CHAPTER 2

Materials and Methods

2.1 Devices and methods for water quality monitoring

In this thesis, the 10 parameters were chosen for water quality monitoring (see details in 1.4). In order to be able to make rapid measurements, digital probe meters were used for measuring pH, temperature, DO, Conductivity, TDS and turbidity while test kits were used for determination of ammonium, nitrate, phosphate and COD.

2.1.1 Digital probe meter

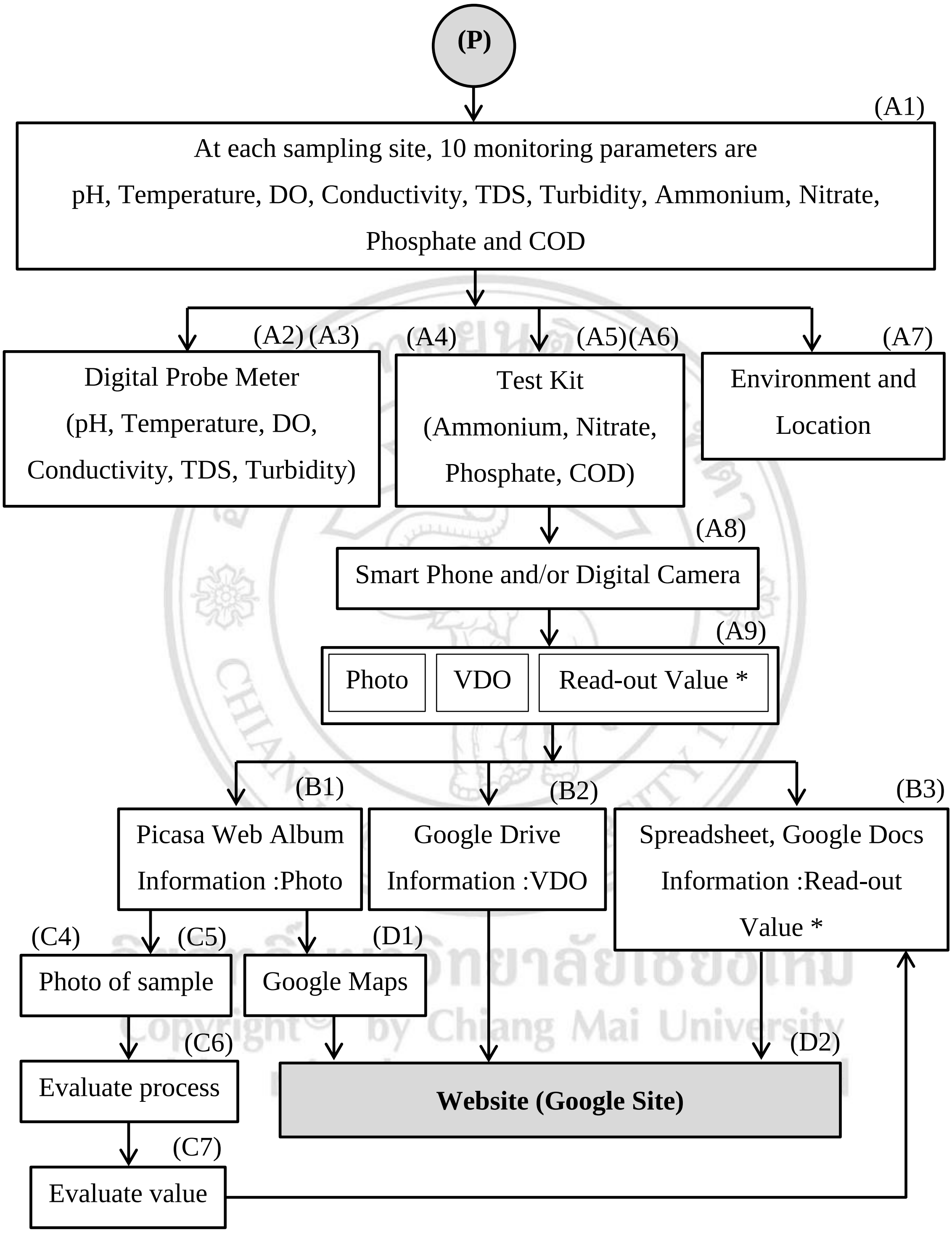
Various digital probe meter were used to measure physical and chemical properties of water quality; pH (pH Meter, EZDO, Model pH-6110), temperature and DO (DO Meter, Lurton, Model DO-5519), conductivity and TDS (Conductivity Meter, Lurton, Model CD-4307SD) and turbidity (Turbidi Meter, HACH, Model 2100P). For pH and turbidity probes, a water sample was taken for measurement. For all other probes, the measurement was made below water surface at the depth of 15 – 30 cm. All read-out data were recorded by a digital camera (Sony Model Alpha 500) and/or a smart phone (LG Optimus Black, Samsung Galaxy Note 2 and Apple iPad 3).

2.1.2 Test Kit

Several types of test kits (Packtest) were used in this study. A water sample was collected using a plastic syringe (50 mL, NIPRO), and filtered with a nylon syringe filter (diameter 25 mm, pore size 0.45 µm, Xiboshi). Then, each parameter was determined following the procedure (Figure A1, Appendix A); ammonium (Kyoritsu Packtest ion selective Ammonium-N Model WAK-NH4 using indophenol blue color comparison method, no. 1, Appendix A), nitrate (Kyoritsu Packtest ion selective Nitrate nitrogen Model WAK-NO3 using naphthylethylenediamine method, no. 2, Appendix A), phosphate (Kyoritsu Packtest ion selective Phosphate (Low range) Model WAK-PO4 (D) using emzymatic method and Kyoritsu Packtest ion selective Phosphate (High range) Model WAK-PO4 (C) using molybdenum blue method, no. 3, Appendix A) and COD (Kyoritsu Packtest ion selective COD Model WAK-COD and Kyoritsu Packtest ion selective COD (250: High range) Model WAK-COD (H) both using oxidation by potassium permanganate in alkaline medium, (no. 4, Appendix A). The color result of Packtest was recorded by digital camera and/or smart phone.

2.2 Water quality monitoring employing modern information technology

In this study, a modern IT was applied for water quality monitoring which can be divided into 5 steps consisting of water quality monitoring and photograph (A), information upload (B), Packtest evaluation (C), display (D) and process operation planning (P). The process is summarized as shown in Figure 2.1 and Figure 2.2, the detail of each step as follows:



Remark: * = Information input

Figure 2.1 Process of water quality monitoring employing Modern IT

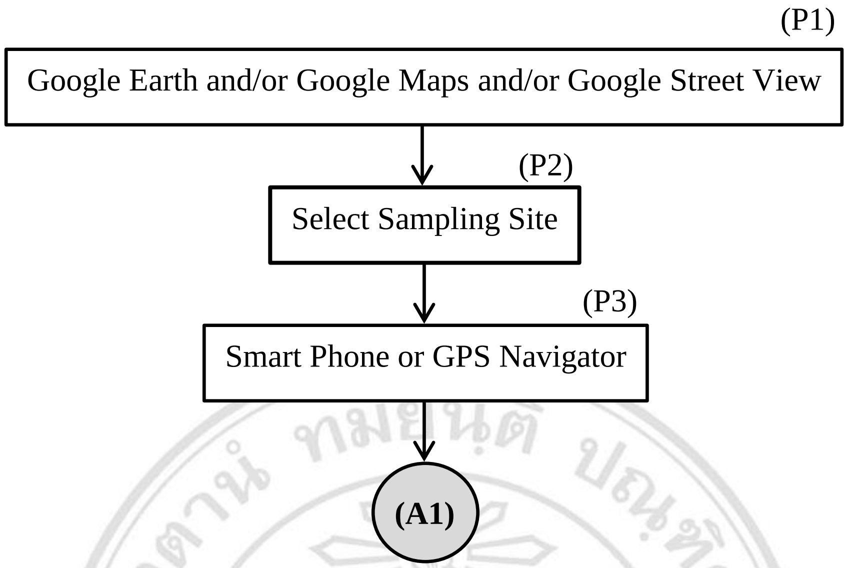


Figure 2.2 Process of planning

2.2.1 Water quality monitoring and photograph

At the sampling site, 10 parameters of water quality were examined. The pH, temperature, DO, conductivity, TDS and turbidity were measured using specific digital probe meters by dipping the probe either under the water surface or into the water sample (A2 and A3, Figure 2.3). After that, the results were recorded as photo, VDO or read-out value (A8 and A9, Figure 2.3). Meanwhile, other parameters were measured using various test kits (Packtest) including ammonium, nitrate, phosphate and COD (A5, Figure 2.3). The water samples were filtrated (A4, Figure 2.3) before proceeded following the procedure for each parameter (A6, Figure 2.3) (section 2.1.2). Then, the result color of Packtest was compared with the standard chart color. A photo of the Packtest result and standard chart color was recorded (A8 and A9, Figure 2.3). In addition, a photo and/or VDO of sampling site were also recorded to show environment at the time of sampling including geographical coordinates (A7, Figure 2.3).

The photograph of each parameter was labelled with the sampling site and date of measurement. For example, the label in Figure 2.4 (A) indicates the measurement at CM 1 in Trip 1 on 29 March 2013. It is corresponding with the detail of the photo recorded by a smart phone and/or digital camera. Also, each photo contains the details about the geographical coordinates, image resolution, model of the device, flash, focal length, white balance, aperture, exposure time and ISO. These information can be accessed by click ‘view details’ (in smart phone) or ‘properties’ (in computer) (Figure 2. 4 (B)). This makes all data traceable.

For the smart phone without geographical position tracking support, some applications such as GPS Device Data [70], GPS Data [71] and GPS Status [72], was installed on a smart phone to display and record geographic coordinates, altitude, time and accuracy at sampling site (A7, Figure 2.3).

After water quality data with digital probe meters and test kit were recorded including environments and geographical coordinates of each sampling site. Three different formats of information were obtained consisting of photos, VDO and the read-out value, which will be uploaded into the information process system.

During the data collection process, some communication applications like Skype, TeamViewer, Line, Viber, WhatApp may be used to share information among the monitoring team. This is very useful for double-checking. Moreover, the ‘on-site’ team could communicate with experts or specialists via these communication applications to discuss and plan the work together.

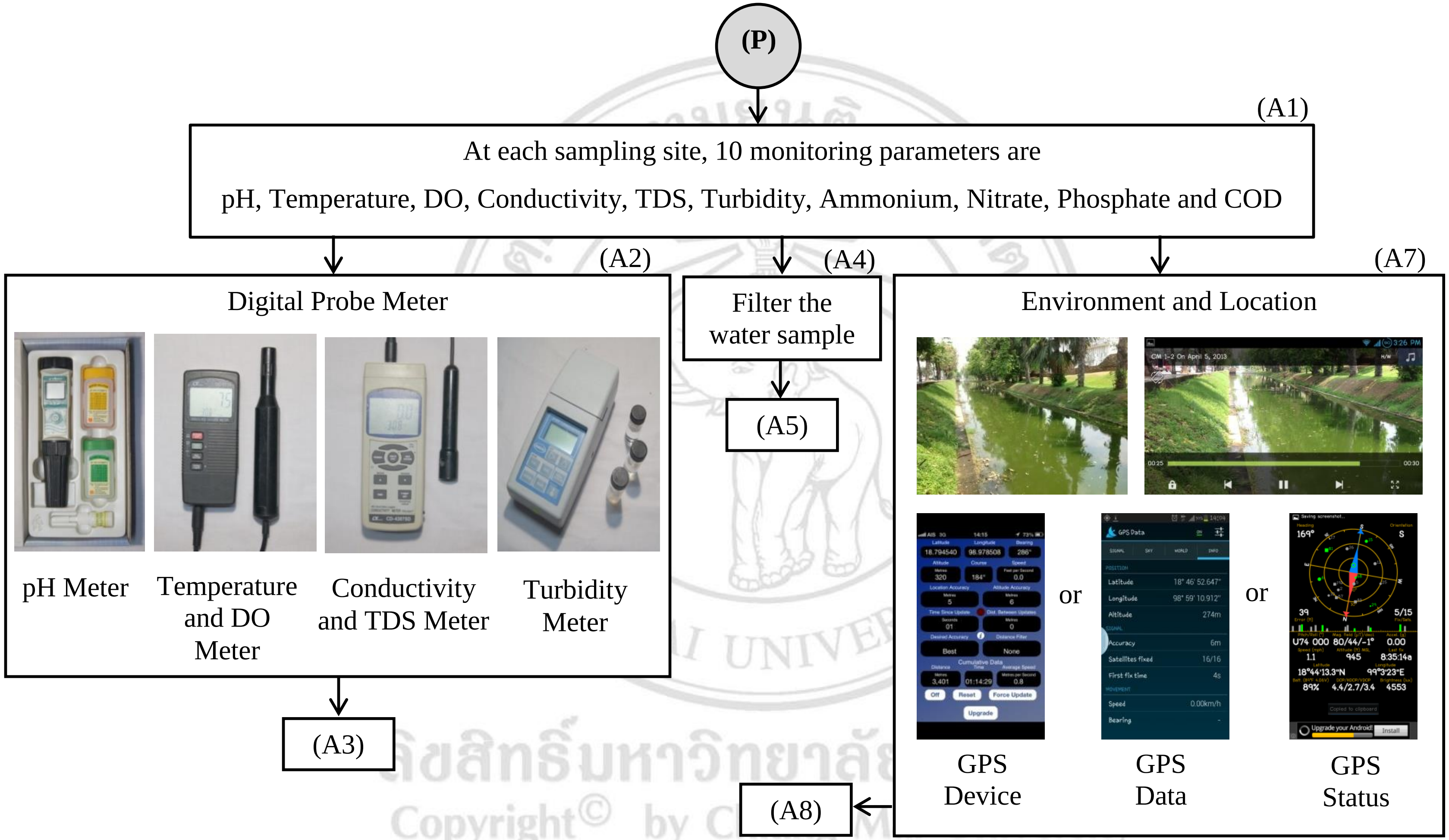


Figure 2-3 Process of water quality monitoring at sampling site

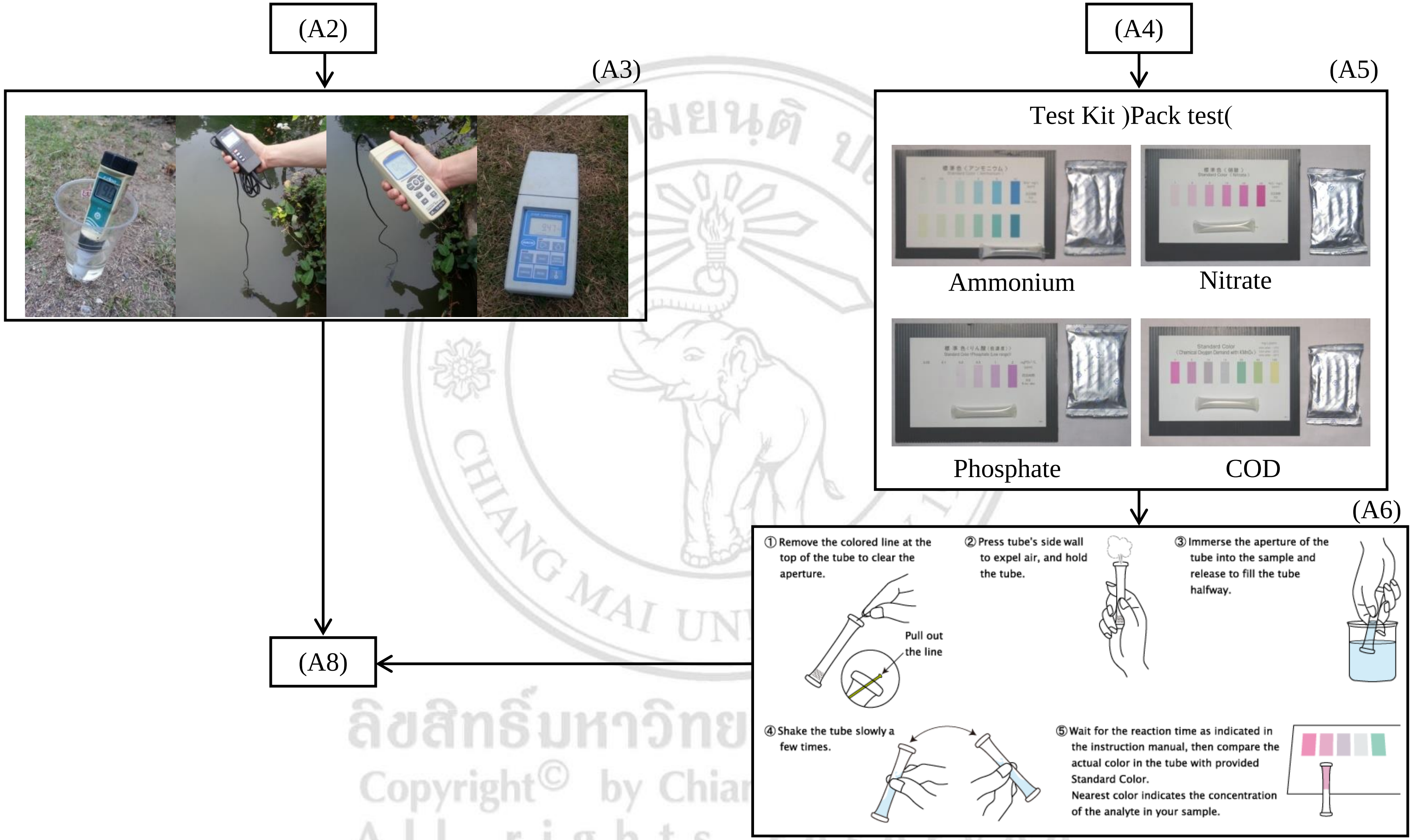


Figure 2-3 Process of water quality monitoring at sampling site (continued)

