4.6 System Testing

For the system testing, we conduct two types of tests: unit testing and integration testing.

4.6.1 Unit Testing

We conduct unit testing on the water level estimation algorithm, web application, and notification system as follow:

4.6.1.1 Water level estimation algorithm

In total, there are 13 test cases, with 5 cases for the Water level estimation algorithm and 8 cases for the Water level data insertion criteria.

Table 4.8 Water level estimation algorithm unit test cases from ID 1 to 5

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
1. Water level estimation algorithm							
1	Image capturing	High	Verify the ability to capture an image from the Public Nakhon website	https://noc.nakhoncity.org/live-cctv	PNG image file	PNG image file	Pass [Punn 10/05/ 2024 16:01]
2	Image perspective transformation	High	Verify that the system correctly applies perspective transformation to a PNG image file	PNG image file	Perspective corrected PNG image file	Perspective corrected PNG image file	Pass [Punn 10/05/ 2024 16:12]
3	Canny Edge Detection	High	Verify that the system able to detect edges on a perspective corrected image	Perspective corrected PNG image file	Binary image of Canny edge detection result	Binary image of Canny edge detection result	Pass [Punn 10/05/ 2024 16:20]
4	Waterline detection	High	Verify that the system can correctly detect the waterline in a binary image of Canny edge detection result	Binary image of Canny edge detection result	y coordinate of waterline position	y coordinate of waterline position	Pass [Punn 10/05/ 2024 16:42]
5	Water level estimation	High	Verify that the system able to estimate the water level based on the coordinate of the waterline position and the predefined water level	y coordinate of waterline position, predefined y coordinates of water level and zone	Water level, water zone	Water level, water zone	Pass [Punn 10/05/ 2024 16:55]

Table 4.9 Water level estimation algorithm unit test cases from ID 6 to 8

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
2. Water level data insertion criteria							
6	Retrieve two latest water level records	High	Verify that two latest water level data can be retrieved correctly from the “waterLevelRecord” database in Google Cloud BigQuery.	SELECT * FROM waterLevelRecord WHERE cctvID = 1 ORDER BY dateTime DESC LIMIT 2	[“cctvID”: “1”, “dateTime”: “2024-05-11 09:02:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”:”2024-05-11 09:00:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0”]	[“cctvID”: “1”, “dateTime”: “2024-05-11 09:02:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-05-11 09:00:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0”]	Pass [Jidapa 11/05/2024 09:03]
7	Water level data insertion criteria validation	High	Verify that if the difference between the actual water level and latest water level exceeds ±1 level, then replace the actual water level with the latest one and insert it to the database.	The actual water level from the water level estimation algorithm and latest water level. Given the actual water level = 3 and latest water level = 1	Insert water level = 1 into the database.	Insert water level = 1 into the database.	Pass [Jidapa 11/05/2024 09:20]
8	Water level data insertion criteria validation	High	Verify that if the second latest level is lower than the latest level, and the second latest level matches the actual water level, then update the latest recorded level in the database to match the second latest level and insert the actual water level to the database	The actual water level from the water level estimation algorithm, latest, and second latest water level. Given the actual level = 1 , latest level = 2, and second latest level = 1	Update the latest level = 1 and insert the actual water level = 1 to the database	Update the latest level = 1 and insert the actual water level = 1 to the database.	Pass [Jidapa 11/05/2024 09:30]

