Evaluating Non-Revenue Water in DMA's by using GIS methods to assess individual and customer/meter usage; and
- Future mapping of leakage information and related pipeline conditions.

Further details are provided in the remainder of this section.

Access to existing infrastructure asset data while in the field

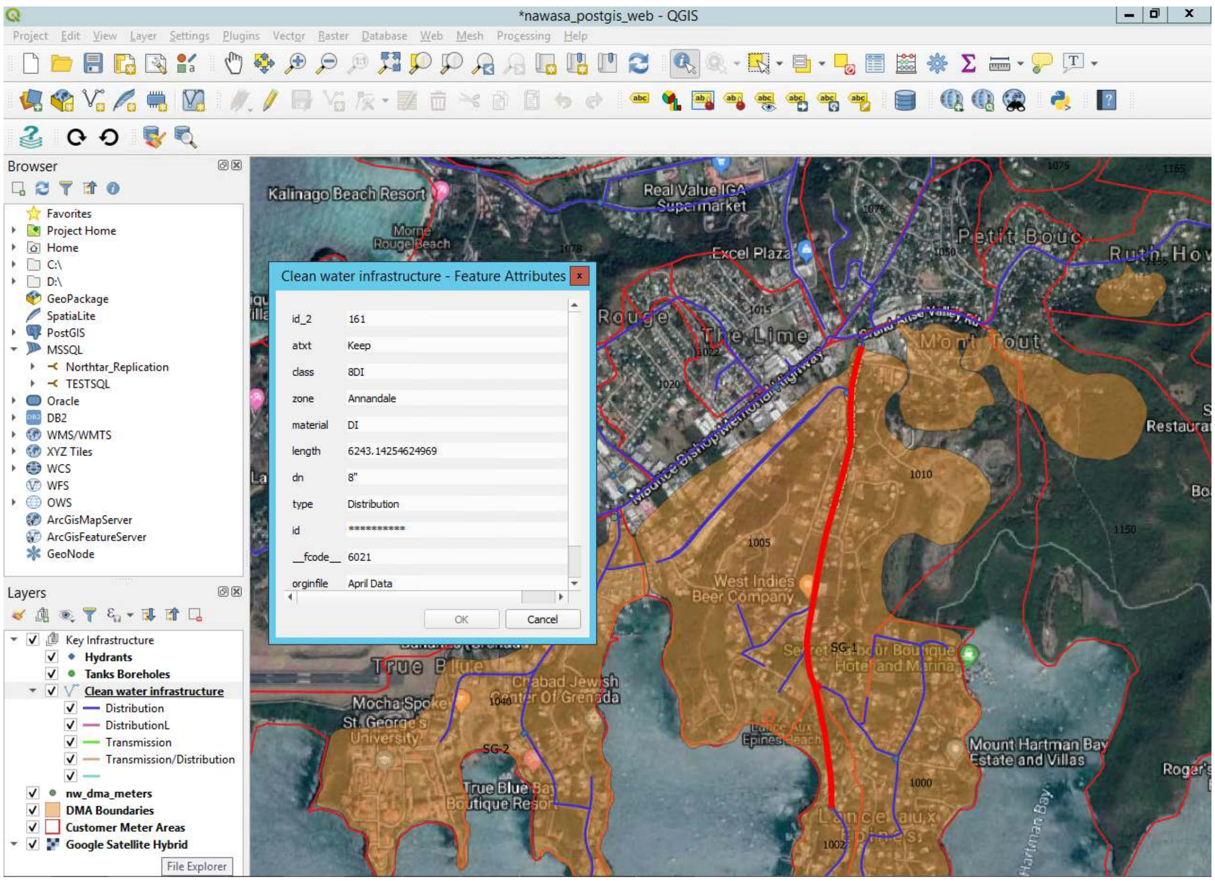
The development of the centralised GIS system will also improve the capability of NAWASA to provide future controlled access to infrastructure data for field workers. This includes the future provision of the Qfield app on Android based devices. A typical workflow includes the following steps:

- Creation of QField package. This is a working copy in a separate folder;
- Copy by O&M staff of the QField package to an Android based phone or tablet;
- Go out and either view/edit existing data or collect new data;
- Copy any new / modified data back to your desktop computer; and
- Synchronize the modified data with a central database or files.

This workflow approach would will allow O&M staff to see key infrastructure data while in the field, providing several important benefits. These benefits include:

- providing fieldwork staff access to infrastructure data while in the field;
- ability to capture of data in a digital format – further details on this in the following section;
- ensuring that NAWASA staff are aware of the location of customer meters and thereby help to minimise any potential third-party land ownership access issues; and
- flagging of any specific hazardous / risk locations for staff working in the field.

Plate 2.15 Visualisation of NAWASA asset data using QGIS



The access to these tools will also enables to send details and imagery directly (via a centralised email address) and enable the reporting of issues which required immediate or potential action for resolution.

This functionality was tested during the fieldwork undertaken in early October 2019.

Using GIS to visualise customer locations

The development of the central GIS and creation of links to NorthStar data tables will enable O&M staff to access a range of information for individual or groups of customers. This could include:

- Identification of individual meters or data capture areas with unusually low/high meter readings;

- Comparison of groups of meters (DMA or meter areas) to available bulk flow meter measurement to help identify level of NRW;
- Helping to plan the installation of new flow monitoring at locations identified using the GIS.

To achieve this capability, a parallel and secure MS SQL Server database was created by NAWASA's IT manager. This database was created to hold copies of three tables from NAWASA's NorthStar customer management and billing database. This is a customised database system which is based upon MS Server 2008 database technology.

The three tables included in the parallel database are:

- nw_pu_account NAWASA's customer account information
- nw_pu_meter NAWASA's customer meter information
- nw_pu_hist Time series of monthly meter readings

The parallel approach was designed to help improve the speed of the queries undertaken in the GIS and to ensure that there was no direct impact upon the master NorthStar database used for primary data entry and customer billing. The content of the database is currently being updated on an infrequent basis, but this frequency will be increased to ensure that the data used in subsequent queries remains active and valid.

Within the parallel database, a series of SQL queries were developed to join and summarise the three tables to provide new tables which could be joined to the customer meters layer within QGIS. The format of the individual SQL queries, accompanying batch script and scheduling task are presented in Appendix B.