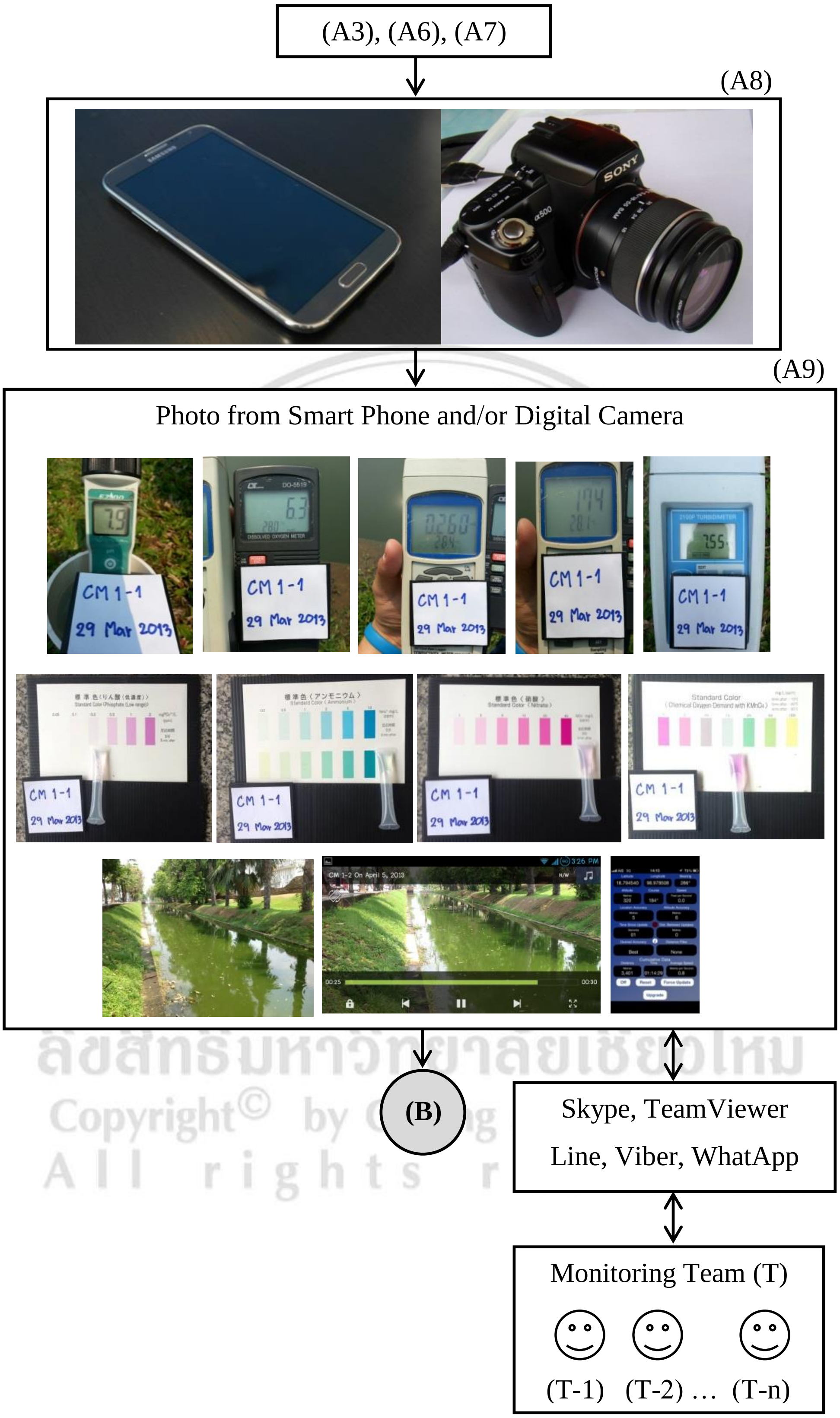


Figure 2-3 Process of water quality monitoring at sampling site (continued)

(A) (B)

Figure 2.4 (A) A label showing name of sampling site (such as CM 1-1) and date of measurement (such as 29 Mar 2013), (B) Data on a photo file showing date, time, geographic coordinate and details of photo (see text)

2.2.2 Information upload

The Data recorded with smart phone was able to be uploaded directly while the data recorded with digital camera must be imported to a notebook computer (Toshiba Model 640M) and then uploaded via the smart phone internet (Figure 2.5). The three-formatted data were uploaded as follows;, photos were uploaded to the Picasa Web Album (B1, Figure 2.5), VDOs were uploaded to Google Drive (B2, Figure 2.6) and read-out values were ensembled to the Spreadsheet, Google Docs (B3, Figure 2. 7).

Each photo on the Picasa Web Album was labelled with the related information (Figure 2.4). These information will be automatically shown on the webpage, including the traceable location on Google Maps where a photo was taken (B1-1-1 and B1-1-1-1, Figure 2.5).

Spreadsheet application of Google Docs is a cloud computing system that can calculate, create and display a graph. Thus, the read-out value data recorded on Spreadsheet, Google Docs (B3, Figure 2.7) could be calculated and displayed as a graph of water quality monitoring data (D4, Figure 2.8). In addition, other applications of Google Docs such as Document used to report water quality, Presentation used to present results of water quality monitoring, Form used to collect visitor data of the website in a form of questionnaire and Drawing used to edit photo.

During monitoring process, the communication application such as Skype, TeamViewer, Line, Viber and WhatApp, could be used to share photos among the monitoring team to help following the overall work progress.

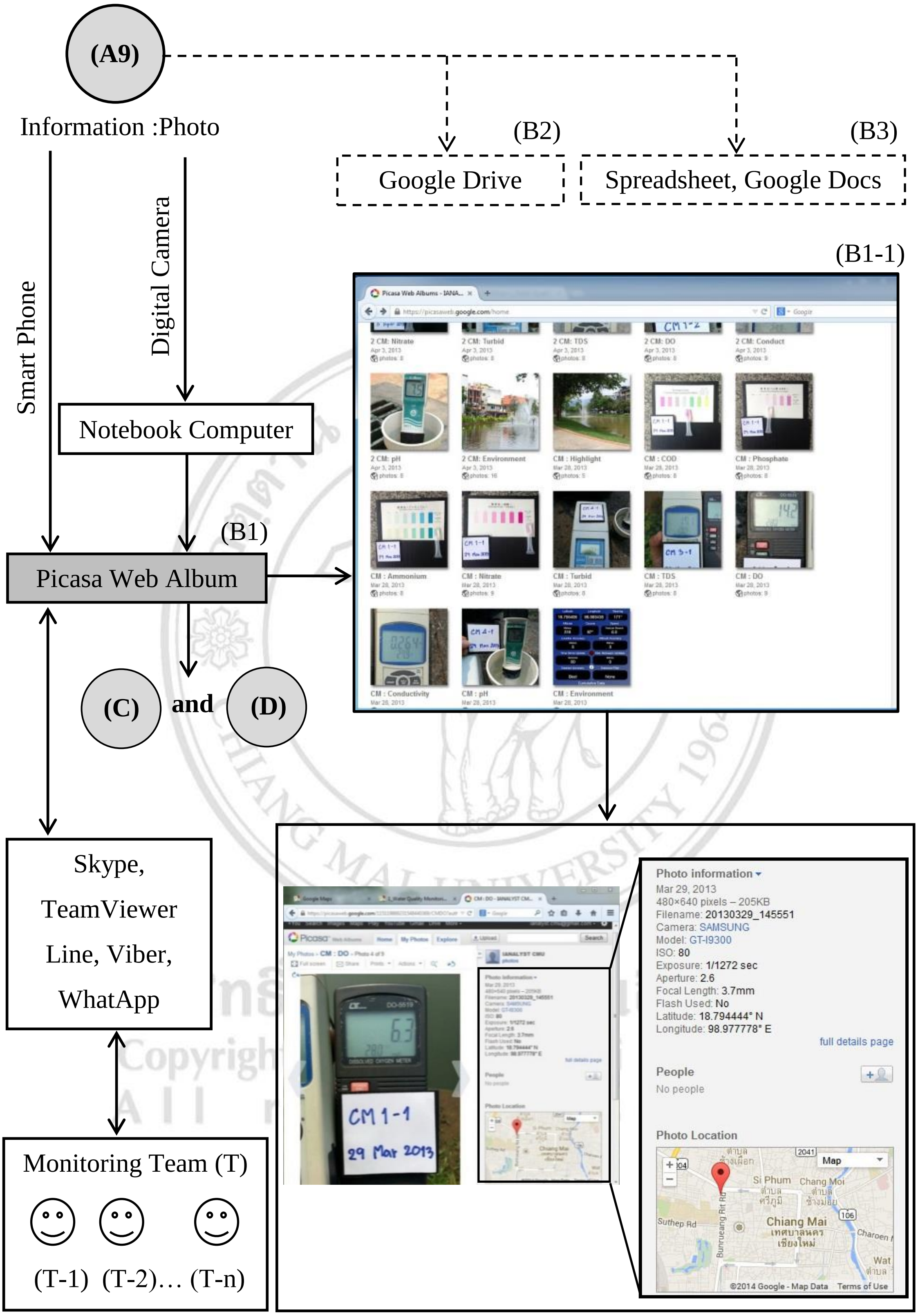


Figure 2.5 Process of information upload; photos to Picasa Web Album

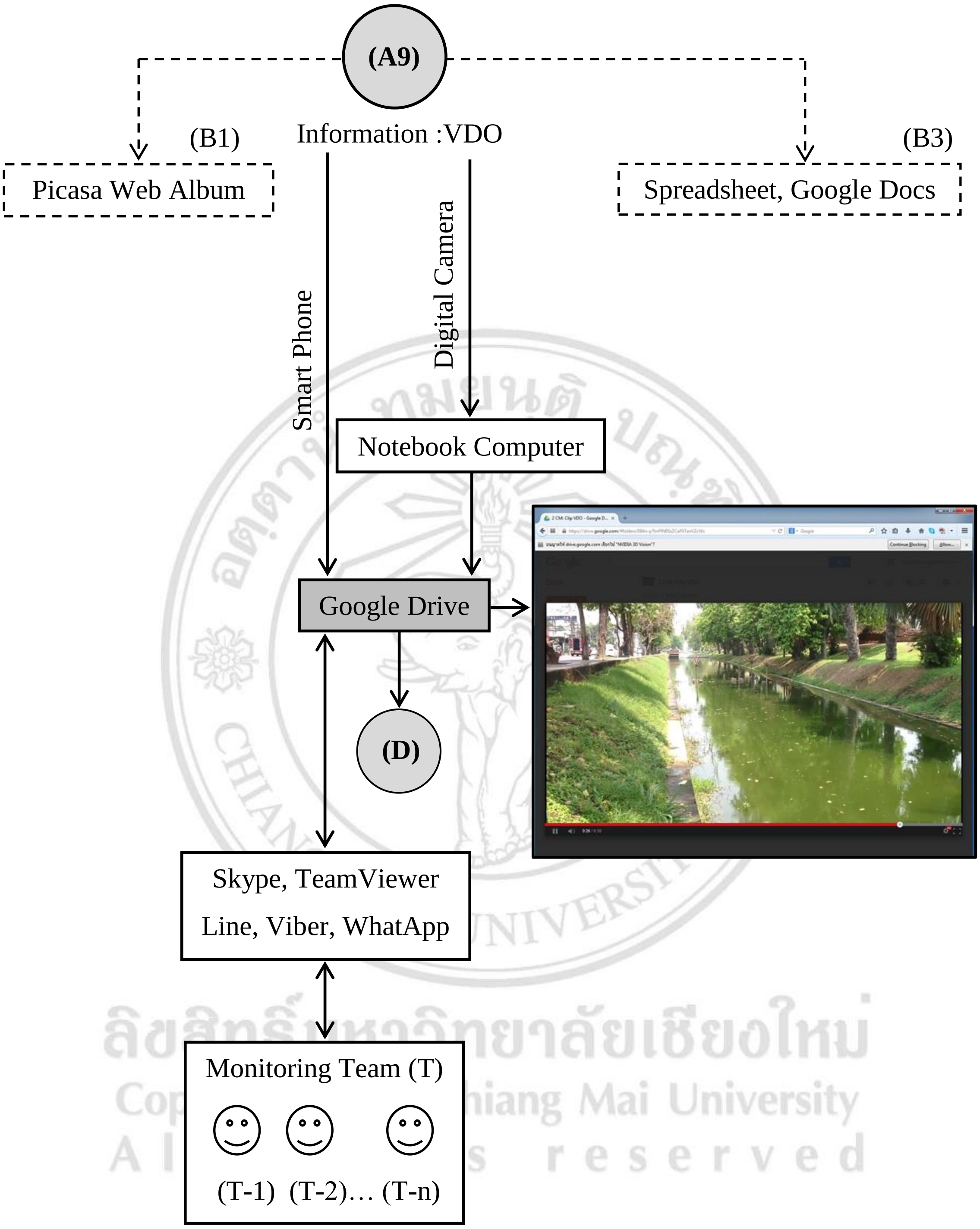
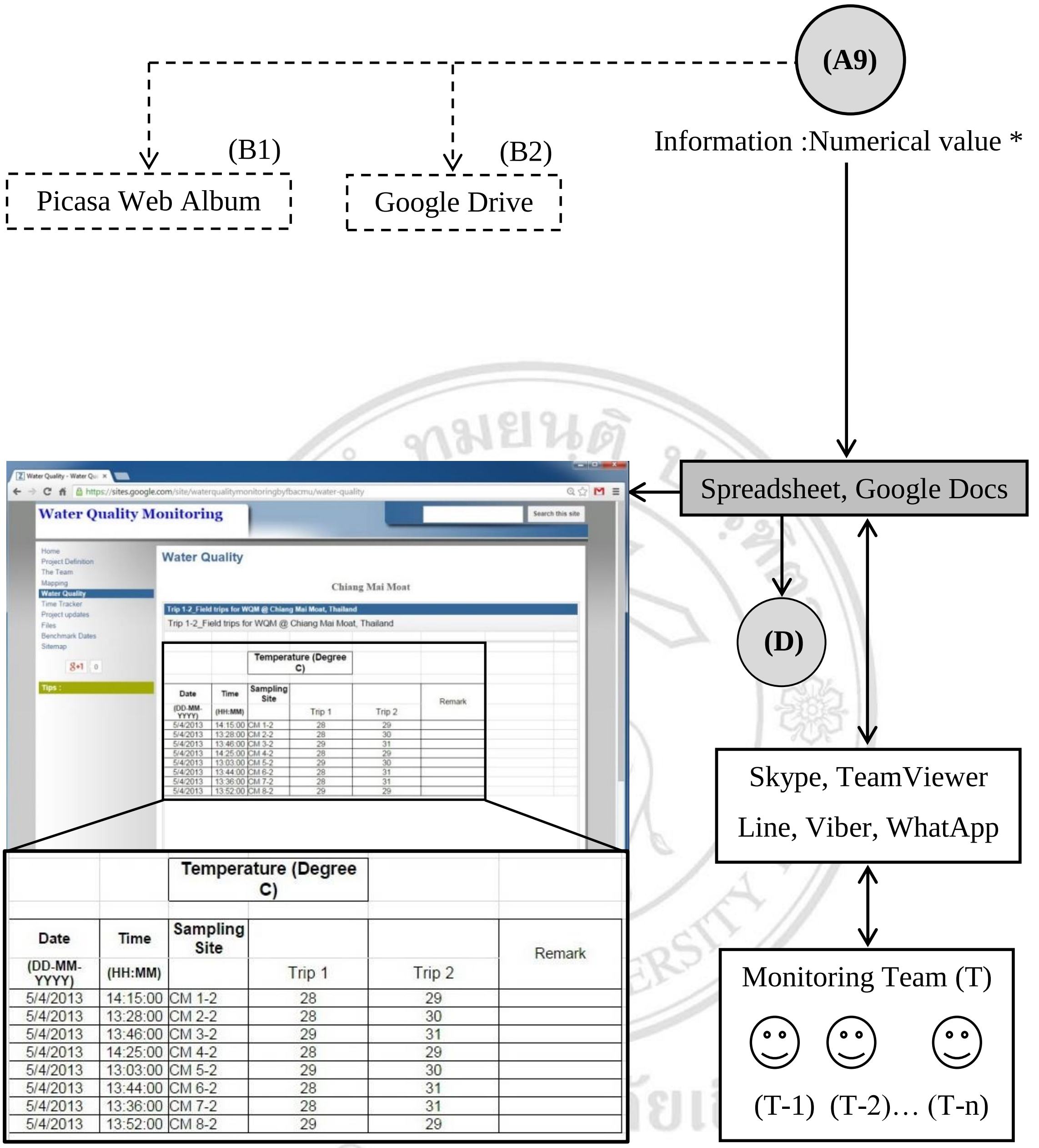