Table 4.10 Water level estimation algorithm unit test cases from ID 9 to 11

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
2. Water level data insertion criteria							
9	Water level data insertion criteria validation	High	Verify that if the second latest level is greater than the latest level, and the second latest level matches the actual water level, then update the latest recorded level in the database to match the second latest level and insert the actual water level to the database	The actual water level from the water level estimation algorithm, latest, and second latest water level. Given the actual level = 3, latest level = 2, and second latest level = 3	Update the latest level = 3 and insert the actual water level = 3 to the database.	Update the latest level = 3 and insert the actual water level = 3 to the database.	Pass [Jidapa 11/05/2024 09:40]
10	Water level data insertion criteria validation	High	Verify that if the second latest, latest, and actual water levels are all identical, then insert the actual water level into the database	The actual water level from the water level estimation algorithm, latest, and second latest water level. Given the actual level = 3, latest level = 3, and second latest level = 3	Insert water level = 3 into the database	Insert water level = 3 into the database	Pass [Jidapa 11/05/2024 09:50]
11	Water level data insertion criteria validation	High	Verify that if the second latest level is lower than the latest level, and the latest level matches the actual water level, then insert the actual water level to the database.	The actual water level from the water level estimation algorithm, latest, and second latest water level. Given the actual level = 2, latest level = 2, and second latest level = 1	Insert water level = 2 into the database	Insert water level = 2 into the database	Pass [Jidapa 11/05/2024 10:00]

Table 4.11 Water level estimation algorithm unit test cases from ID 12 to 13

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
2. Water level data insertion criteria							
12	Water level data insertion criteria validation	High	Verify that if the second latest level is greater than the latest level, and the latest level matches the actual water level, then insert the actual water level to the database	The actual water level from the water level estimation algorithm, latest, and second latest water level. Given the actual level = 2, latest level = 2, and second latest level = 3	Insert water level = 2 into the database	Insert water level = 2 into the database	Pass [Jidapa 11/05/2024 10:10]
13	Water level data insertion criteria validation	High	Verify that if no case is matched, then insert the actual water level to the database	The actual water level from the water level estimation algorithm, latest, and second latest water level. Given the actual level = 2, latest level = 1, and second latest level = 1	Insert water level = 2 into the database	Insert water level = 2 into the database	Pass [Jidapa 11/05/2024 10:30]

In the unit testing of the water level estimation algorithm, which consists of 13 test cases, we found that all test cases successfully passed. This indicates that the algorithm works correctly and provides accurate results.

4.6.1.2 Web application

We conduct unit testing on two components of the web application: the Front-end and APIs. In total, there are 28 test cases, with 25 cases for the front-end and 3 cases for the APIs.

1. Front-end unit testing

   Our web application comprises three main pages: Homepage, Dashboard, and Manual. We conduct unit testing for components and features across all three pages, totaling 25 test cases. Specifically, there are 8 test cases for the Homepage, 11 for the Dashboard, and 2 for the Manual page. Additionally, each page undergoes 2 general test cases, and there are 2 test cases dedicated to user devices.

Table 4.12 Front-end unit test cases from ID 14 to 18

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
1. All pages							
14	Launch website	High	Verify that the website can be accessed via web browsers such as Microsoft Edge, Google Chrome, Mozilla Firefox, and Safari using the link.	http://27.254.145.207/	Website homepage	Website homepage	Success- fully launch on all web browsers [Jidapa 04/04/ 2024 11:14]
15	Verify navigation tab click	High	Verify that clicking each navigation tab leads to the correct page.	Clicking each navigation tab, including Home, Dashboard, and Manual.	It directs to the correct page corresponding to the clicked tab.	All clicked tabs direct to their correct pages.	Pass [Jidapa 04/04/ 2024 11:30]
2. Homepage							
16	Verify the loading of the homepage	High	Verify that all elements on the homepage load correctly without any errors within a 1-minute interval.	Access the homepage	The homepage loads without errors, and all page elements are visible within a 1-minute interval.	The homepage loads correctly, and all elements are displayed in *less than 2 seconds.*	Pass [Jidapa 04/04/ 2024 11:50]
17	Language selection	High	Verify that when selecting a language, the content will change correctly according to the selected language.	Clicking the language option within the navigation tab	The content changes based on the selected language.	The content changes correctly based on the selected language.	Pass [Jidapa 05/04/ 2024 10:00]
18	CCTV camera location selection drop-down menu	High	Verify that clicking to select a CCTV camera location from the drop-down menu on the homepage will display the water level data correctly for each selected CCTV camera.	Selecting each CCTV camera location from the drop-down menu	It displays the water level data corresponding to the selected CCTV camera correctly.	It displays the water level data corresponding to the selected CCTV camera correctly.	Pass [Jidapa 05/04/ 2024 10:30]