The creation of these links will enable O&M staff to have access to better information regarding the location of existing customers, while both planning new O&M works and having access to this information while working in the field. This is illustrated in Plate 2.16, where a QGIS selection tool has been used to highlight a group of customer locations and return more detailed account and /or meter information held in the NorthStar database . The related information for these records can be easily exported to other software packages such as MS Excel if required.

QGIS also provides "out of the box" capability for users to search for specific values in fields and then zoom to these locations. This can be achieved by using "Field Filter" tool within the Attribute Table to enter specific criteria. The example shown in Plate 2.17 involves a search for a specific account number.

Plate 2.16 Using QGIS to review of customer details

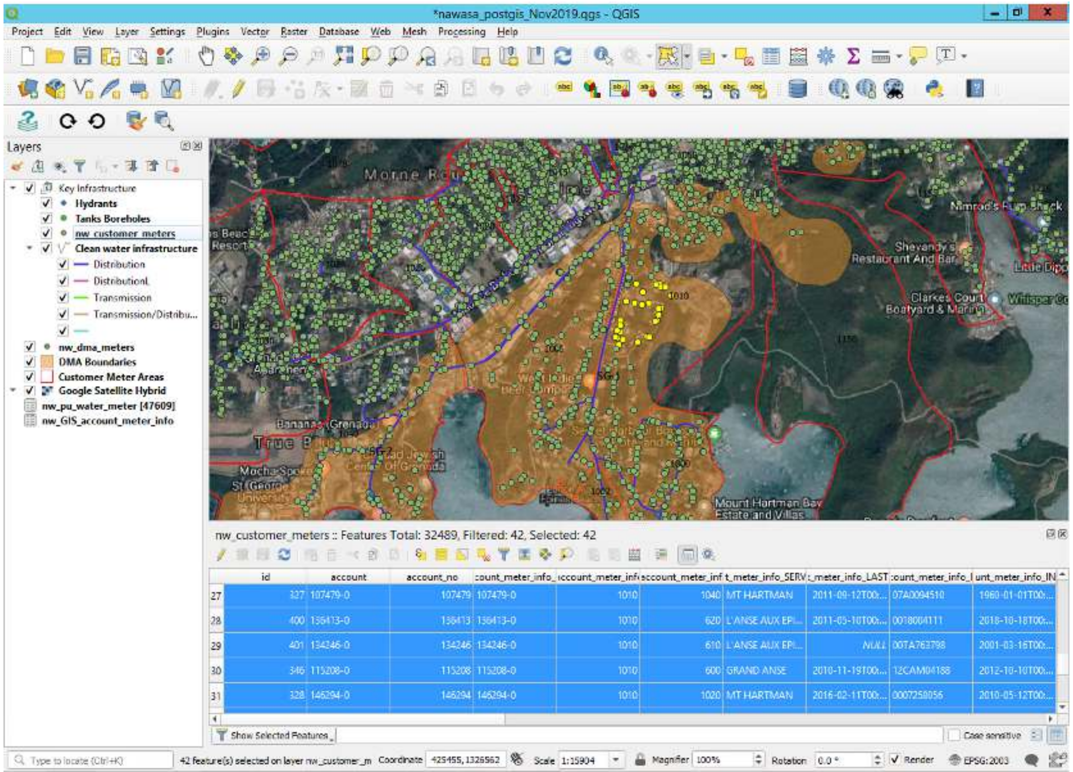
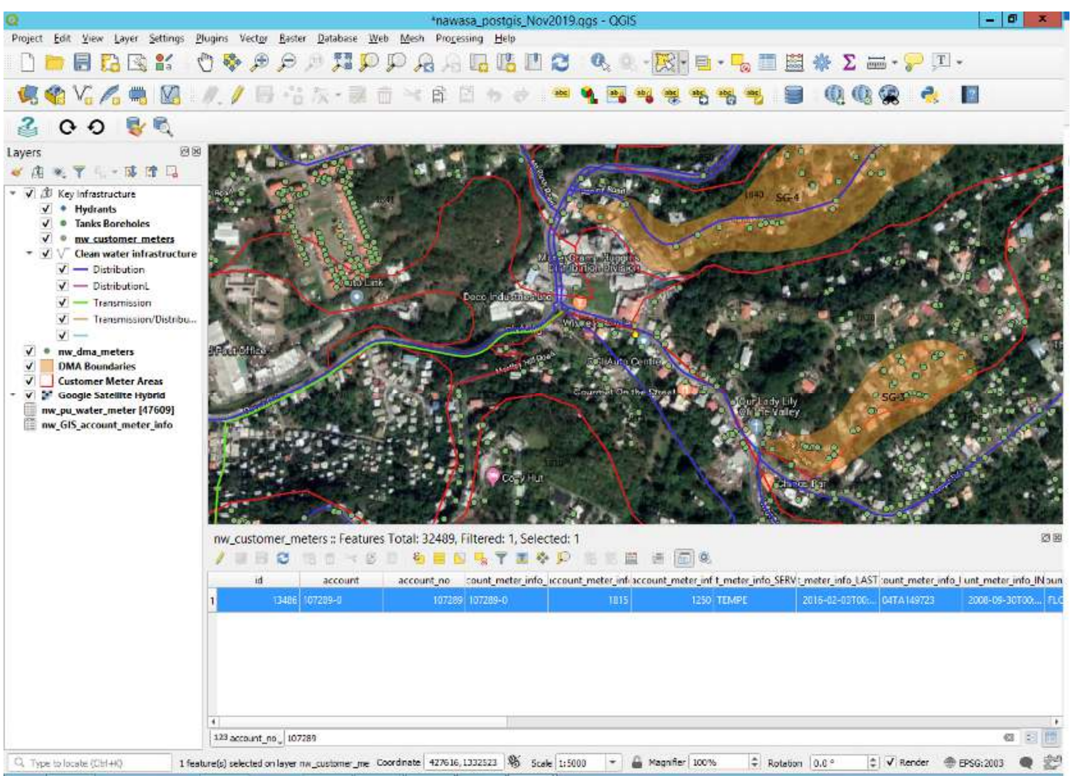


Plate 2.17 Using QGIS to find the location of a specific account or meter locations



Using GIS to record and visualise leak locations

A key input into the development of a non-revenue water (NRW) assessment is information regarding the location and extent of system leakages. At present, this information is not recorded systematically in a spatial GIS dataset, with limited information recorded in work orders logged in the NorthStar system.