Figure 2.6 Process information upload; VDO to Google Drive



			Temperature (Degree C)		
Date (DD-MM-YYYY)	Time (HH:MM)	Sampling Site	Trip 1	Trip 2	Remark
5/4/2013	14:15:00	CM 1-2	28	29	
5/4/2013	13:28:00	CM 2-2	28	30	
5/4/2013	13:46:00	CM 3-2	29	31	
5/4/2013	14:25:00	CM 4-2	28	29	
5/4/2013	13:03:00	CM 5-2	29	30	
5/4/2013	13:44:00	CM 6-2	28	31	
5/4/2013	13:36:00	CM 7-2	28	31	
5/4/2013	13:52:00	CM 8-2	29	29	

Remark: * = Information input

Figure 2.7 Process of information upload; read-out value to Spreadsheet, Google Docs

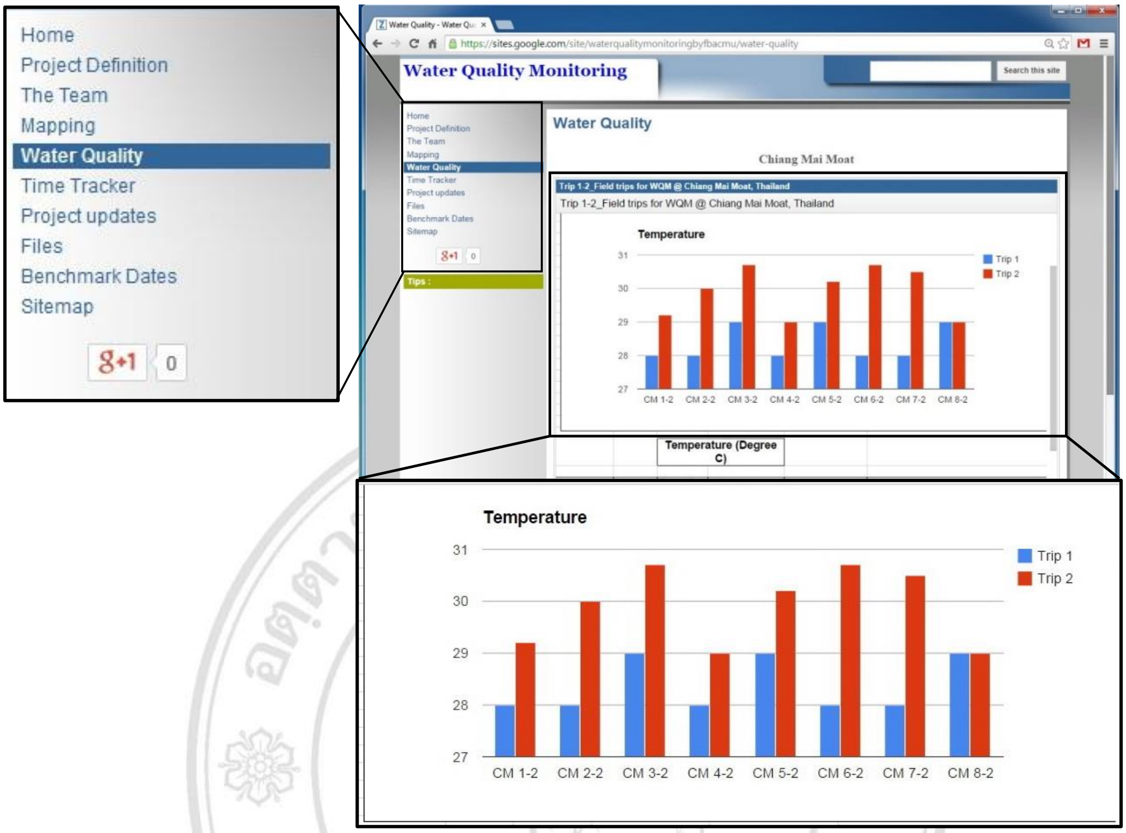


Figure 2.8 Display of the graph from cloud computing system of Spreadsheet, Google Docs

2.2.3 Evaluation of Packtest

The results of Packtest (Test kits) were evaluated by two methods; using eyes to compare the result color with a Packtest standard color chart and using software to analyze the result color and the standard chart. The Image J program [73] is a tool for measuring color value of the photo, the evaluation process is as follows:

In the laboratory, the optimum color values of Red (R), Green (G) and Blue (B) were studied beforehand due to difference in color of Packtest chemical reaction for each parameter. The color value of standard solutions at varied concentrations (as labelled on the standard chart color) was examined. The adjustment was made regarding light effect for the use on field trip (C1, C2, C3, Figure 2.9).

The Center Lab team can then evaluate the Packtest results by downloading photo from Picasa Web Album (B1-1-2, Figure 2.9). The color value of standard chart and the Packtest results were measured with program Image J (C4, C5, Figure 2.9). After that, it was proceeded into color adjustment process (C6, Figure 2.9) and evaluation process (C7, Figure 2.9) to calculate the concentration of sample. Then, the results were input onto Spreadsheet, Google Docs.

The developed evaluation methods were applied for determination of nitrate and phosphate.

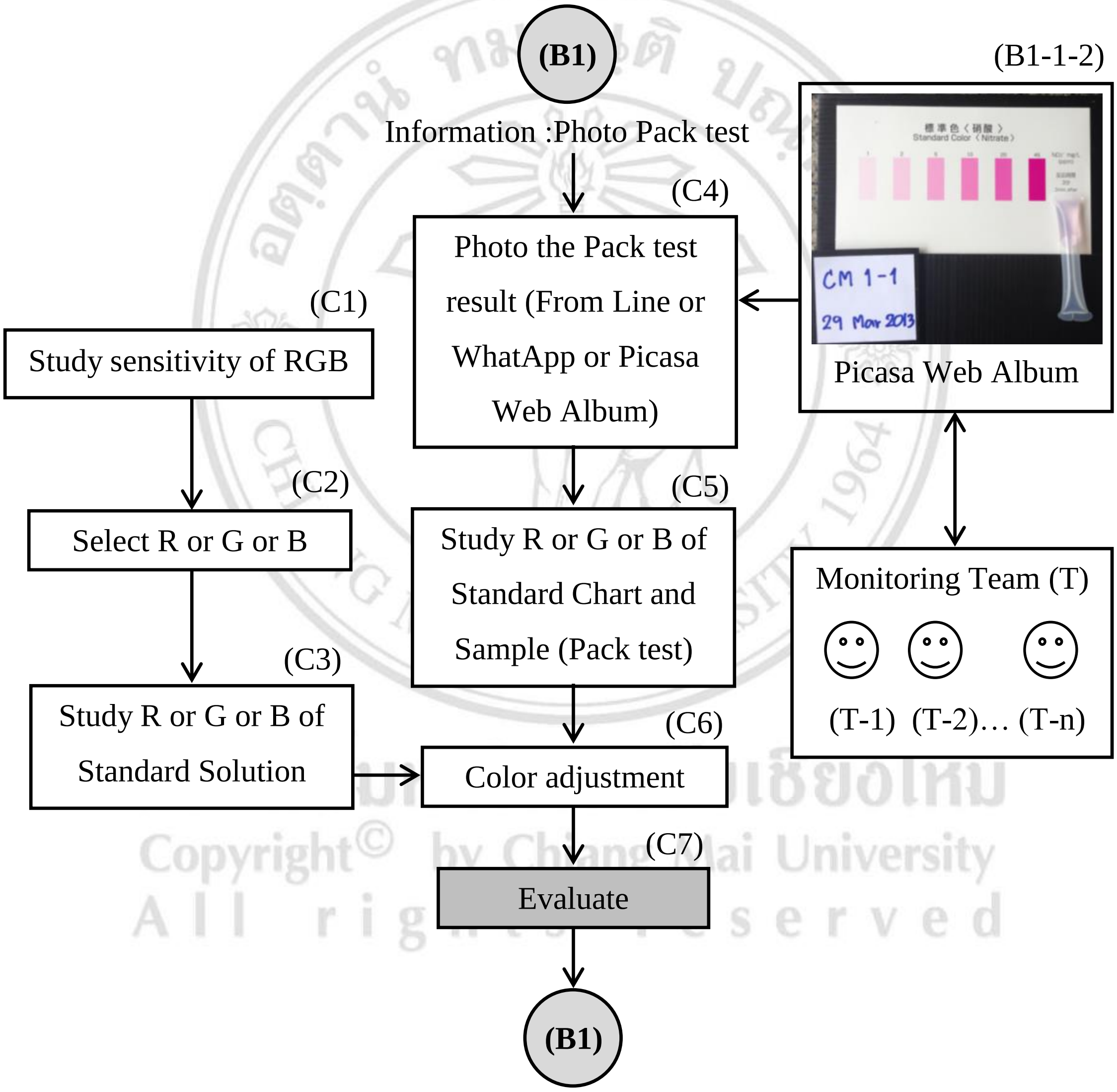


Figure 2.9 Process of evaluate Packtest

2.2.4 Data display

On the Website (https://sites.google.com/site/waterqualitymonitoringbyfbacmu/mapping), the webpage appearance will be divided into two parts: the left-hand side is the menu bar (D2-1-1, Figure 2.10) and the right-hand side is the display (D2-1, Figure 2.10). For example, by clicking title “Mapping” on the menu bar (D3-1-1, Figure 2.11), the mapping of sampling site will be shown on the right-hand side (D3-1, Figure 2.11), or by clicking title “Water Quality” on the menu bar (D4-1-1, Figure 2.12), the information of water quality will be shown on the right hand side (D4-1, Figure 2.12). A website created for collecting the water quality information together could promote the public access and help the water quality monitoring in real time or semi-real time.

On these website, administrator(s) can control user access to the information such as permission to access the photo information on Google Maps only or permission to access the detail like date, time, location, position on Google Maps and more details (B1-1-1, Figure 2.4). The website can also be set up for either ‘public’ or ‘only those with the link’ access.

(D2)

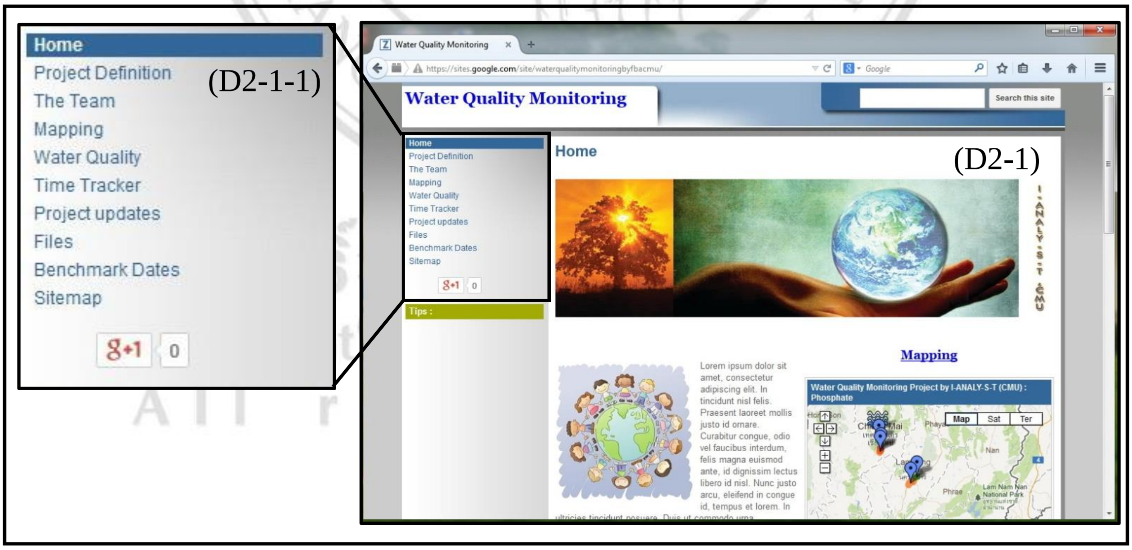


Figure 2.10 Website display main page of water quality monitoring

(D3)

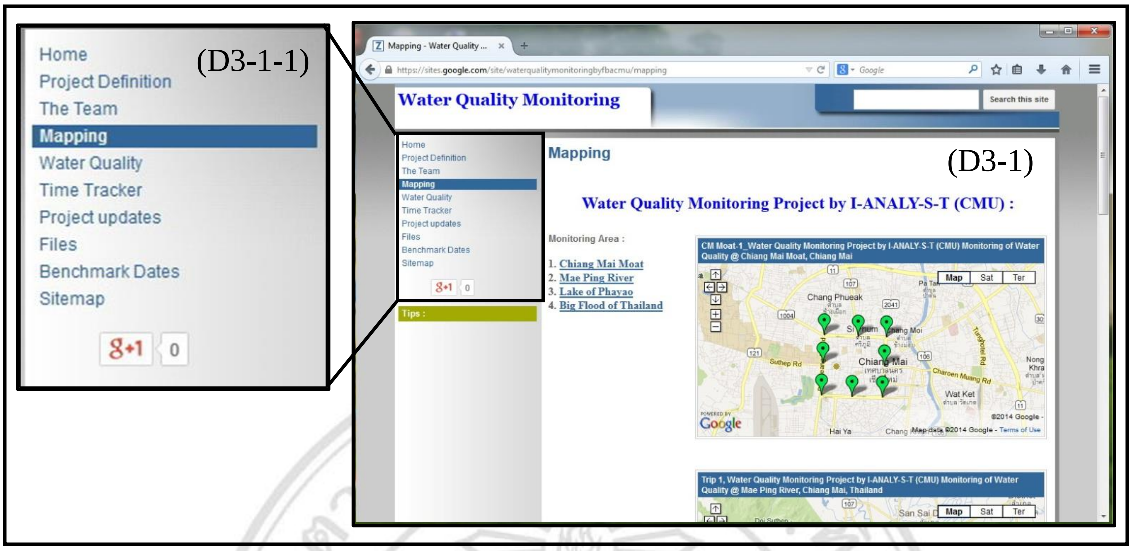


Figure 2.11 Website display mapping of sampling site on Google Maps

(D4)

Figure 2.12 Website display information of water quality

This website has been developed by the application of Google Site which can link and display information from other Google service such as Google Maps containing the mapping of sampling sites and the water quality information both texts and photos (D3, Figure 2.11), Spreadsheet of Google Docs (Document, Presentation, Draw, Form and More) containing the information of both result values and graphs for each parameter (D4, Figure 2.12) and Google Drive containing VDO Clip of environment and location of the sampling sites (B2-1, Figure 2.6).

Mapping of sampling site could be created on Google Maps in the process of operation planning beforehand (details in 2.2.5). After monitoring of water quality at each sampling site, the information both text and photos will be uploaded. The photos will be linked from Picasa Web Album. By clicking on the photo, more details can be viewed on Picasa Web Album. This process was done before linked to Google Site (D1, Figure 2-13) (details in 2.2.4).

Figure 2.14 shows functional design and structural components of the system. The process of information linking from Google Maps, Google Docs and Google Drive on the website are as follows.