Table 4.13 Front-end unit test cases from ID 19 to 23

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
2. Homepage							
19	CCTV camera icons on the map	Low	Verify that when clicking on a CCTV camera icon on the map, located on the homepage, results in it changing to a different icon and displaying a message regarding CCTV camera data, allowing for a single selection.	Clicking on each CCTV camera icon on the map	It switches to a different icon and displays a pop-up message regarding CCTV camera data.	It switches to a different icon and displays a pop-up message regarding CCTV camera data correctly.	Pass [Jidapa 05/04/2024 11:00]
20	Year selection drop-down menu	High	Verify that users can click to select a year for downloading water level records from the drop-down menu on the homepage.	Selecting a year for downloading water level records from the drop-down menu	It can select a year from the drop-down menu.	It can select a year from the drop-down menu.	Pass [Jidapa 05/04/2024 11:30]
21	Download button	High	Verify that the download button appears when both the CCTV camera and year are selected.	Selecting a CCTV camera and year from the drop-down menu	The download button appears.	The download button appears.	Pass [Jidapa 05/04/2024 12:00]
22	Download historical water level data records	High	Verify that when clicking the download button, historical water level data within the selected year range will be downloaded onto the user's device in Excel file format within a 1-minute interval.	Clicking the download button after selecting a CCTV camera and year from the drop-down menu	Historical water level data is downloaded onto the user's device in Excel file format within a 1-minute interval.	Historical water level data is downloaded onto the device in Excel file format in *less than 40 seconds.*	Pass [Jidapa 09/04/2024 10:00]
23	Water level data update	High	Verify that the water level data is updated every two minutes on the homepage.	Water level data at 11:30 and 11:32.	At 11:32, the water level data is updated.	At 11:32, the water level data is updated.	Pass [Jidapa 09/04/2024 11:32]

Table 4.14 Front-end unit test cases from ID 24 to 29

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
3. Dashboard page							
24	Verify the loading of the dashboard page	High	Verify that all elements on the dashboard page load correctly without any errors within a 1-minute interval.	Access the dashboard page	The dashboard page loads without errors, and all page elements are visible within a 1-minute interval.	The dashboard page loads correctly, and all elements are displayed in *less than 30 seconds.*	Pass [Jidapa 04/04/2024 12:00]
25	Date selection on the dashboard	High	Verify that the dashboard can select a start and end date using a calendar or slider.	Selecting a start and end date using a calendar or slider on the dashboard	A start and end date are selected.	A start and end date are selected.	Pass [Jidapa 09/04/2024 11:50]
26	The available date range for selection on the dashboard	Medium	Verify that the date range selection on the dashboard should only allow users to choose dates within current one-month period.	Selecting 25/03/2024 as the start date and 10/04/2024 as the end date	The start date cannot be selected.	The start date cannot be selected.	Pass [Jidapa 10/04/2024 10:00]
27	The validity of the date selection on the dashboard	High	Verify that the dashboard only allows selecting a start date that comes before the end date.	Selecting 09/04/2024 as the start date and 05/04/2024 as the end date	The start date cannot be selected.	The start date cannot be selected.	Pass [Jidapa 10/04/2024 11:00]
28	Single selection option for CCTV cameras on the dashboard	High	Verify that the dashboard only allows the selection of one CCTV camera option at a time.	Clicking the first and second CCTV camera options	The second CCTV camera cannot be selected.	The second CCTV camera cannot be selected.	Pass [Jidapa 10/04/2024 11:30]
29	CCTV camera selection on the dashboard	High	Verify that when clicking on a CCTV camera option, the dashboard displays water level data corresponding to the selected CCTV.	Clicking on a CCTV camera option	The dashboard displays data corresponding to the selected CCTV.	The dashboard displays data corresponding to the selected CCTV.	Pass [Jidapa 11/04/2024 10:00]