It is therefore recommended digital methods (Qfield and QGIS) is used to record all future major leakage event on the clean water pipeline system. This data capture effort should record both the location (as point or section of pipeline), known of expected cause; length of time for the leak and details of the O&M operations take to fix the problem.

Further access to this information will not only help the creation of improved NRW assessment but also help to evaluate the location and reasons for leaks within the overall pipeline system.

3. Integrating GIS into customer department procedures

Current situation

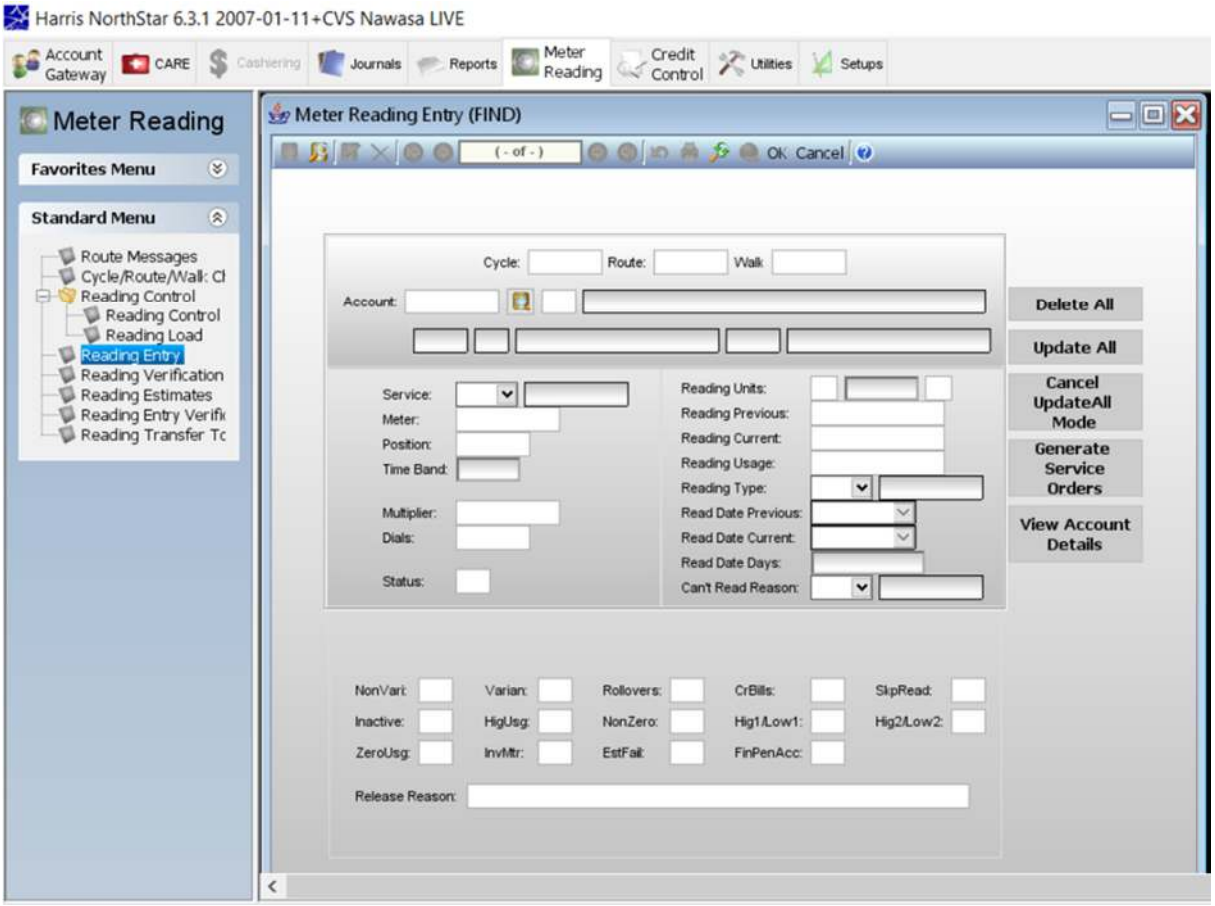
As outlined in project report 2A-2D, the primary tool used for the management of NAWASA's customer information is a software product called NorthStar. At present, the key uses of the NorthStar system by the NAWASA finance and customer service teams are as follows:

- Creation of new user accounts and/or update of details for existing customers;
- Manual data entry of monthly water usage values for the 33,400 register water meters across Grenada. This information is currently entered manually from data collected by NAWASA in-field survey teams using paper spreadsheets;
- Generation of customer bills using the monthly meter data information;
- Creation of revised spreadsheet to be used for the future monthly data collection by the in-field survey teams;
- Recording of customer issues;
- Management and processing of customer bill payments received from through either one of the three cash offices or three cheque boxes in Grenada; online banking and payment centres;
- Production and issue of overdue payment notices; and
- Generation of regular and ad-hoc financial reports for management report purposes.

At present, updated meter readings are entered manually on an account by account basis using the data entry form shown below in Plate 8. The form/user interface does not include any mapping functionality. The reports generated from the system are currently exported pre-defined tabular format and there is no current process to present any of the information held in the NorthStar system in a map form.

It should also be noted that NAWASA are also considering the future deployment of smart meters, which is expected over time to avoid the requirement for manual reading of customer meters and entry of data into the centralised customer management system.

Plate 3.1 Current NorthStar data entry form for monthly meter readings



Future GIS applications

The ongoing development of the centralised GIS system, data capture workflows and creation of links to selected NorthStar tables will also help support a variety of NAWASA customer service and finance and capabilities and ultimately long-term benefits. These will include:

- Increasing the digital capture of monthly customer meter readings
- Ability to check key customer account details using a map-based interface. This map would include access to adjacent customer account / meter details to provide additional context;
- Enable staff to search/query the monthly water usage at a specific location or for a group of accounts or individual meters. This capability would be helpful to identify water use in specific area and potential spatial patterns of abnormal water use; and
- Enable NAWASA staff to see the spatial location of customers currently registering as having overdue payments. This would help to understand potential geographical hotspots and/or to optimise O&M requirements for future service disconnections.