(D1)

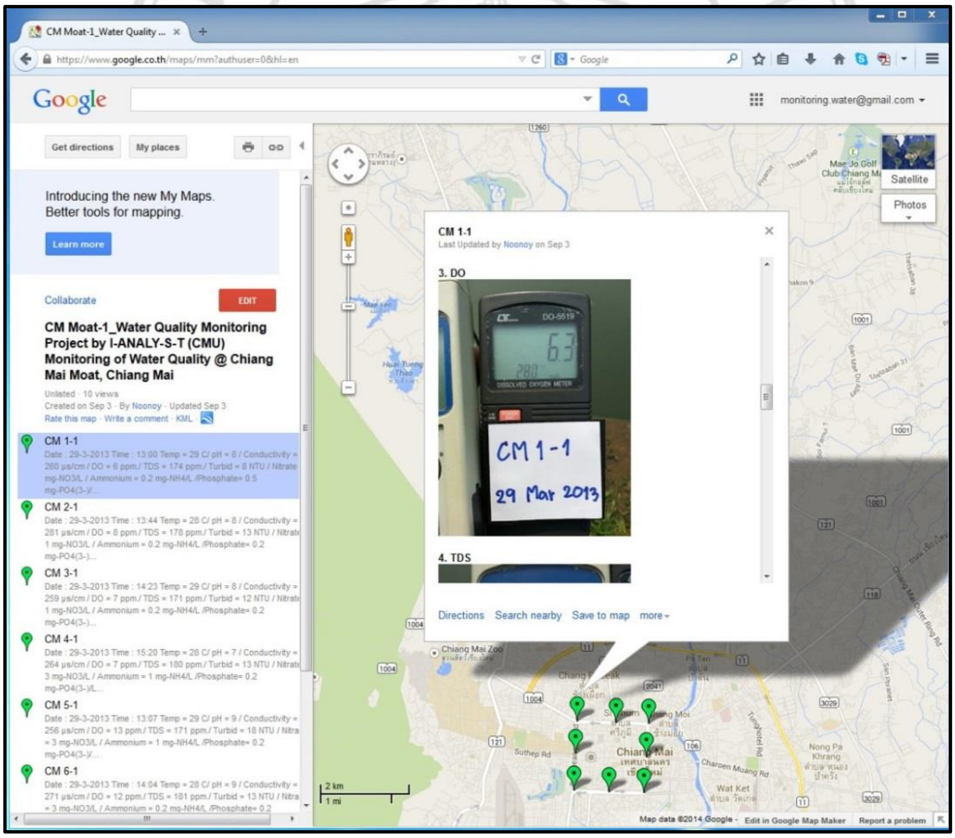


Figure 2.13 Website display information on Google Maps

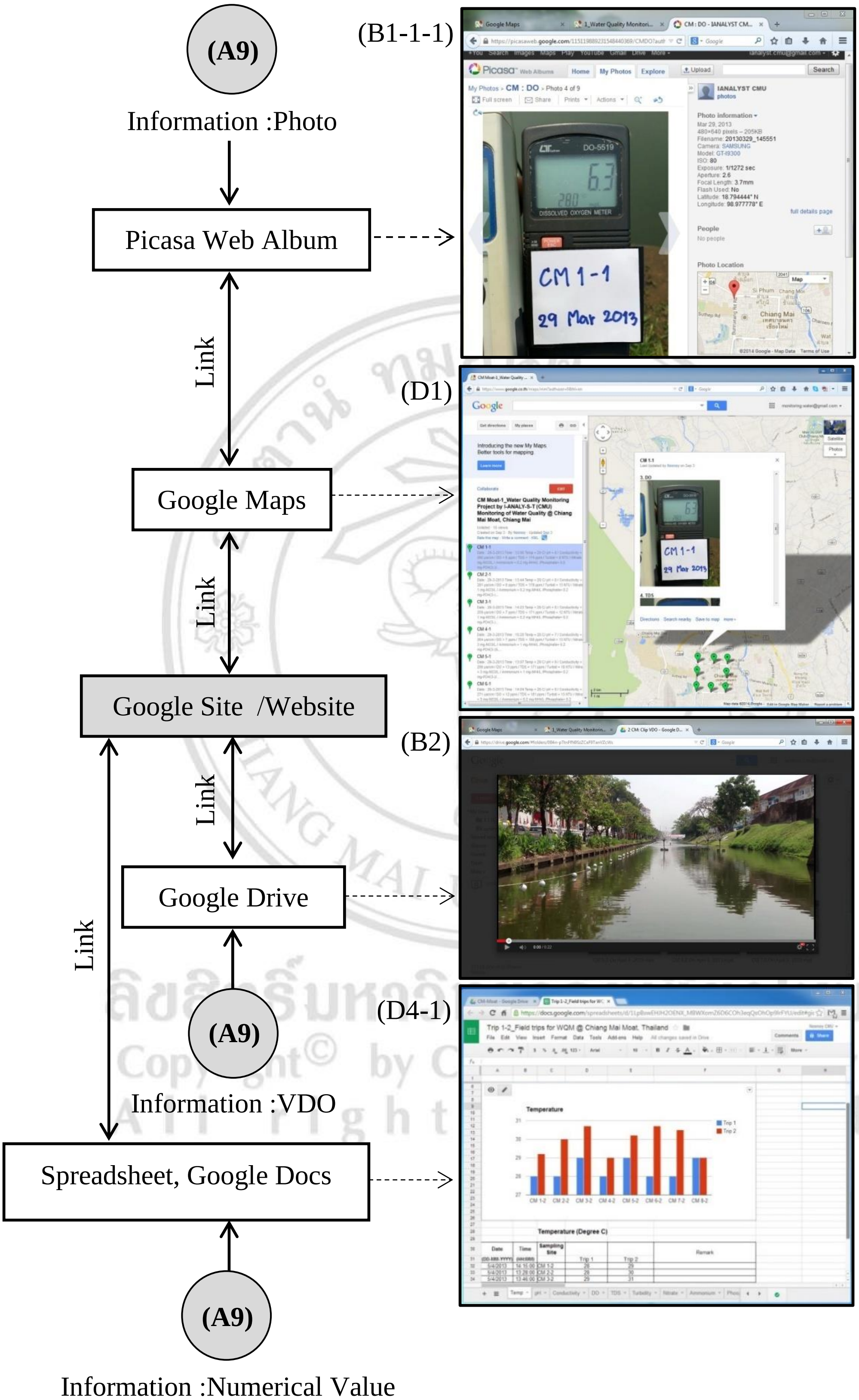


Figure 2.14 Functional design and structural components of the system

1) Example of linking photo information from Picasa Web Album to display on Google Maps. (only Google Maps and Picasa Web Album will be explained in this process).

1.1) After login to Google Service, go to Google Maps. After that, click on  and select My Places to create mapping (Figure 2.15).

1.2) Select 

to create new maps (Figure 2.16) and then change to new webpage to fill details of maps (Figure 2.17).

1.3) Select  to add a placemark on Google Maps (Figure 2-18).

1.4) Click  on the Google Maps, the box for adding information will appear. Text can be input and photo can be linked from Picasa Web Album (Figure 2.19).

1.5) Linking photo from Picasa Web Album to show in box of  on Google Maps by go to Picasa Web Album and choose the photo (Figure 2.20).

1.6) Copy link of photo by following steps in Figure 2.21.

1.7) In the box of  click icon  (Insert Image) and then massage box for pasting link will appear from 2.2.4.1.6 (Figure 2.22).

1.8) After that, click Done. The photo will be shown on Google Maps (Figure 2.23).