Table 4.15 Front-end unit test cases from ID 30 to 34

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
3. Dashboard page							
30	Water level criteria image on the dashboard	High	Verify that the image displaying water level criteria corresponds correctly to the selected CCTV camera.	Clicking on a CCTV camera option	The dashboard displays a water level criteria image corresponding to the selected CCTV.	The dashboard displays a water level criteria image corresponding to the selected CCTV.	Pass [Jidapa 11/04/2024 10:30]
31	Stacked area chart on the dashboard	High	Verify that the water level data on the stacked area chart is displayed within the selected date range.	Selecting 01/04/2024 as the start date and 05/04/2024 as the end date and clicking on a CCTV camera option.	The stacked area chart displays water levels within 01/04/2024 to 05/04/2024.	The stacked area chart displays water levels within 01/04/2024 to 05/04/2024.	Pass [Jidapa 11/04/ 2024 11:00]
32	Lowest and highest water levels on the dashboard	High	Verify that the lowest and highest water levels are displayed correctly according to the selected CCTV camera and date range.	Selecting 01/04/2024 as the start date and 10/04/2024 as the end date. The CCTV camera option is the Tha Yai canal.	The lowest water level is 1 and highest water level is 2.	The lowest water level is 1 and highest water level is 2.	Pass [Jidapa 11/04/2024 11:30]
33	Map on the dashboard	Low	Verify that each marker on the dashboard map correctly represents the latitude and longitude of each CCTV camera location.	Clicking on each CCTV camera option	Position of each marker is displayed correctly.	Position of each marker is displayed correctly.	Pass [Jidapa 11/04/2024 11:50]
34	Dashboard update	High	Verify that the dashboard updates its data every 15 minutes.	Dashboard and water level data at 13:30 and 13:45.	At 13:45, the dashboard updates the water level data.	At 13:45, the dashboard updates the water level data.	Pass [Jidapa 11/04/2024 13:45]

Table 4.16 Front-end unit test cases from ID 35 to 38

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
4. Manual page							
35	Verify the loading of the manual page	High	Verify that all elements on the manual page load correctly without any errors within a 1-minute interval.	Access the manual page	The manual page loads without errors, and all page elements are visible within a 1-minute interval.	The manual page loads correctly, and all elements are displayed in *less than 3 seconds.*	Pass [Jidapa 04/04/2024 14:00]
36	Video tutorial on the manual page	Medium	Verify that the video tutorial is displayed for users to watch.	Video tutorial	The video tutorial can be watched	The video tutorial can be watched	Pass [Jidapa 11/04/2024 14:00]
5. User's device							
37	The downloaded Excel file	High	Verify that the downloaded Excel file can be opened and contains water level data within the selected year range consisting of 5 columns: CCTV ID, CCTV camera name, date and time, water level, and zone.	The downloaded Excel file	The file can be opened and contains water level data within the selected year range, consisting of 5 columns.	The file can be opened and contains water level data within the selected year range, consisting of 5 columns.	Pass [Jidapa 09/04/2024 10:30]
38	The name of the downloaded Excel file	Medium	Verify that the Excel file name contains the selected CCTV ID and year. For instance, the file name should be in the format "waterLevel-Data_cctvId1_year 2024", where the selected CCTV ID is 1 and the selected year is 2024.	The downloaded Excel file	The file name contains the selected CCTV ID and year.	The file name contains the selected CCTV ID and year.	Pass [Jidapa 09/04/2024 11:00]

In the unit testing of the front-end, which focuses on the three main pages, we conducted a total of 25 test cases. All cases passed, and some even yielded better results than expected. This indicates that the front-end works perfectly for all users.