Digital capture of monthly customer meter readings

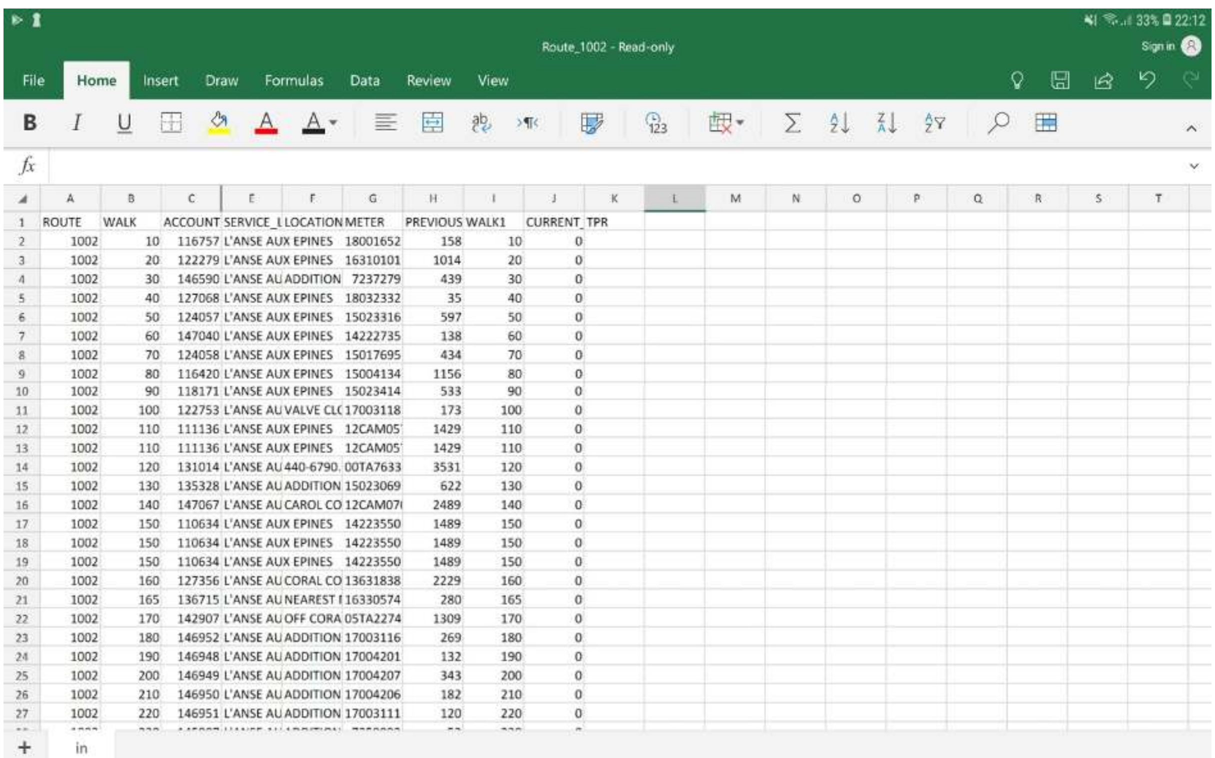
The work undertaken in this project has also investigated the use of tablet devices to aid the future capture of monthly customer meter readings. This was examined using two approaches during the field trials, namely:

- Capture of meter readings using QGIS and the Qfield Android app
- Tablet based data entry into a digital version (MS Excel) of the current meter reading sheet

This first of these workflows was tested during the three days of fieldwork training and evaluation in Grenada at the end of September and early October. This work highlighted that although Qfield could be used to capture future meter readings, it was concluded that this might not be the most effective approach. This decision was reached after careful consideration of the time required to upload/download data capture on each device and considering that NAWASA's preferred long term solution is the deployment of Smart Meters, which would remove the future requirement for manual reading of customer meters.

To provide an alternative short terms solution, the Wood team also examined the ability to enter customer meter reading using the MS Excel app hosted on a Samsung Galaxy Tab Android tablet. This was achieved by copying a digital version of the current meter recording sheet (stored in MS Excel spreadsheet) format onto the tablet, using email or direct copy of the spreadsheet onto the device. An illustration of this data entry form on a tablet is shown in Plate 3.2.

Plate 3.2 Digital meter reading data entry using MS Excel



	A	B	C	E	F	G	H	I	J	K
1	ROUTE	WALK	ACCOUNT	SERVICE_L	LOCATION	METER	PREVIOUS	WALK1	CURRENT_	TPR
2	1002	10	116757	L'ANSE AUX EPINES		18001652	158	10	0	
3	1002	20	122279	L'ANSE AUX EPINES		16310101	1014	20	0	
4	1002	30	146590	L'ANSE AU	ADDITION	7237279	439	30	0	
5	1002	40	127068	L'ANSE AUX EPINES		18032332	35	40	0	
6	1002	50	124057	L'ANSE AUX EPINES		15023316	597	50	0	
7	1002	60	147040	L'ANSE AUX EPINES		14222735	138	60	0	
8	1002	70	124058	L'ANSE AUX EPINES		15017695	434	70	0	
9	1002	80	116420	L'ANSE AUX EPINES		15004134	1156	80	0	
10	1002	90	118171	L'ANSE AUX EPINES		15023414	533	90	0	
11	1002	100	122753	L'ANSE AU	VALVE CL(	17003118	173	100	0	
12	1002	110	111136	L'ANSE AUX EPINES		12CAM05	1429	110	0	
13	1002	110	111136	L'ANSE AUX EPINES		12CAM05	1429	110	0	
14	1002	120	131014	L'ANSE AU	440-6790.	00TA7633	3531	120	0	
15	1002	130	135328	L'ANSE AU	ADDITION	15023069	622	130	0	
16	1002	140	147067	L'ANSE AU	CAROL CO	12CAM07	2489	140	0	
17	1002	150	110634	L'ANSE AUX EPINES		14223550	1489	150	0	
18	1002	150	110634	L'ANSE AUX EPINES		14223550	1489	150	0	
19	1002	150	110634	L'ANSE AUX EPINES		14223550	1489	150	0	
20	1002	160	127356	L'ANSE AU	CORAL CO	13631838	2229	160	0	
21	1002	165	136715	L'ANSE AU	NEAREST I	16330574	280	165	0	
22	1002	170	142907	L'ANSE AU	OFF CORA	05TA2274	1309	170	0	
23	1002	180	146952	L'ANSE AU	ADDITION	17003116	269	180	0	
24	1002	190	146948	L'ANSE AU	ADDITION	17004201	132	190	0	
25	1002	200	146949	L'ANSE AU	ADDITION	17004207	343	200	0	
26	1002	210	146950	L'ANSE AU	ADDITION	17004206	182	210	0	
27	1002	220	146951	L'ANSE AU	ADDITION	17003111	120	220	0	

This approach was successfully tested during October 2019 and will be tested in more detail by NAWASA staff during the remainder of the project and beyond.