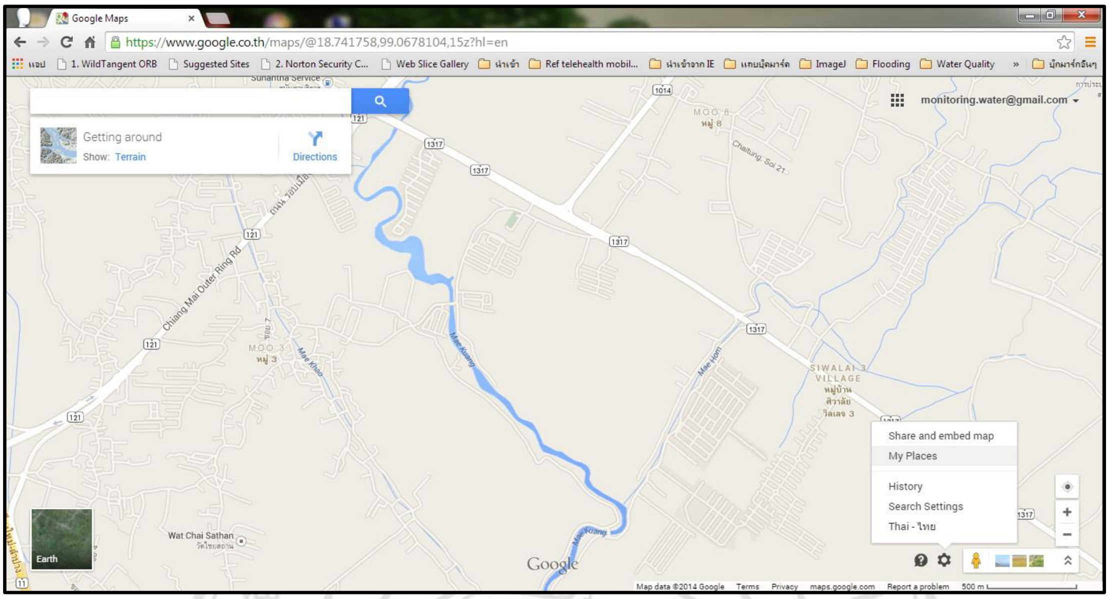


Figure 2.15 Google Maps and how to access to My Places

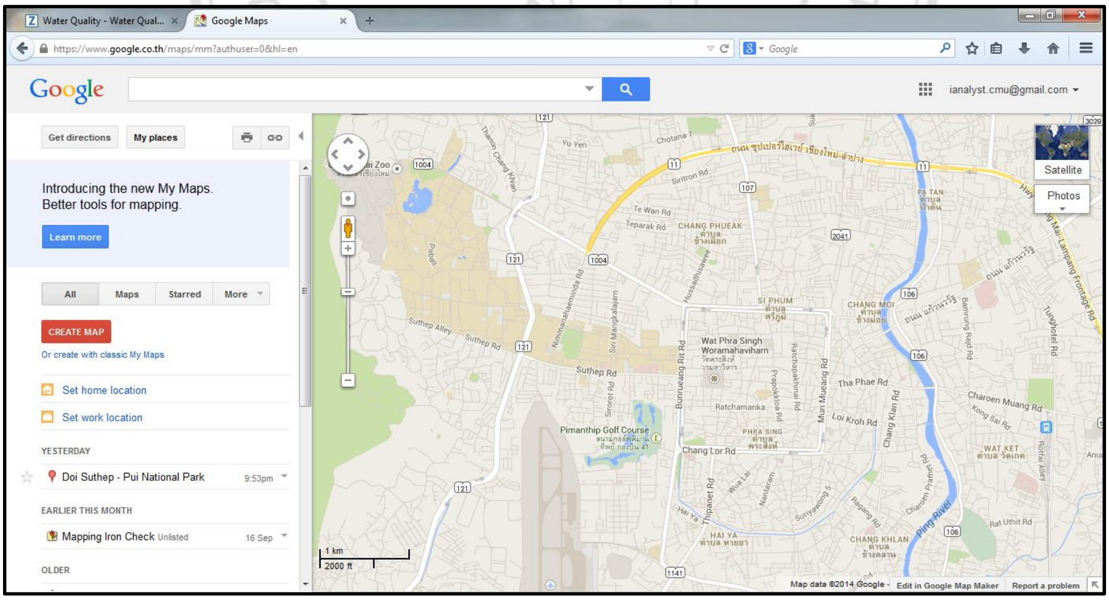


Figure 2.16 Create a new map

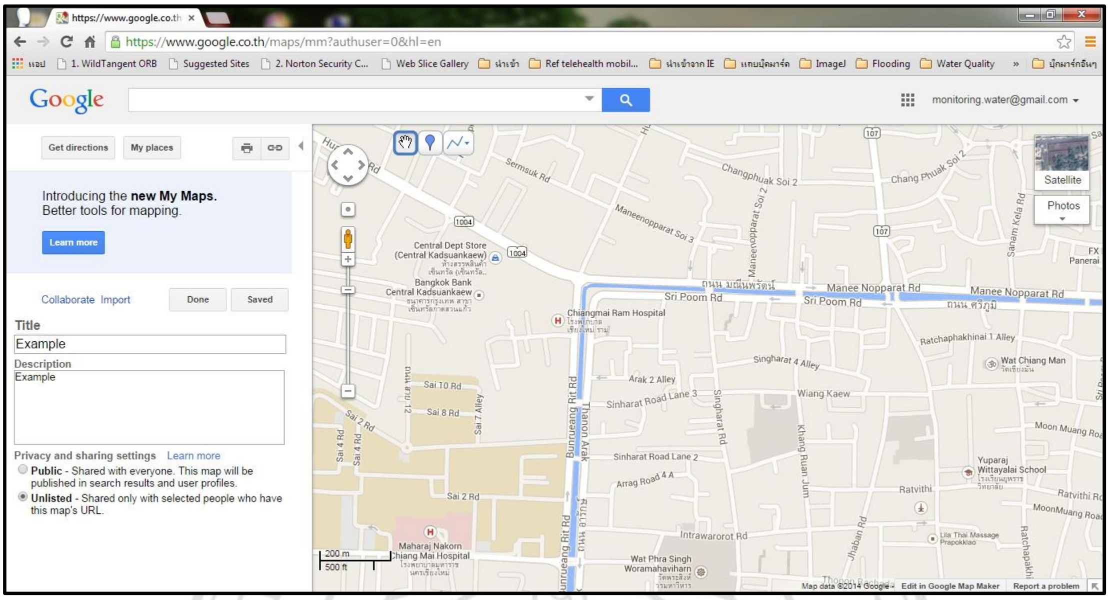


Figure 2.17 Enter the name and details of the new map

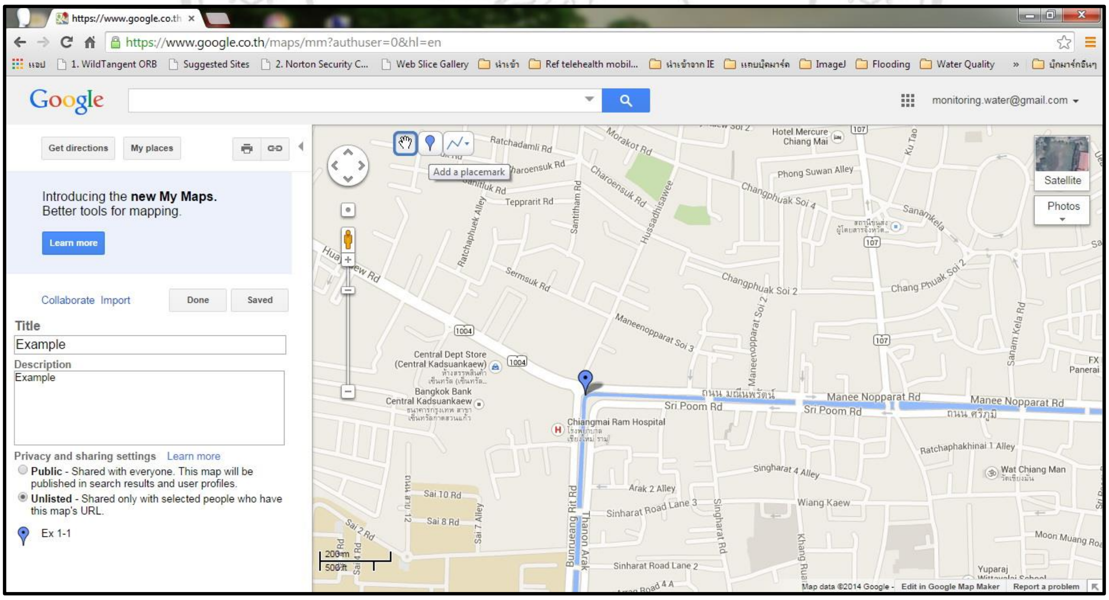


Figure 2.18 Add place mark on the map

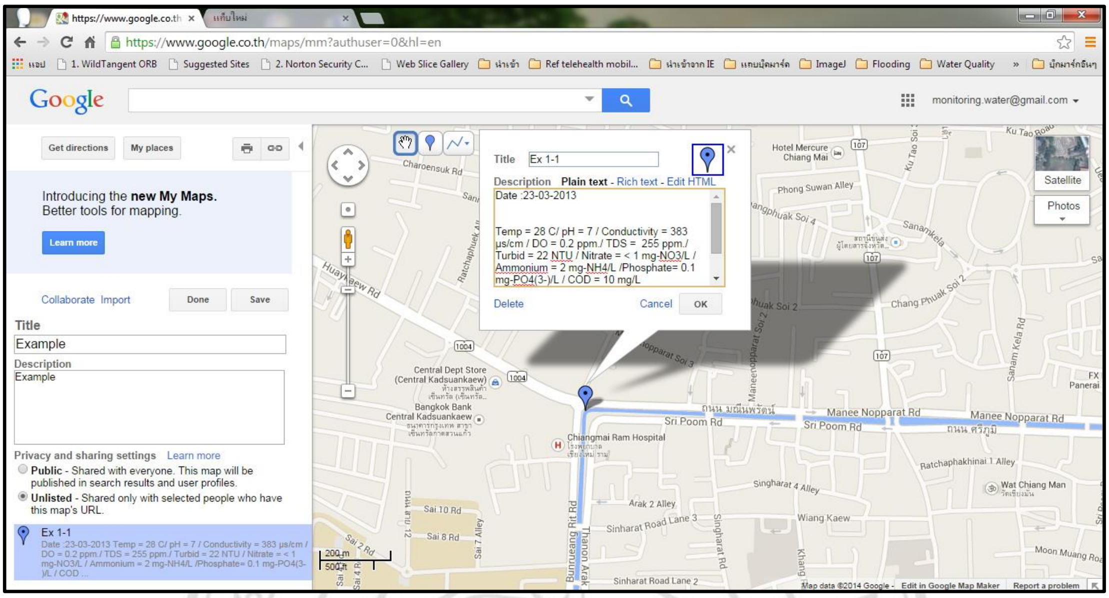


Figure 2.19 Add details in the box of the place mark

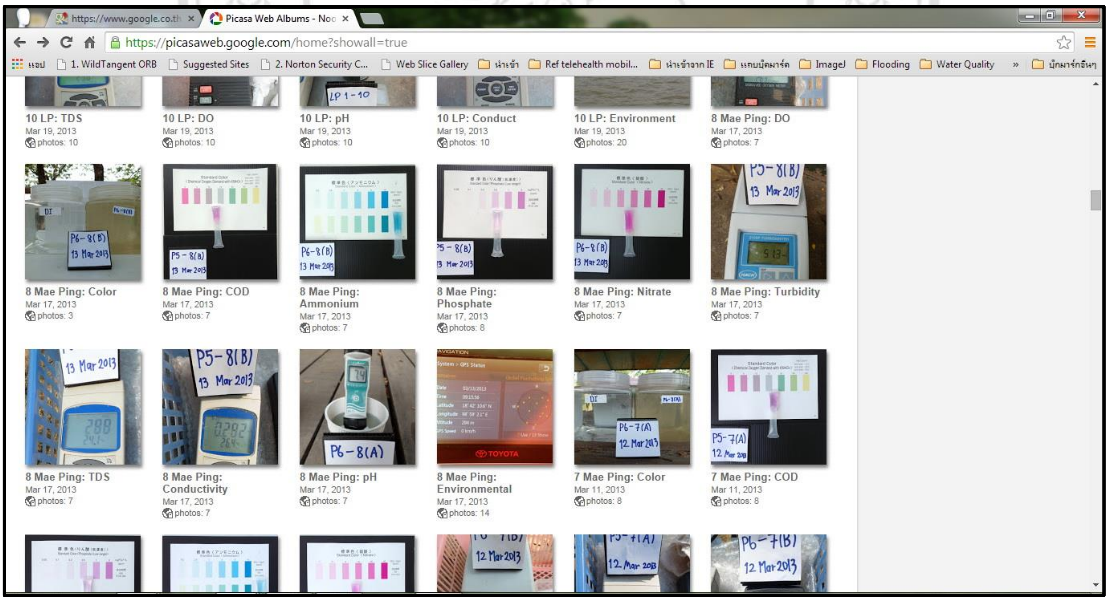


Figure 2.20 Photo storage on Picasa Web Album

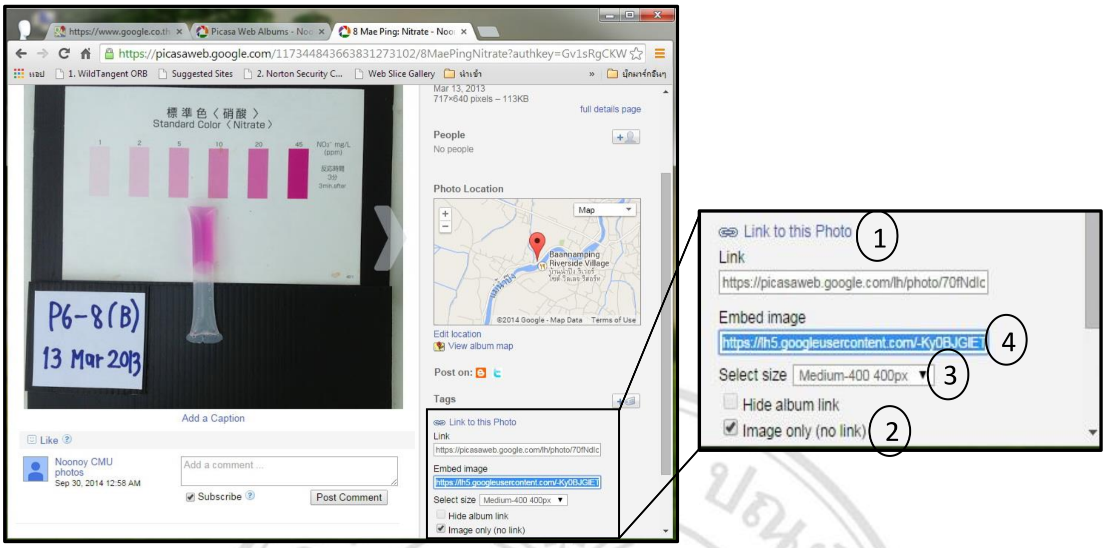


Figure 2.21 Generate a link on Picasa Web Album for linking to Google Maps

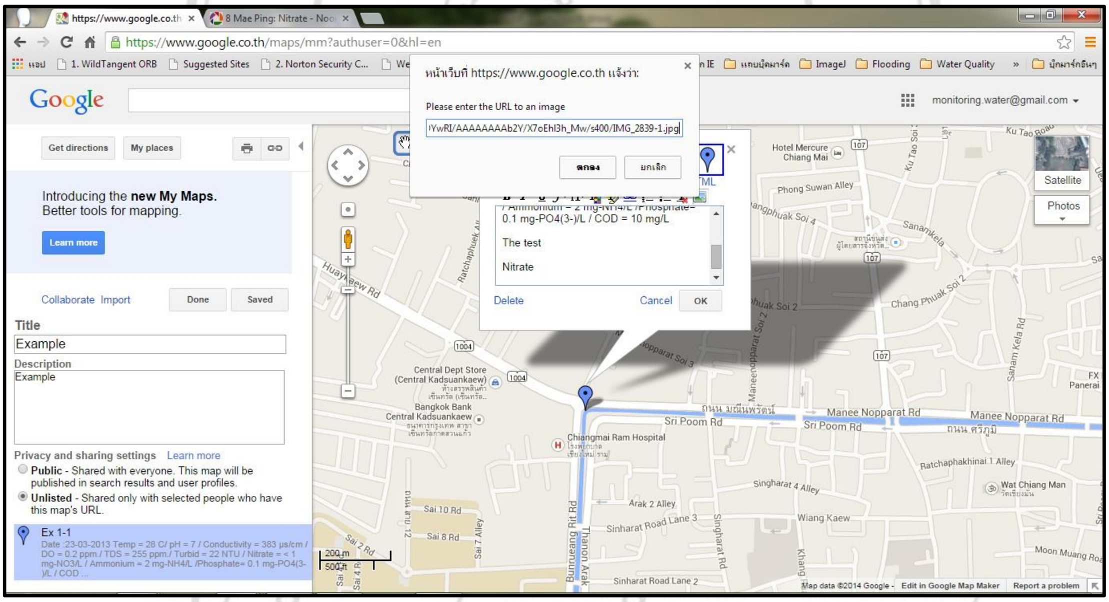


Figure 2.22 Copy link from Picasa Web Album and past on the box of place mark in Google Maps

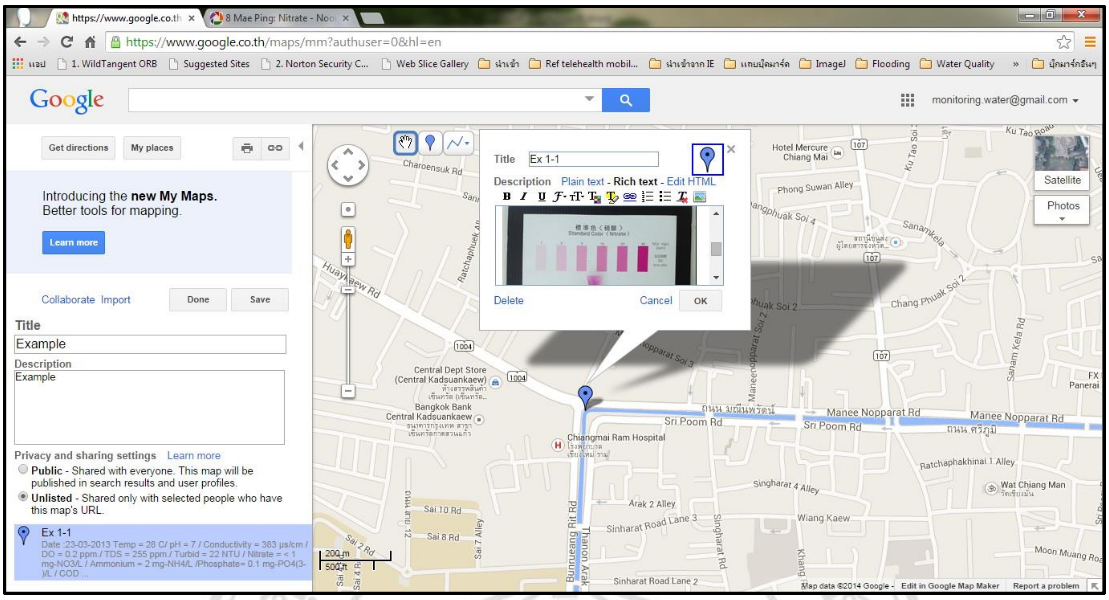


Figure 2.23 Photo shown on Google Maps

2) Example of linking Google Maps to display on the website.

2.1) After login to Google Site, create a new webpage to display Google Maps by click on  (Figure 2.24).

2.2) Enter the name of webpage (Figure 2.25), after that click on 

new webpage will appear to display information (Figure 2.26).

2.3) Linking Google Maps by go to insert menu and then choose Map (Figure 2.27).

2.4) In the box, select My Maps in title bar and a list of map will appear. After that, choose the map and click select (Figure 2.28).

2.5) Setting box will appear, and then click save, draft and detail of information will be showed on webpage (Figure 2.30).

2.6) After save on webpage, mapping of sampling site which linked to Google Maps will be displayed (Figure 2.31)