2. API testing

We have two APIs: one for retrieving water level data from the database and another for downloading water level data to the user's device. The retrieval API communicates between the website and database, fetching data in JSON format using the GET HTTP method, which is then displayed on the front-end. The download API also communicates between the website and database, retrieving data and downloading it to the user's device in CSV format using the GET HTTP method. We conduct unit testing on both APIs. In total, we have three test cases: 2 test cases for the retrieval API and 1 test case for the download API.

Table 4.17 API unit test cases from ID 39 to 40

ID	Priority	Description	HTTP method	Inputs	Expected output	Actual output	Test result
1. API for retrieving water level data							
39	High	Verify that the API can successfully retrieve water level data, including CCTV ID, date and time, water level, and zone of all three CCTV cameras.	GET	http://27.254.145.207:8000/waterLevel/latest	[“cctvID”:1, “dateTime”: “2024-04-17 T09:02:00+00:00”, “waterLevel”:1, “zone”:0, “cctvID”:2, “dateTime”: “2024-04-17 T09:02:00+00:00”, “waterLevel”:2, “zone”:0, “cctvID”:3, “dateTime”: “2024-04-17 T09:02:00+00:00”, “waterLevel”:1, “zone”:0]	[“cctvID”:1, “dateTime”: “2024-04-17 T09:02:01+00:00”, “waterLevel”:1, “zone”:0, “cctvID”:2, “dateTime”: “2024-04-17 T09:02:01+00:00”, “waterLevel”:2, “zone”:0, “cctvID”:3, “dateTime”: “2024-04-17 T09:02:01+00:00”, “waterLevel”:1, “zone”:0]	Pass [Jidapa 17/04/2024 09:02]
40	High	Verify that the API can retrieve water level data updated every 2 minutes and query water level data correctly from the ’water-LevelRecord’ database.	GET	http://27.254.145.207:8000/waterLevel/latest , At 09:02, [“cctvID”:1, “dateTime”: “2024-04-17 T09:02:01+00:00”, “waterLevel”:1, “zone”:0, “cctvID”:2, “dateTime”: “2024-04-17 T09:02:01+00:00”, “waterLevel”:2, “zone”:0, “cctvID”:3, “dateTime”: “2024-04-17 T09:02:01+00:00”, “waterLevel”:1, “zone”:0]	At 09:04, [“cctvID”:1, “dateTime”: “2024-04-17 T09:04:01+00:00”, “waterLevel”:1, “zone”:0, “cctvID”:2, “dateTime”: “2024-04-17 T09:04:01+00:00”, “waterLevel”:2, “zone”:0, “cctvID”:3, “dateTime”: “2024-04-17 T09:04:01+00:00”, “waterLevel”:1, “zone”:0]	At 09:04, [“cctvID”:1, “dateTime”: “2024-04-17 T09:04:01+00:00”, “waterLevel”:1, “zone”:0, “cctvID”:2, “dateTime”: “2024-04-17 T09:04:01+00:00”, “waterLevel”:2, “zone”:0, “cctvID”:3, “dateTime”: “2024-04-17 T09:04:01+00:00”, “waterLevel”:1, “zone”:0]	Pass [Jidapa 17/04/2024 09:10]

Table 4.18 API unit test case for ID 41

ID	Priority	Description	HTTP method	Inputs	Expected output	Actual output	Test result
2. API for downloading water level data							
41	High	Verify that the API can retrieve water level data for the selected year and CCTV camera, and save the water level data to the user's device as an Excel file.	GET	http://27.254.145.207:8000/download/1/2024 Note: The number '1' represents the selected CCTV camera ID, and '2024' represents the selected year.	The Excel file containing water level data within a selected year range and CCTV ID should be successfully downloaded to my device. It should comprise five columns: CCTV ID, CCTV camera name, date and time, water level, and zone.	The Excel file containing water level data within a selected year range and CCTV ID is successfully downloaded to my device. It comprises five columns: CCTV ID, CCTV camera name, date and time, water level, and zone.	Pass [Jidapa 17/04/2024 09:20]

From the API unit testing, which includes 3 test cases, we found that the output results passed all tests. This indicates that the communication between each module works correctly, retrieving and transmitting data as expected.