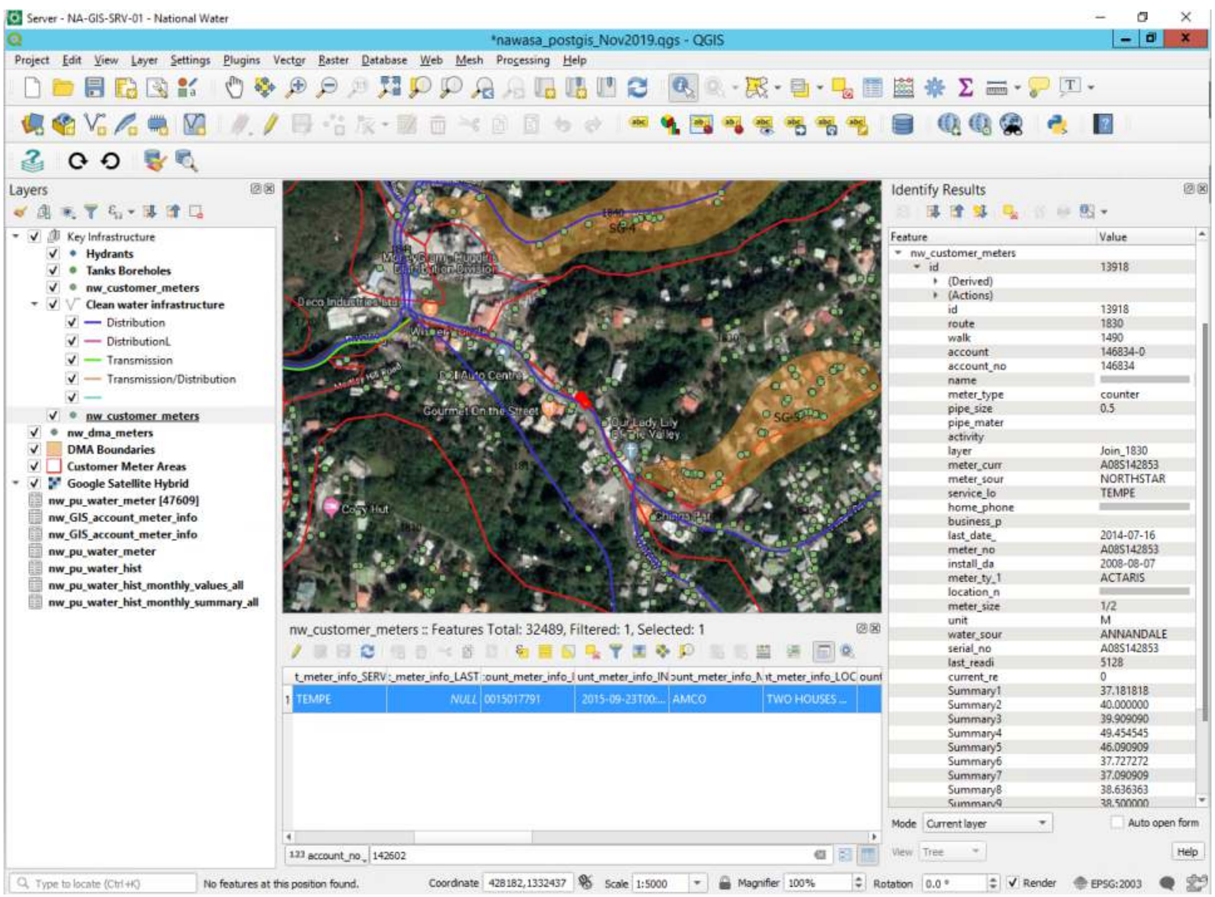
Other functionality

The development of the new centralised GIS will enable customer and finance department staff to access a variety of new query and analysis tools. These tools include:

- Searching and querying customer account details using a map-based interface.
- Enable staff to search/query the monthly water usage at a specific location or for a group of accounts or individual meters. This capability would be helpful to identify water use in specific area and potential spatial patterns of abnormal water use; and
- Enable NAWASA staff to see the spatial location of customers currently registering as having overdue payments. This would help to understand potential geographical hotspots and/or to optimise O&M requirements for future service disconnections.

An example of these types of query are provided below in Plate 3.3.

Plate 3.3 Using QGIS to review water usage for individual or groups of customers



Note: Selected fields have been greyed out in the report image due to confidential nature of the information

These capabilities could ultimately be delivered using an online web viewer. However, the current focus of the current UNIDO project remains on developing suitable data structures to enable the effective management, query and visualisation of the data using QGIS desktop.

4. Secure backup of GIS information

A key technical development within this project has been the creation of a centralised GIS database for NAWASA using PostgreSQL database technology hosted on a new virtual server. Remote access to this central server is provided through a software tool called Barracuda Managed Workplace, a facility managed by NAWASA's external IT provider - Mod1[6]. Further details of the configuration of the database are outlined in accompanying project reports 2C and 2D.

The effective and secure management of the information within the database is dependent on two key factors, namely (a) the effective operation of systematic IT backup process and (b) manual training/guidance for the entry and update of data within the system. The remainder of this section covers the first of the points.

At the time of writing this report, NAWASA are working with ModOne to implement a new organisational wide process for the backup of all servers including the new virtual MS Server 2012 server created to host the new GIS data structure

This process will over time ensure that the database is backup several times a day to a separate data store in Grenada. This backup device will be located on a different physical location from the primary server cluster. The backup system will also ensure that the primary database is backed up to the cloud to provide increased off-site resilience. This system also provides the capability for the VM to be rebooted/recovered and individual files/folders to be recovered from the primary server cluster or cloud, if required.

The need for an effective backup process was highlighted by the Wood team and discussed fully with Mod1 at the start of the study and during subsequent field missions. The implementation of the new server under the Mod1 backup system described above will ultimately provide NAWASA with a stable and secure centralised GIS capability, which will ensure the long-term effective management of NAWASA's spatial data.