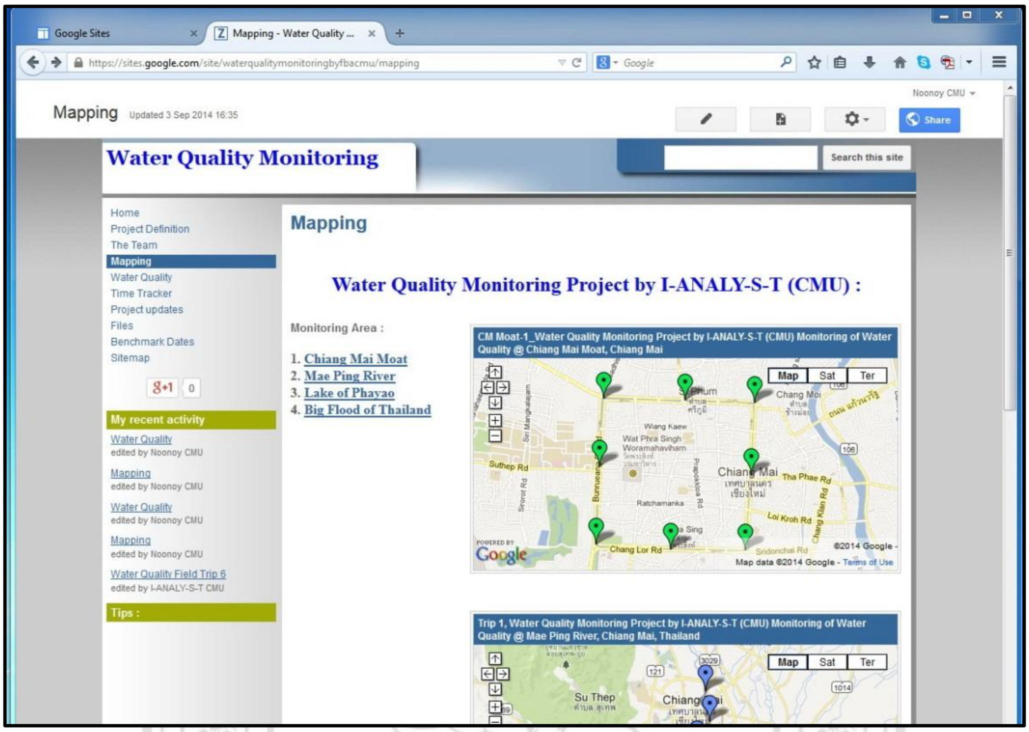


Figure 2.24 Example display of edit website

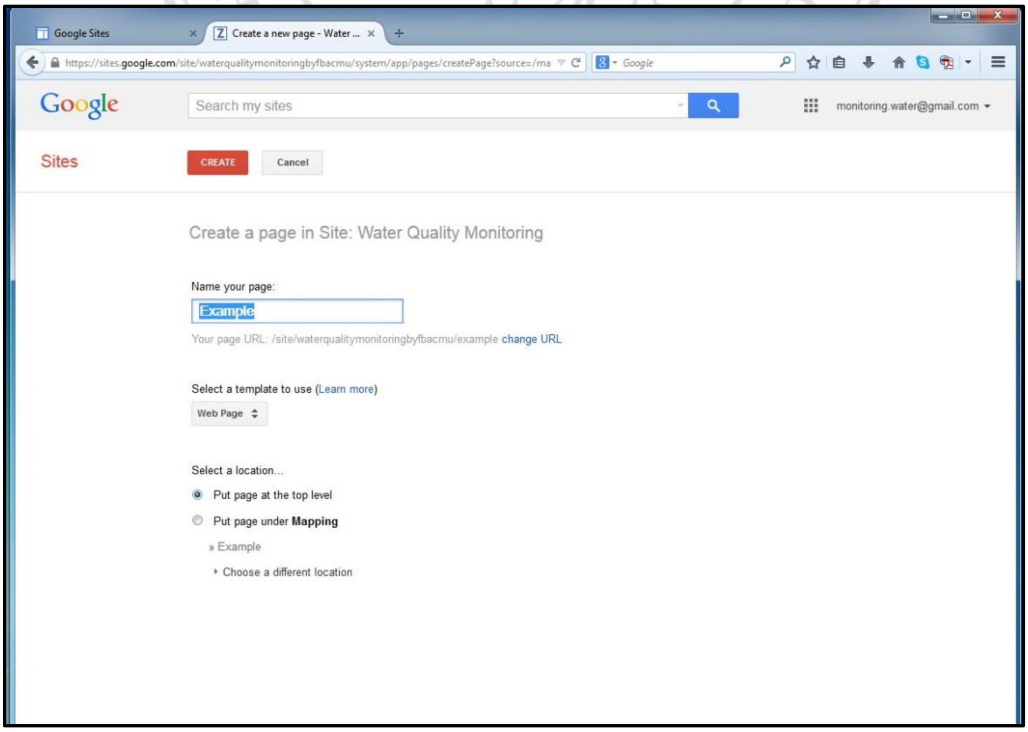


Figure 2.25 Create a new webpage

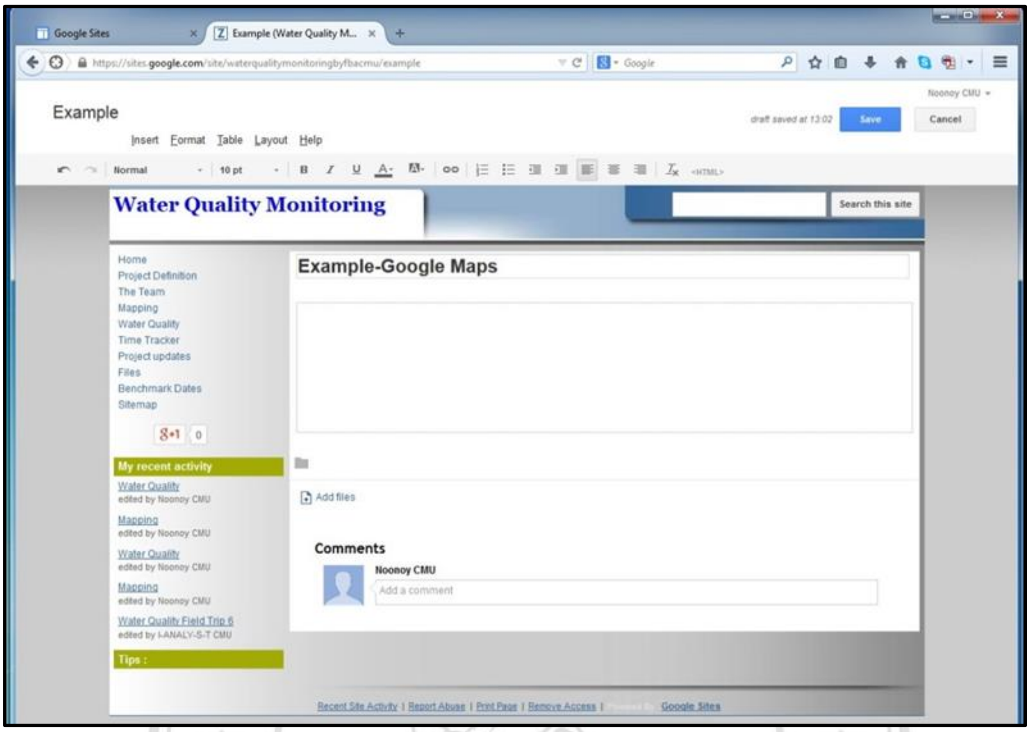


Figure 2.26 New webpage to display information

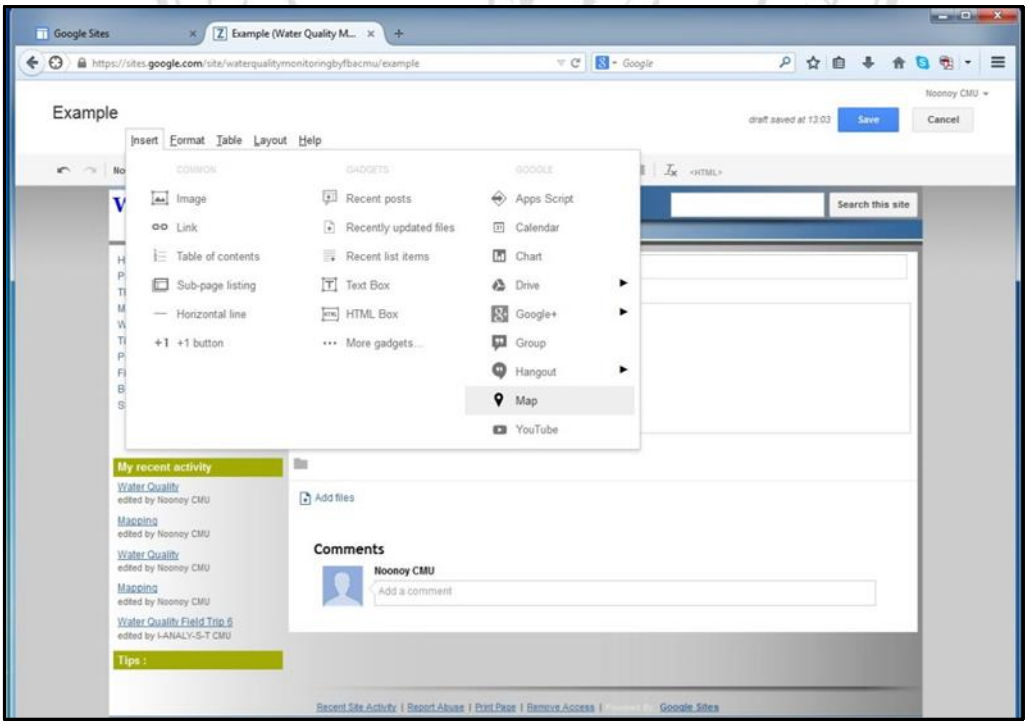


Figure 2.27 Insert Google Maps to display on webpage

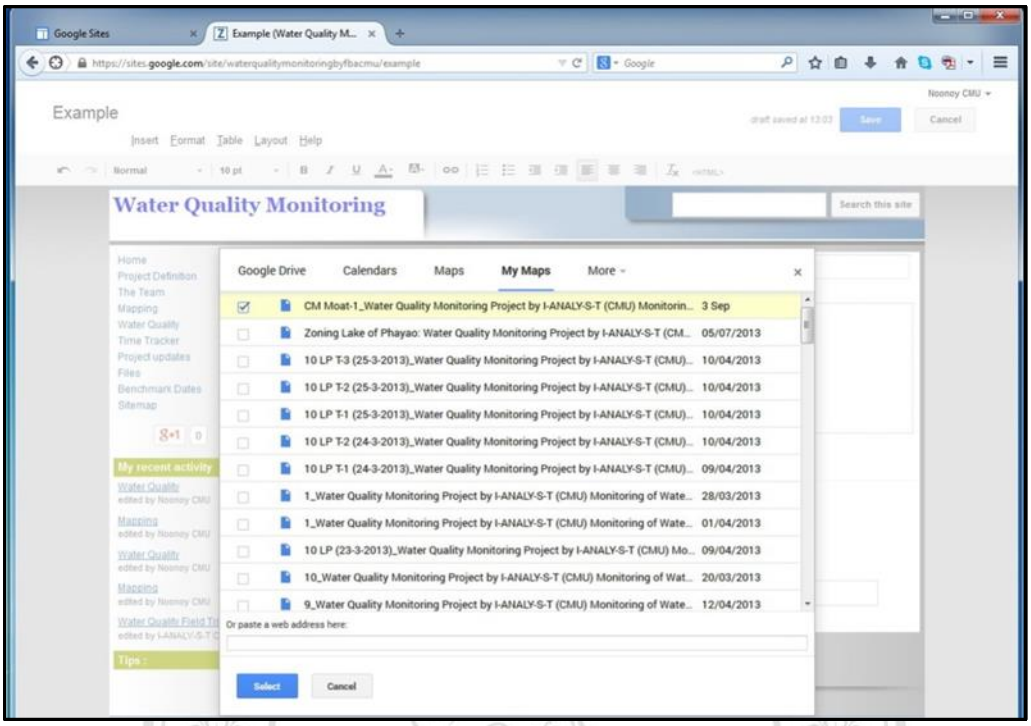


Figure 2.28 Choose the map created on Google Maps

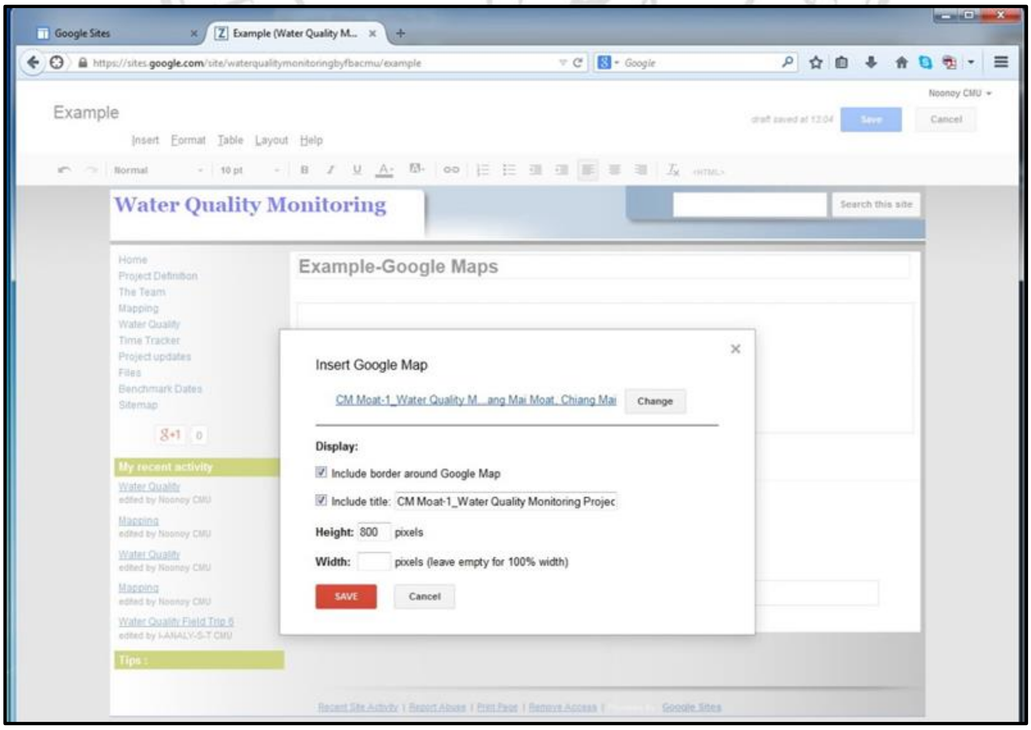


Figure 2.29 Setting box of display

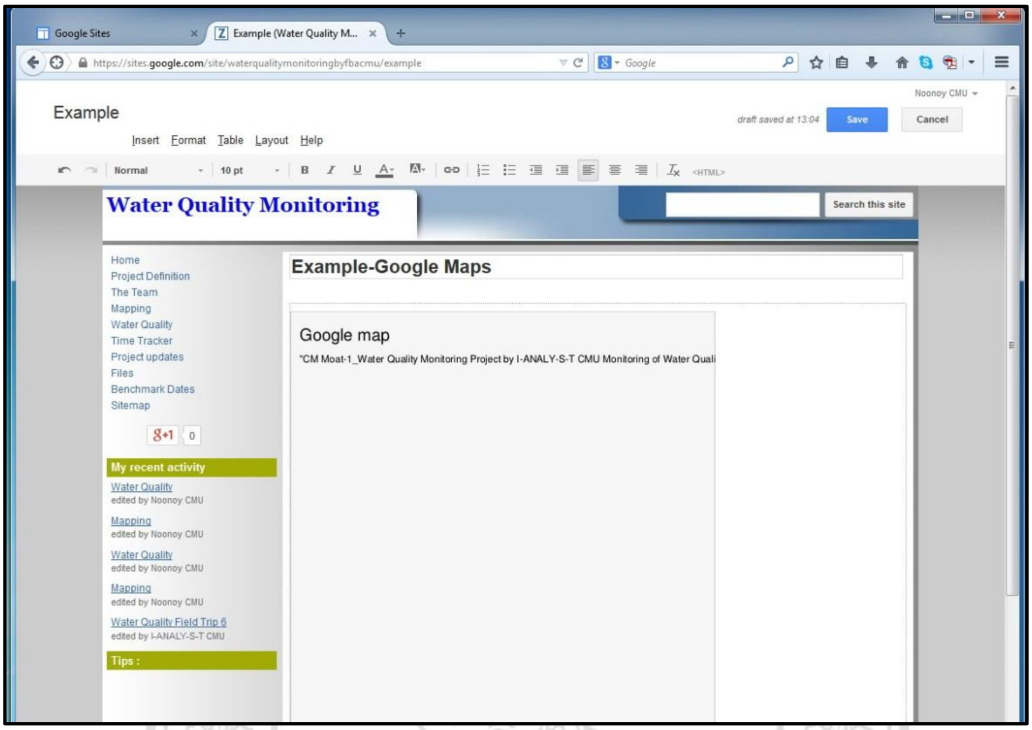


Figure 2.30 Draft and detail of information for display

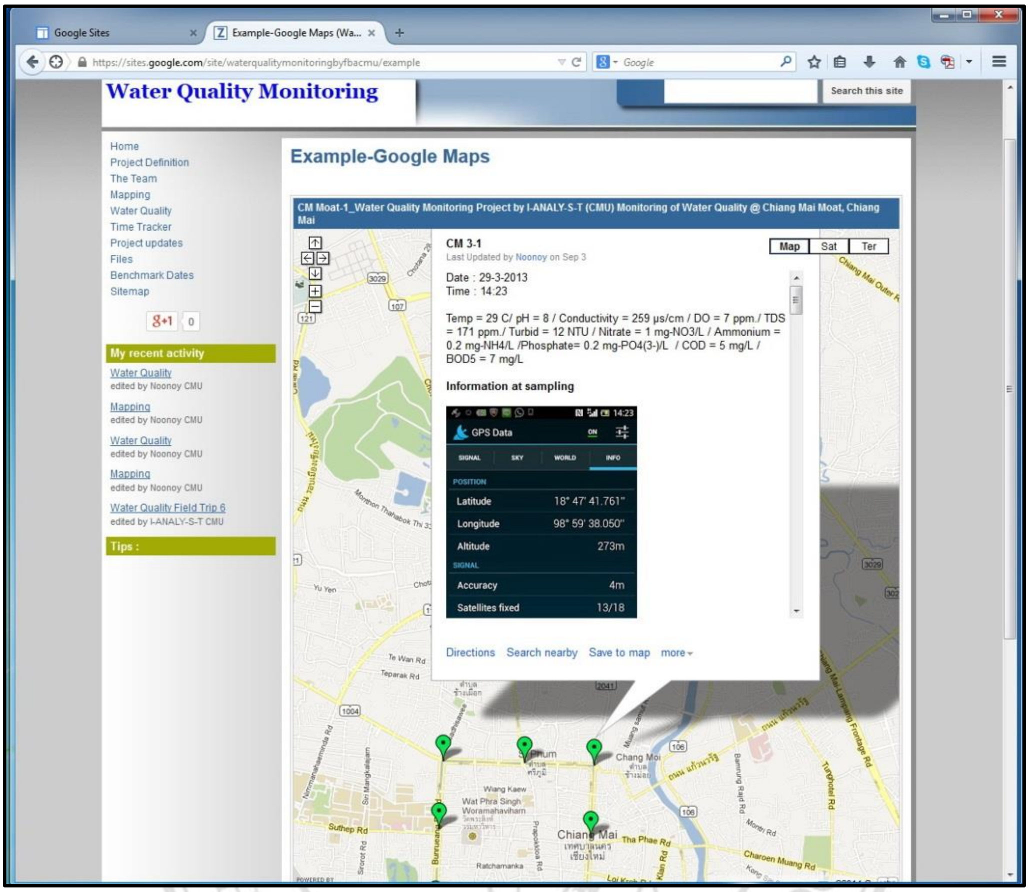


Figure 2.31 Sampling site and information on Google Maps displayed on webpage

3) Example of linking VDO Clip on Google Drive to display on Website.

3.1) After create a new webpage (Figure 2.32) create a link of VDO clip on Google Drive by go to insert menu and select Drive. After that, files of all format will appear (Document, Drawing, Folder, Form, Image, Presentation, Spreadsheet and Video), select Video (Figure 2.33).

3.2) In the box of Google Drive, select VDO clip to display on webpage and click Select (Figure 2.34).

3.3) Setting box will appear, and then click save, draft and detail of information will be shown on webpage (Figure 2.36).

3.4) Finally click save webpage, VDO will be displayed on the webpage (Figure 2.37).