As this backup process has yet to be fully implement, we recommended that the new PostgreSQL database is regularly backed up using the functionality available within the pgAdmin interface. Wood will be providing training on this essential data management task during the final stages of the study. Further details of the processes for manually backing up and restoring PostgreSQL backup can be obtained from the following websites:

http://www.postgresqltutorial.com/postgresql-backup-database/

http://www.postgresqltutorial.com/postgresql-restore-database/

[6] https://www.mod1.co/

5. Recommendations

The work undertaken in the study to-date have led to the identification of the following recommendations for the future adoption in the work undertaken by NAWASA staff and ultimately contribute to the development of more advanced GIS systems and layers for use across the organisation. Many of these recommendations were identified through the in-country work undertaken in May, September and October 2019 and subsequent discussions with NAWASA staff.

5.1 Capturing new asset information – pipeline infrastructure or meter locations

Capturing core digital pipeline infrastructure

- The field testing undertaken in this project has demonstrated the potential for both Qfield, SW Maps and Terraflex to aid the capture of actual or inferred routes of pipeline features.
- NAWASA will need to continue to develop their pipeline dataset though undertaking a future programme of field walking and the capture of visible and 'interpreted' assets. This should start in the remaining DMA areas and then extend across the remainder of the island.
- QGIS desktop software should be used to refine the location of any new pipeline features, captured or updated in the field prior to integration with the master pipeline layer held on the NAWASA GIS system. This includes ensuring that all features are split and snapped at appropriate junction locations and where possible tagged with a full set of attributes.

Capture of new customer meters

- The capture of new meter locations should be undertaken using a more detailed Trimble Catalyst type GPS linked to a smartphone. This will provide the best geographical location for future use in NAWASA's GIS system. This location should only be recorded once, even when a meter is directly replaced. The only exception should be where a meter has been moved spatially to meet a specific client or operational need.
- Any new data points should be provided directly to a GIS trained member of staff for entry into the master GIS customer meter layer. This will ensure that the GIS and NorthStar systems are fully aligned in the future

5.2 Capture of leakage information

- Digital methods (Qfield and QGIS) need to be used to record all future major leakage event on the clean water pipeline system. This data capture effort should record both the location (as point or section of pipeline, known of expected cause; length of time for the leak and details of the O&M operations taken to fix the problem.

5.3 Capturing monthly meter readings

- The field walking sessions demonstrated that the potential to use either Qfield or SW Maps app to capture current monthly meter readings using a pre-prepared survey form. However, NAWASA staff observed that would take some time to change current working practices by survey teams to adopt this approach. It was concluded that full adoption of this approach would not be the most effective way forward, especially given the expected move to Smart metering in the future.

- The initial field testing showed the potential to use tablets to capture digital format monthly readings using a digital version of the current monthly meter reading sheet (MS Excel) and then email this information to a central email address for entry into the NorthStar database system. This approach was successfully tested while in the field and will now be subject to further testing by NAWASA field staff.

5.4 Data backup

- The continued development and integration of a GIS capability within NAWASA will be dependent on the long-term development of a comprehensive backup process for all IT servers used by the organisation. This issue needs to be addressed as soon as possible.

Issued by

Neil Thurston
....

Approved by

Neil Thurston
....

Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

Appendix A QFieldSync workflow

QFieldSync plugin

The QFieldSync plugin helps preparing and packaging QGIS projects for QField.

QFieldSync supports your project preparation with automating the following:

- Required steps for project setup (e.g. Portable Project)
- Creating basemaps from a single raster layer or from a style defined in a map theme.
- Configuring the offline editing functionality and synchronizing changes back.

Workflow

To get a quick overview of the process, here is a list of typical steps:

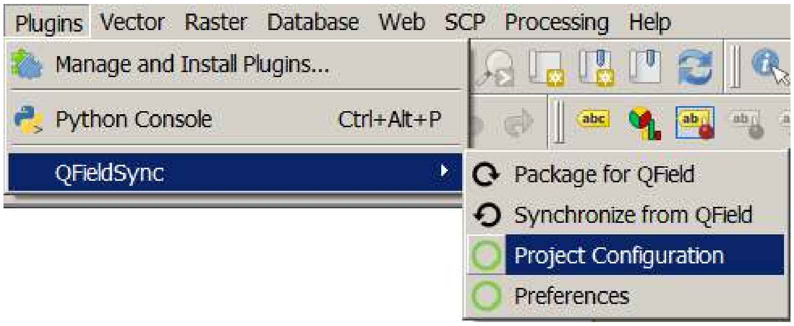
1. Create a QField package. This is a working copy in a separate folder.
2. Copy the QField package to the target device.
3. Go out and collect data.
4. Copy the modified data back to your desktop computer.
5. Synchronize the modified data with your database or files.

Installation

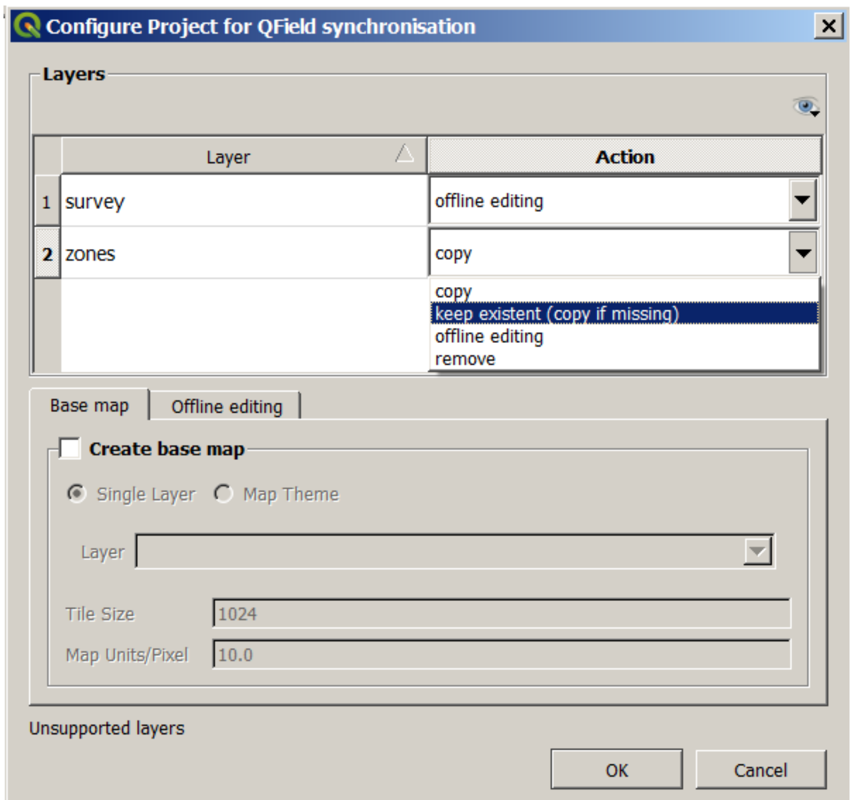
In QGIS, open the plugin library and search for **qfield sync**. Select the plugin in the list and click on **Install**.

Configuration

The project configuration is saved in the master .qgs project file. This way it is possible to pre-configure a project once and use it repeatedly.



Layer configuration



In the project configuration dialog, an *action* can be defined for each layer individually. Depending on the layer type, different types of actions are available.

Copy

The layer will be copied to the package folder. This is only available for file-based layers.

No action

The layer source will be left untouched. This is only available for non-file-based layers like WMS, WFS, PostGIS.

Offline editing

A working copy of the layer is copied into the package folder. Every change which is done in the packaged project during work is recorded in a changelog. When synchronizing the changes back later on, this log will be replayed and all changes also be applied to the main data base. There is no conflict handling in place.

Remove

The layer will be removed from the working copy. This is useful if a layer is used in the basemap and will not be available in the packaged project.

Base map configuration

A base map is a raster layer which is added as the bottommost layer to the packaged project file.

If the base map option is enabled, a base map will be rendered, whenever the project is packaged. The area of interest - the extent which will be rendered - will be chosen at packaging time.

There are two possible sources for a base map:

Layer

A raster layer. This is useful to take an offline copy of an online layer like a WMS or to take a working copy of an unsupported format like an ECW or MrSID layer.

Map Theme

A map theme. This is useful to create a base map based on a combination of several layers with styling. These layers can then be removed from the working package and do not need to be rendered on the device. This can save some disk space and battery on the device.

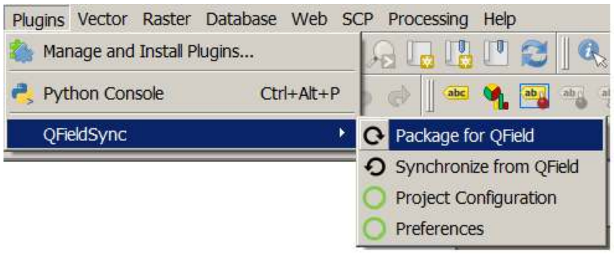
The tile size defines the spatial resolution. It determines the number of map units per pixel. If the map canvas CRS has meters as units and tile size is set to 1, each raster pixel will have a spatial extent of 1x1 m, if it is set to 1000, each raster pixel will have a spatial extent of 1 square kilometer.

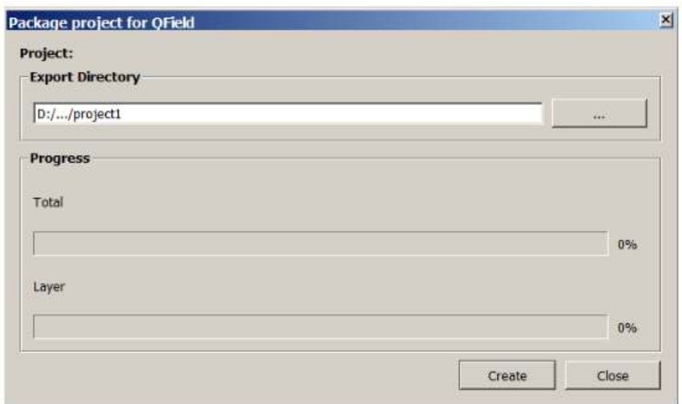
Offline editing configuration

If *only synchronize features in area of interest* is checked, only features which are within the extent of the map canvas as packaging time will be copied to the offline editing working copy.

Package for Qfield

Once the project is configured, package it in a folder. This folder will contain the .qgs and the data used in it.





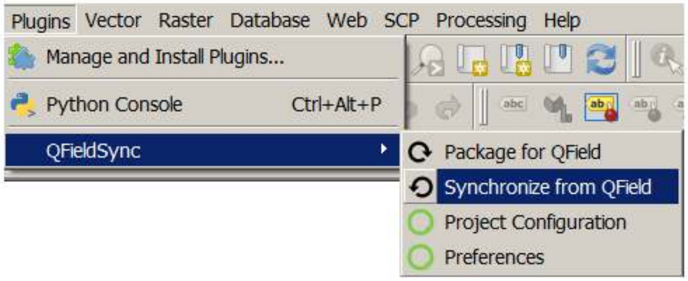
Copy the folder on your device. Open Qfield, open the project and start collecting data.

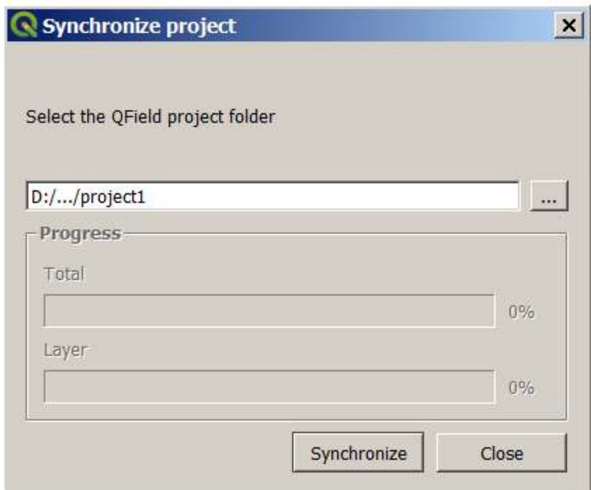
Make also sure to save the QGIS project using the regular Save As of QGIS as you'll have to re-open it later when you want to synchronize the changes.

Synchronize from Qfield

When you want to synchronize what you have collected, re-open the project in QGIS (the one you saved with a regular Save As).

Copy the project folder from your device to your computer and use the **Synchronize from Qfield** menu to synchronize your changes from the portable project to the main project.