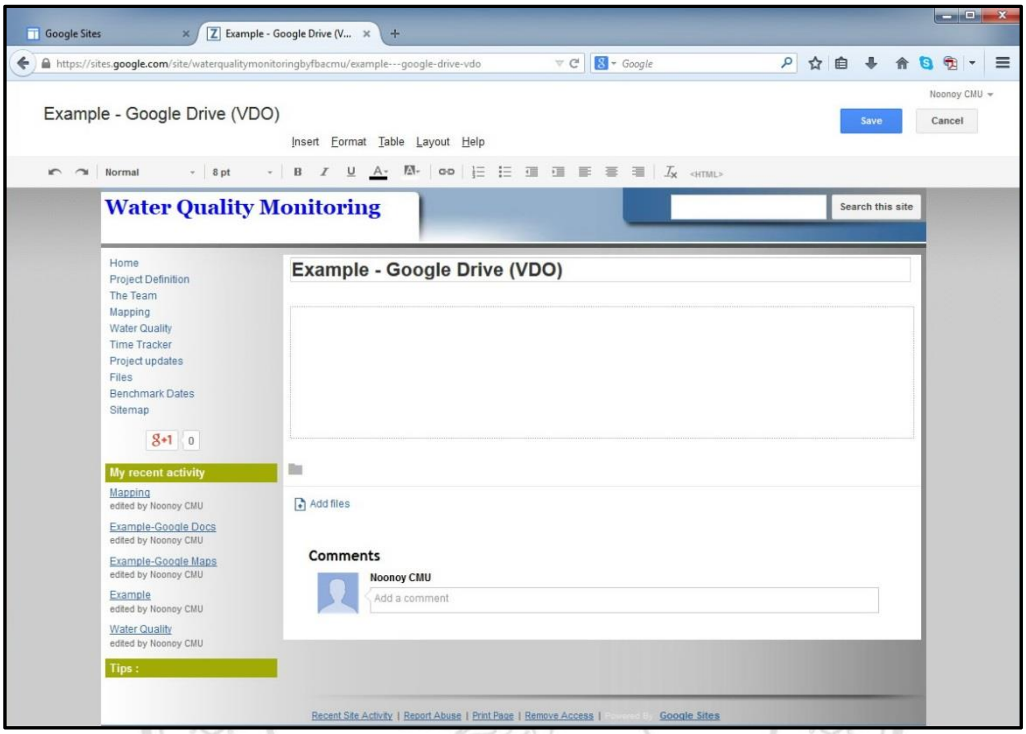


Figure 2.32 Webpage to display information

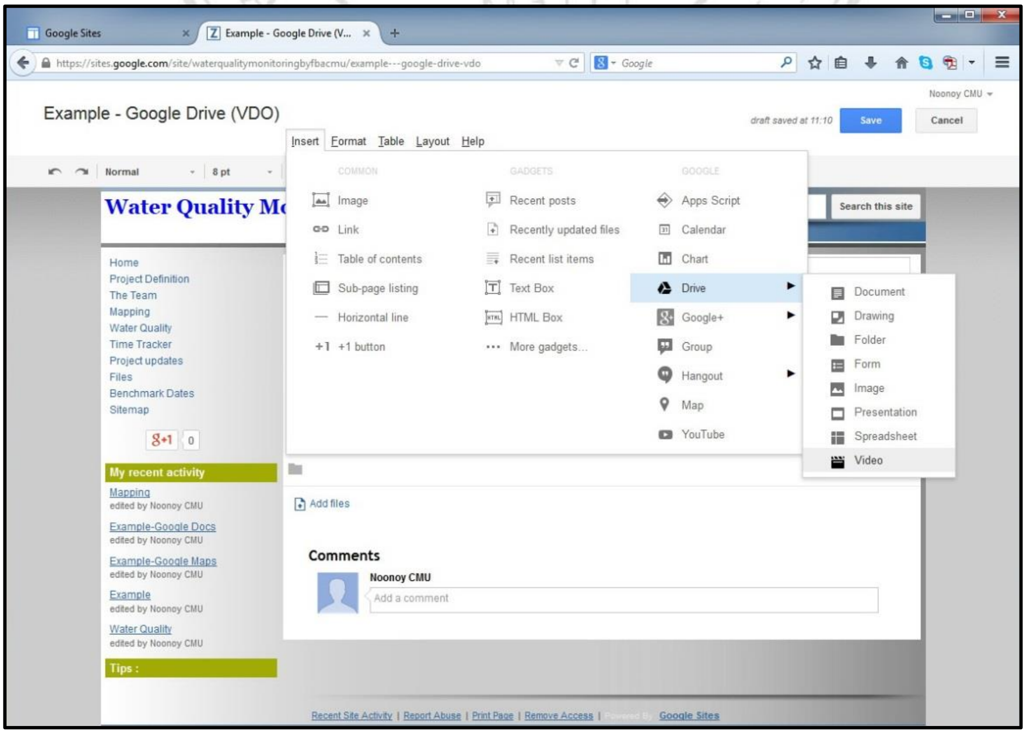


Figure 2.33 Insert video from Google Drive to display on webpage

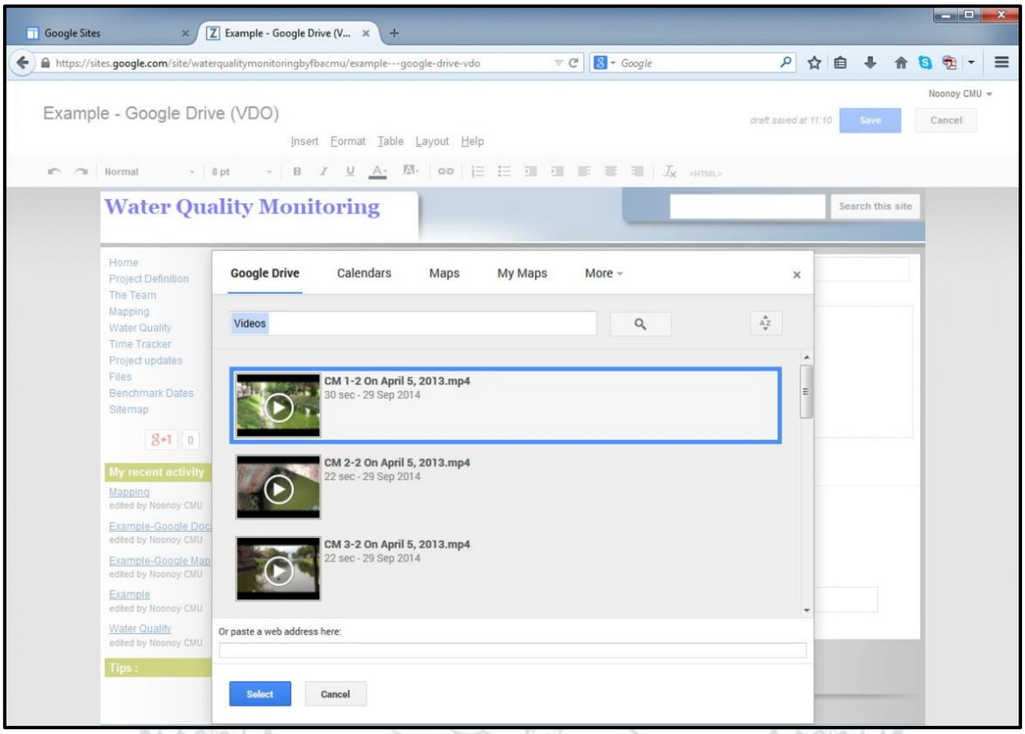


Figure 2.34 Choose video clip on Google Drive to display on webpage

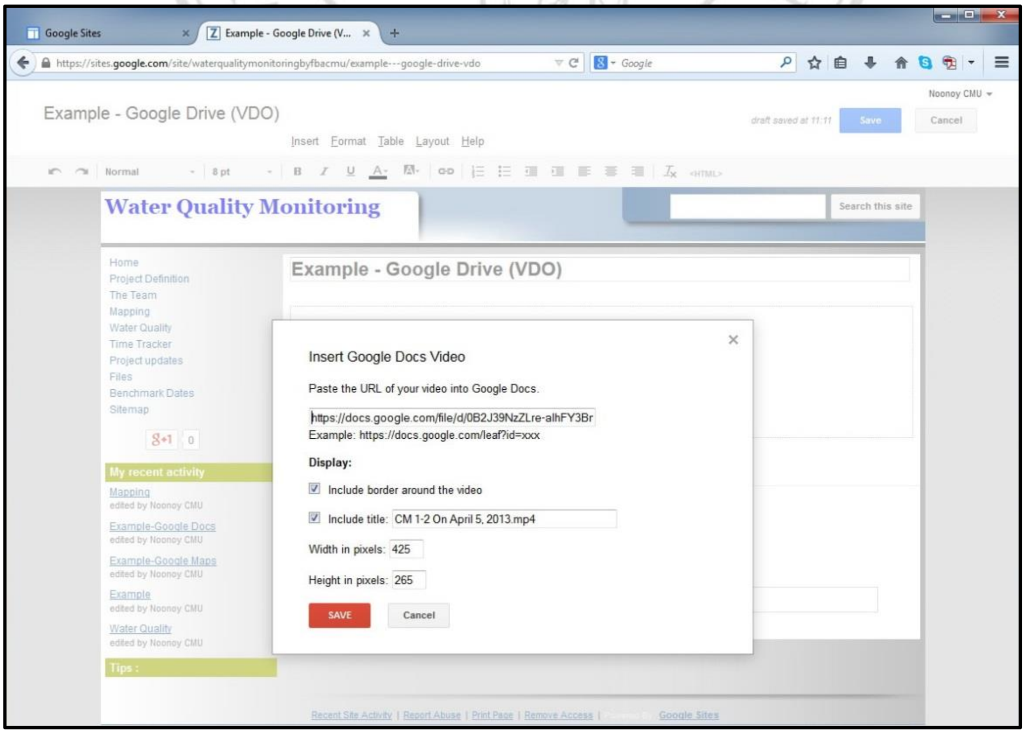


Figure 2.35 Setting box of display

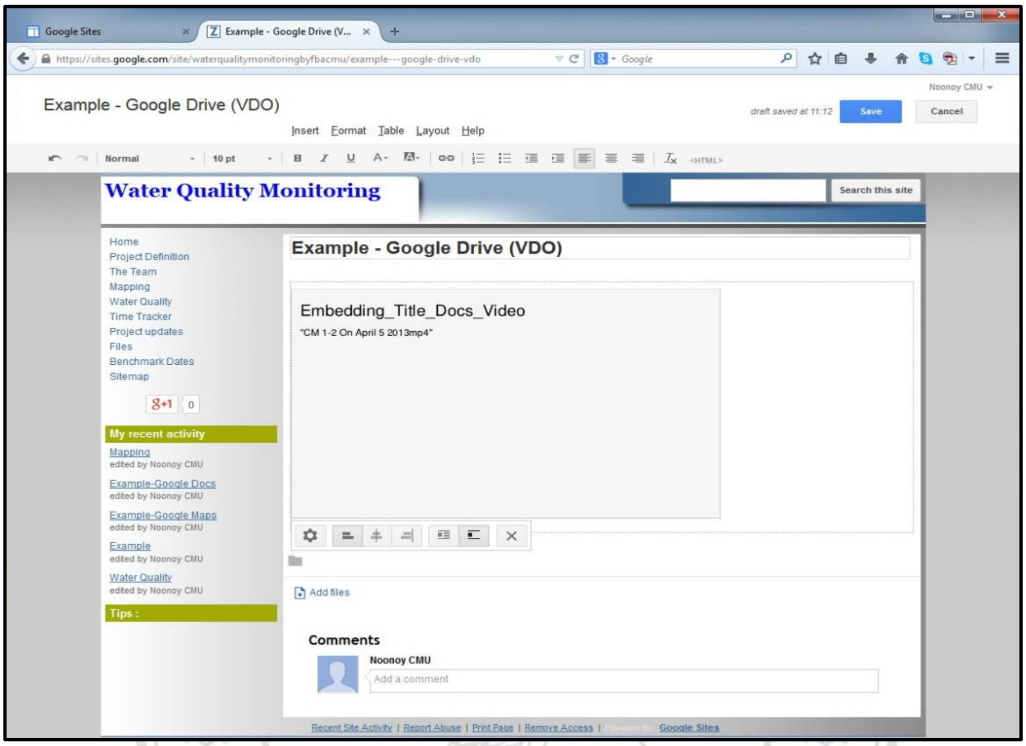


Figure 2.36 Draft and details of information for display

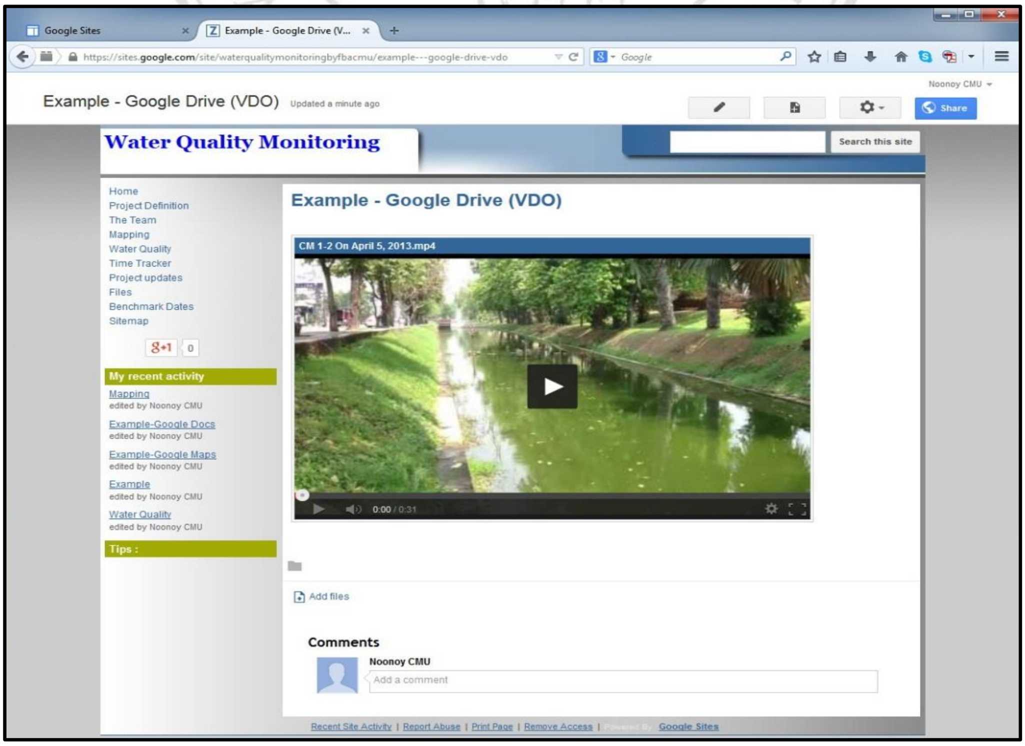


Figure 2.37 VDO clip displayed on website

4) Example of linking Spreadsheet, Google Docs to display on webpage.

4.1) After created a new webpage (Figure 2.38), linking information from Google Docs on Google Drive by select insert menu and select Drive, After that, files of all format will appear (Document, Drawing, Folder, Form, Image, Presentation, Spreadsheet and Video), select Spreadsheet (Figure 2.39).

4.2) In the box of Google Drive, choose the spreadsheet file to display on the webpage and click Select (Figure 2.40).

4.3) Setting box will appear (Figure 2.41), and then click save, draft and detail of information will be shown on the webpage (Figure 2.42).

4.4) Finally click save of webpage, information of spreadsheet will be displayed on webpage (Figure 2.43).