Plugins
Vector
Raster
Database
Web
SCP
Processing
Help
Manage and Install Plugins...
Python Console Ctrl+Alt+P
QFieldSync
Package for QField
Synchronize from QField
Project Configuration
Preferences


Synchronize project
Select the QField project folder
D:/.../project1
...
Progress
Total
0%
Layer
0%
Synchronize
Close

Appendix B PostgreSQL backup

B1 Individual SQL queries

Extract selected fields from the nw_pu_account table

```
Use GIS
IF OBJECT_ID('dbo.nw_pu_account', 'U') IS NOT NULL
  DROP TABLE dbo.nw_pu_account;
Select account_no,[name],serv_street,serv_region,serv_city,mail_city,route,debtor_no,bill_units_wtr,water_source,last_date_update
Into dbo.nw_pu_account
FROM harris_live.pu_account
ORDER BY account_no asc;
```

Extract selected fields from the nw_pu_water_meter table

```
Use GIS
IF OBJECT_ID('dbo.nw_pu_water_meter', 'U') IS NOT NULL
  DROP TABLE dbo.nw_pu_water_meter;
Select account_no,meter_no,serial_no,meter_type,unit_measure,install_date,dials_hi,curr_reading_hi,walk,meter_size,
mod_date
Into nw_pu_water_meter
FROM harris_live.pu_water_meter
ORDER BY account_no asc;
```

Join the nw_pu_account and nw_pu_water_meter tables based upon the account_no field

```
Use GIS
IF OBJECT_ID('nw_pu_account_water_meter_join', 'U') IS NOT NULL
  DROP TABLE nw_pu_account_water_meter_join;
SELECT
nw_pu_account.account_no,nw_pu_account.name,nw_pu_account.serv_street,nw_pu_account.serv_region,nw_pu_account.serv_city,nw_pu_account.mail_city,nw_pu_account.route,nw_pu_account.debtor_no,nw_pu_account.bill_units_wtr,nw_pu_account.water_source,nw_pu_account.last_date_update,
nw_pu_water_meter.meter_no,nw_pu_water_meter.serial_no,nw_pu_water_meter.meter_type,nw_pu_water_meter.unit_measure,nw_pu_water_meter.install_date,nw_pu_water_meter.dials_hi,nw_pu_water_meter.curr_reading_hi,nw_pu_water_meter.walk,nw_pu_water_meter.meter_size,nw_pu_water_meter.mod_date
Into nw_pu_account_water_meter_join
FROM nw_pu_account JOIN nw_pu_water_meter
   ON (nw_pu_account.account_no = nw_pu_water_meter.account_no)
Order by nw_pu_account.account_no
```

Creation of monthly and year profile of water usage summarised by account_no field

```
Use GIS
IF OBJECT_ID('dbo.nw_pu_water_hist_monthly_values_all', 'U') IS NOT NULL
  DROP TABLE dbo.nw_pu_water_hist_monthly_values_all;
Select meter_no, Month(read_date) as [themonth], sum(wood_calc_usage) as Total_Month, count(wood_calc_usage) as Record_Count,
avg(wood_calc_usage) as MeanMonth
Into dbo.nw_pu_water_hist_monthly_values_all
```

```
FROM dbo.nw_pu_water_hist
Where Year(read_date) > 1900
GROUP BY account_no, Month(read_date)
ORDER BY account_no asc

ALTER TABLE dbo.nw_pu_water_hist_monthly_values_all
   ADD ID INT IDENTITY
       CONSTRAINT PK_nw_pu_water_hist_monthly_values_all PRIMARY KEY CLUSTERED
```

Creation of average month by month profile of water use by account_no

```
Use GIS
IF OBJECT_ID('dbo.nw_pu_water_hist_monthly_summary_all', 'U') IS NOT NULL
  DROP TABLE dbo.nw_pu_water_hist_monthly_summary_all;
Select *
INTO dbo.nw_pu_water_hist_monthly_summary_all
from
(
  select account_no, themonth, MeanMonth
  from nw_pu_water_hist_monthly_values_all
) src
pivot
(
  sum(MeanMonth)
  for themonth in ([1], [2], [3],[4],[5],[6],[7],[8],[9],[10],[11],[12])
) piv
Order BY piv.[account_no];

ALTER TABLE dbo.nw_pu_water_hist_monthly_summary_all
   ADD ID INT IDENTITY
       CONSTRAINT PK_nw_pu_water_hist_monthly_summary_all PRIMARY KEY CLUSTERED
```

B2 Batch command (SQL.bat) used to run and update the primary queries

```
sqlcmd -S NAWASA SERVER-U sa -P PASSWORD -i C:\NAWASA_QGIS\SQL\SQL_create_nw_pu_account.SQL

sqlcmd -S NAWASA SERVER-U sa -P PASSWORD -i C:\NAWASA_QGIS\SQL\SQL_create_nw_pu_water_meter.SQL

sqlcmd -S NAWASA SERVER-U sa -P PASSWORD -i C:\NAWASA_QGIS\SQL\SQL_create_nw_pu_water_hist.SQL

sqlcmd -S NAWASA SERVER-U sa -P PASSWORD -i C:\NAWASA_QGIS\SQL\SQL_create_nw_pu_water_meter_status_A.SQL

sqlcmd -S NAWASA SERVER-U sa -P PASSWORD -i C:\NAWASA_QGIS\SQL\SQL_create_nw_pu_account_water_meter.SQL

sqlcmd -S NAWASA SERVER-U sa -P PASSWORD -i C:\NAWASA_QGIS\SQL\SQL_create_nw_pu_water_hist_monthly_values_all.SQL

sqlcmd -S NAWASA SERVER-U sa -P PASSWORD -i
C:\NAWASA_QGIS\SQL\SQL_create_nw_pu_water_hist_monthly_values_010118_230819.SQL

sqlcmd -S NAWASA SERVER-U sa -P PASSWORD -i C:\NAWASA_QGIS\SQL\SQL_create_nw_pu_water_hist_monthly_summary_all.SQL

sqlcmd -S NAWASA SERVER-U sa -P PASSWORD -i
C:\NAWASA_QGIS\SQL\SQL_create_nw_pu_water_hist_monthly_summary_010118_230819.SQL

sqlcmd -S NAWASA SERVER-U sa -P PASSWORD -i
C:\NAWASA_QGIS\SQL\SQL_create_nw_pu_account_water_meter_reading_summary_all.SQL
```