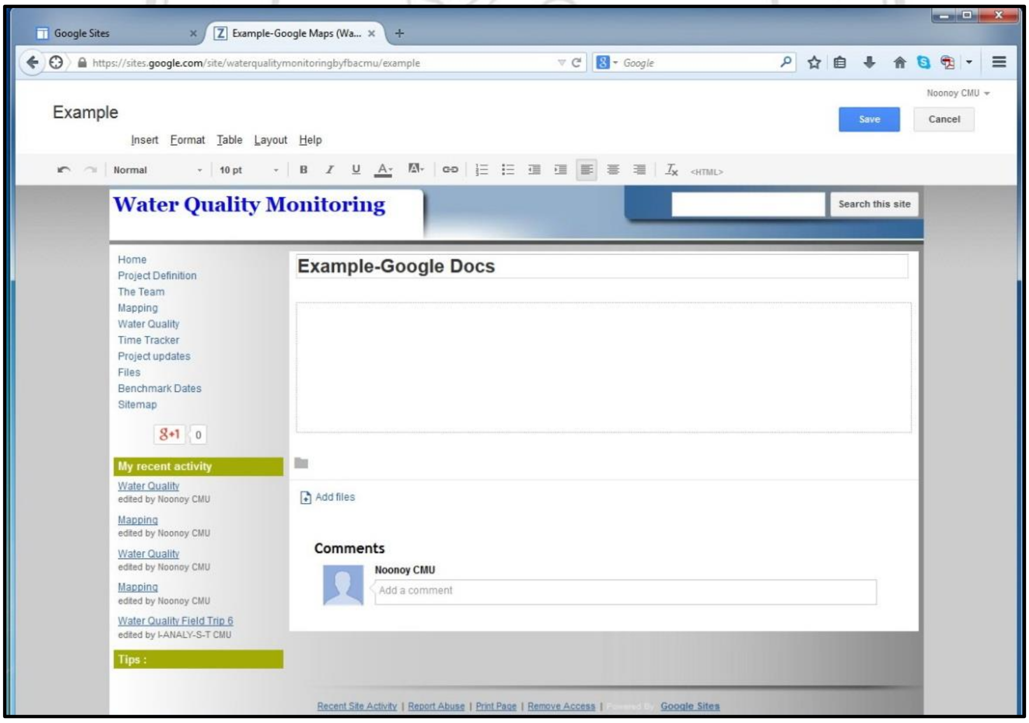


Figure 2.38 Create a new webpage to display information

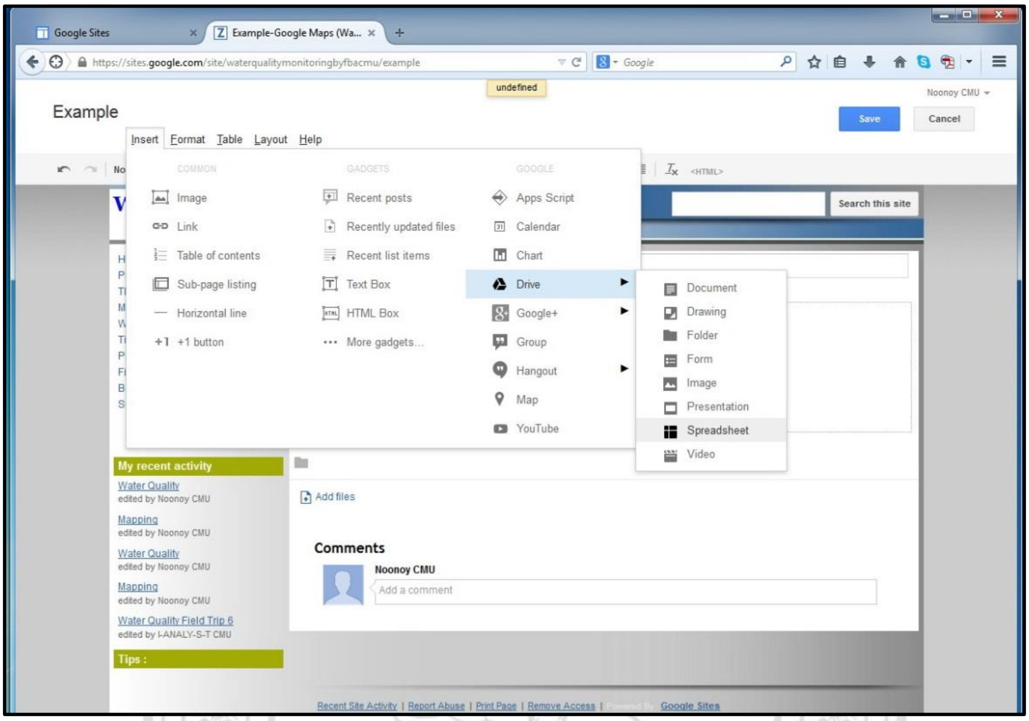


Figure 2.39 Insert Spreadsheet from Google Drive to display on webpage

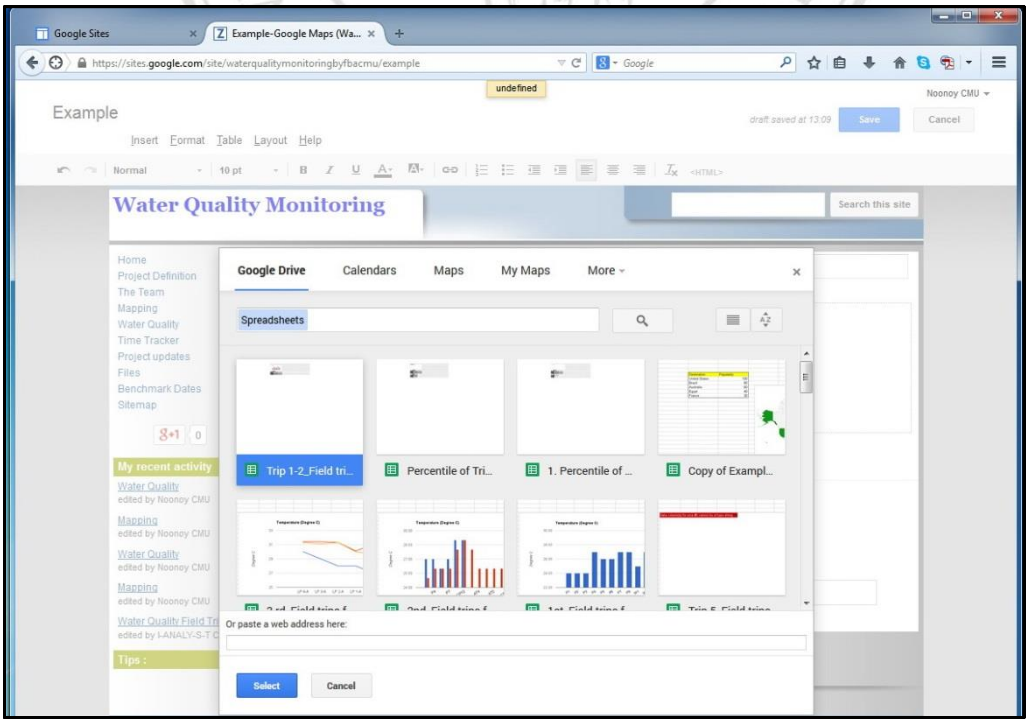


Figure 2.40 Choose Spreadsheet from Google Drive to display on webpage

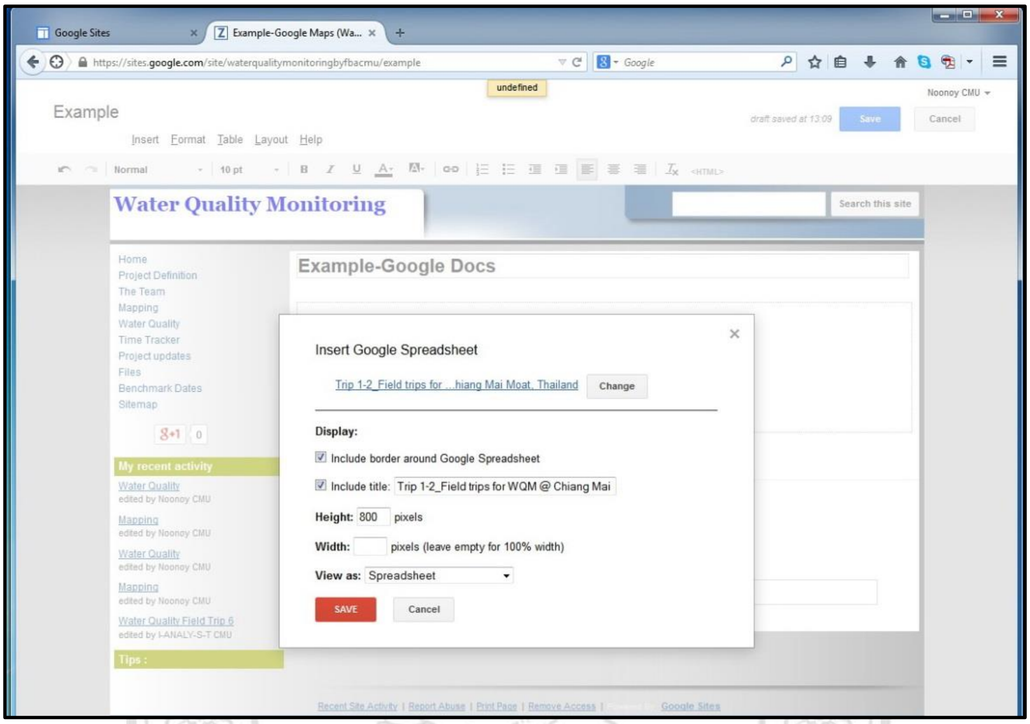


Figure 2.41 Setting box of display

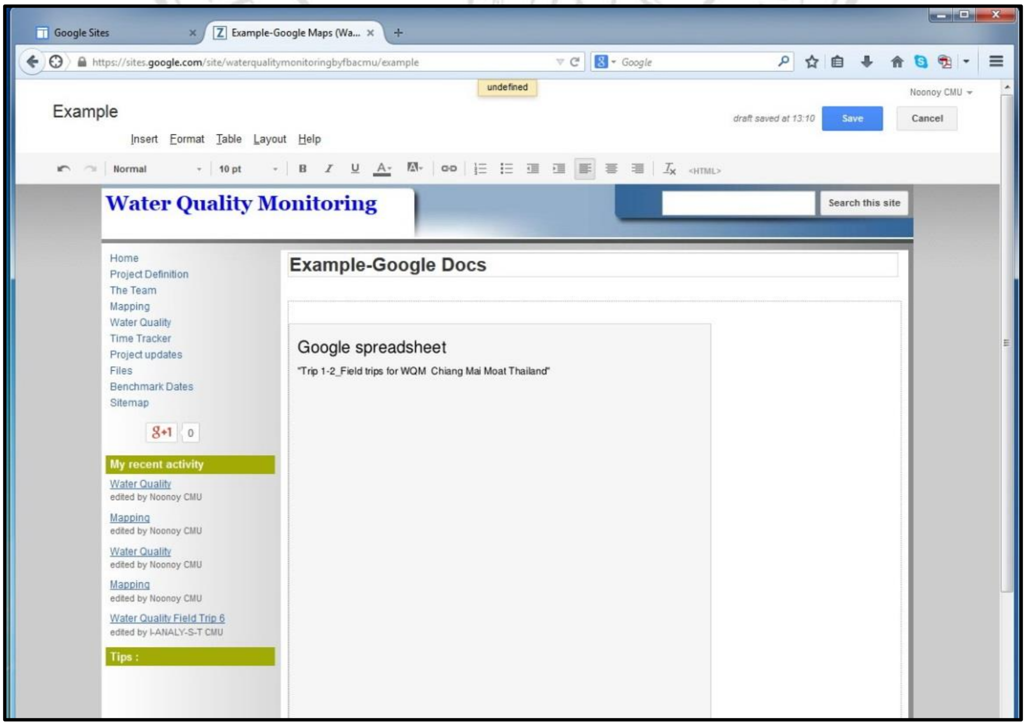


Figure 2.42 Draft and details of information to display

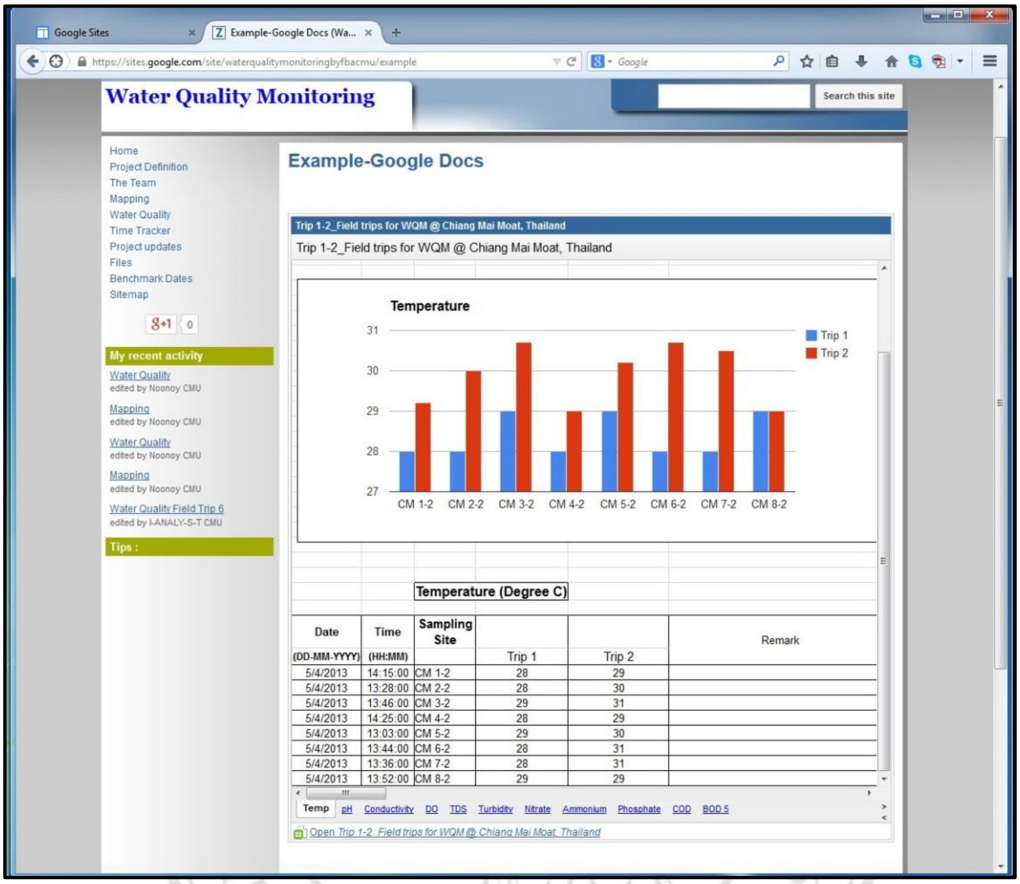


Figure 2.43 Spreadsheet displayed on website

2.2.5 The process of operation planning

In this study, operation planning needs to be done first prior to monitoring of water quality at each sampling site. Google Earth and/or Google Maps are important tools for the sampling site survey. It can show the surrounding and physical appearance of the study area such as which direction a river flows (P1-1 and P1-2, Figure 44), where it flows through (agriculture, urban, dam and weir), or any exploitation of water resources (aquaculture or tourism) etc. (P1-3, Figure 2.44). In addition, Google Earth and Google Maps can display Street View that overlooks the area (P1-4, Figure 2.44). It is very useful in planning the work to collect sample and measurement, help provision of the necessary equipment to work, choose the transport route and so on. These will help the monitoring team to work safely and quickly [6]. After selected the sampling site and added the placemark (details in 2.2.4) on Google Earth and/or Google Maps (P2, Figure 2.44), that latitude and longitude coordinates of the sampling site will be saved into the GPS navigator (P3-1, Figure 2.44).

Also, application Google Maps can be used on a smart phone for navigation to each of the sampling site (P3-2, Figure 2.44).

In the process of planning, the team can use the Skype and/or TeamViewer to communicate with the other team at different place or countries to plan a work together. It can help to share information to save time and lower overall cost.

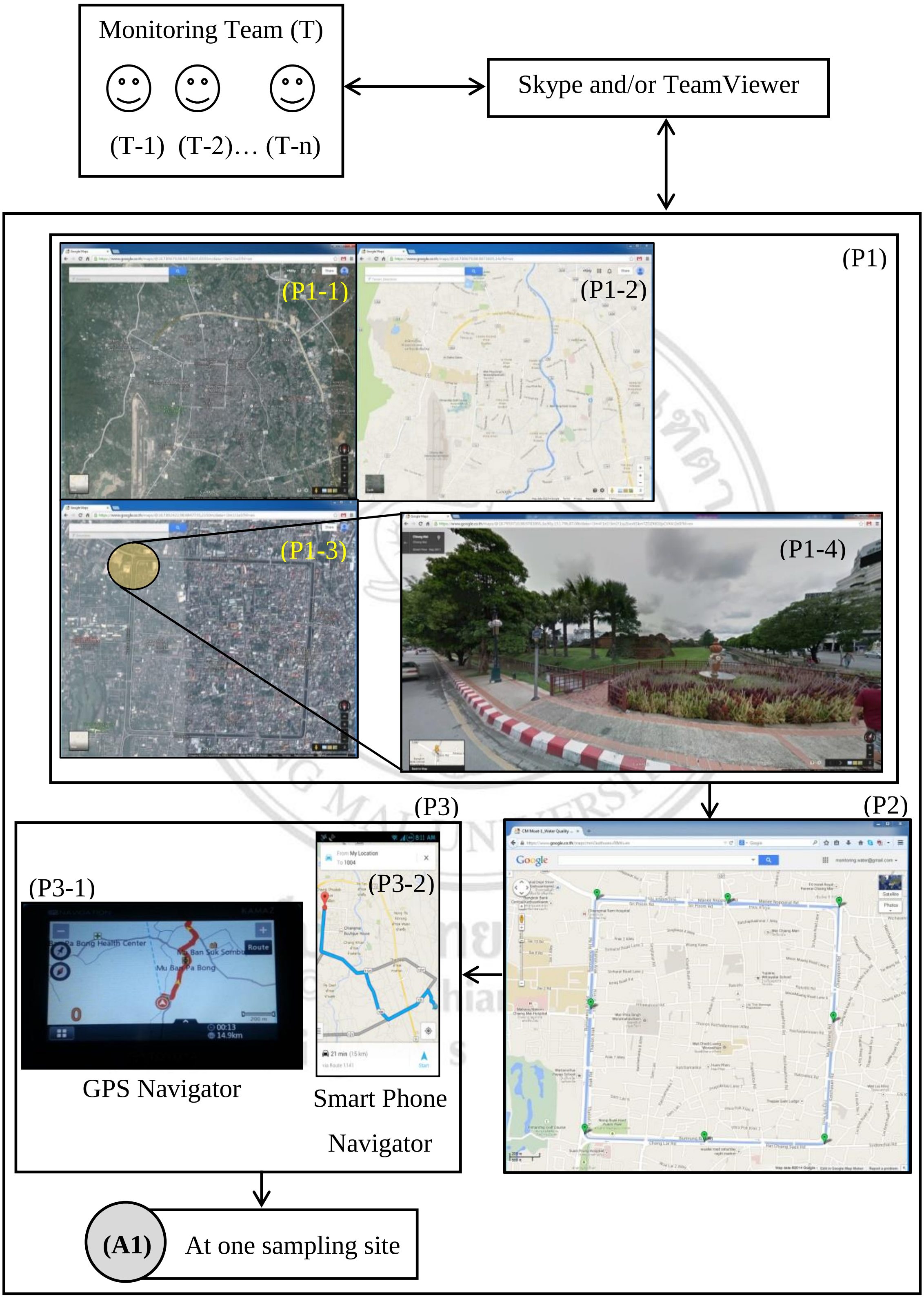


Figure 2.44 Operation planning

2.3 Classification of water quality

In this thesis, water quality was classified by applying mathematics method consisting of Percentile, Median and Mode as the tool for differentiate the baseline and the outlier, the principle as follows:

2.3.1 Rearrange the results of the measurements in each parameter in order by percentile method.

2.3.2 Create a graph between the measured values (axis Y) and percentile values (axis X).

2.3.3 Create baseline (value of the most data) and find outlier (higher value than baseline) (except for outlier of % DO Sat which is lower than the baseline).

2.3.4 The outlier can identify where (Sampling site) and when (trip).

2.3.5 The outlier of sampling site and trip from 2.3.4 can be summarized into the table to find the frequency.