4.6.1.3 Notification system

For the notification system, we conduct unit testing with 20 test cases. Since the criteria for sending notification messages vary for each CCTV camera, detailed notification criteria can be found in the flowchart, as shown in Figure 3.26. Consequently, we conduct unit testing on each CCTV camera. We have a total of three CCTV cameras: CCTV ID 1 is Khlong Tha Yai, CCTV ID 2 is Khlong Na Muang, and CCTV ID 3 is Khlong Liap Thang Rot Fai. There are 4 test cases for CCTV ID 1, 4 test cases for CCTV ID 2, 4 test cases for CCTV ID 3, and 8 test cases for all CCTVs.

Table 4.19 Notification system unit test cases from ID 42 to 43

ID	Function	Priority	Description	Inputs	Actual output	Test result
1. All CCTV cameras						
42	‘waterLevelNotify’ function in Google Cloud Function	High	Verify that Google Cloud Scheduler can execute the ’waterLevelNotify’ function in Google Cloud Function every 10 minutes.	waterLevelNotify function in Google Cloud Function	waterLevelNotify function is executed every 10 minutes.	Pass [Jidapa 18/04/ 2024 09:40]
43	getFiveLastestWaterLevelData() in database.py	High	Verify that the 5 latest water level data can be retrieved correctly from the ’waterLevelRecord’ database in Google Cloud BigQuery.	SELECT * FROM depa-smartcity-thailand.waterlevel.waterLevelRecord WHERE cctvID = 1 ORDER BY dateTime DESC LIMIT 5;	[“cctvID”: “1”, “dateTime”: “2024-04-18 09:48:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-04-18 09:46:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-04-18 09:44:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-04-18 09:42:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-04-18 09:40:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0”]	Pass [Jidapa 18/04/ 2024 09:50]

Table 4.20 Notification system unit test cases from ID 44 to 46

ID	Function	Priority	Description	Inputs	Actual output	Test result
1. All CCTV cameras						
44	Calculate the mode of the water level in checkAndNotify() function in main.py	High	Verify that the mode of the 5 latest water levels, obtained from getFiveLatestWaterLevelData(), can be correctly calculated.	5 latest water levels are 1,1,1,1, and 1.	The mode is 1.	Pass [Jidapa 18/04/2024 09:52]
45	findCurrentWaterLevelData() in main.py	High	After calculating the mode, verify that the latest water level record that matches the mode is returned to checkAndNotify() as the variable named 'currentWaterLevelData'.	The 5 latest water level data and mode	["cctvID": "1", "dateTime": "2024-04-18 09:48:01.000000 UTC", "waterLevel": "1", "zone": "0"]	Pass [Jidapa 18/04/2024 09:54]
46	getPreviousWaterLevelData() in database.py	High	Verify that the previous water level data can be retrieved correctly from the 'waterLevelForNotify' database.	SELECT * FROM 'depa-smartcity-thailand.waterlevel.waterLevelForNotify';	["cctvID": "1", "dateTime": "2024-04-18 09:38:01.000000 UTC", "waterLevel": "1", "zone": "0" , "cctvID": "2", "dateTime": "2024-04-18 09:38:01.000000 UTC", "waterLevel": "1", "zone": "0" , "cctvID": "3", "dateTime": "2024-04-18 09:38:01.000000 UTC", "waterLevel": "1", "zone": "0"]	Pass [Jidapa 18/04/2024 09:56]

Table 4.21 Notification system unit test cases from ID 47 to 49

ID	Function	Priority	Description	Inputs	Actual output	Test result
1. All CCTV cameras						
47	criteriaForNotify() in main.py	High	Verify that if no case is matched, then send currentWaterLevelData to updateDatabase().	CCTV ID, previous zone, current zone, and current water level that do not match any cases.	currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 13:30]
48	updateDatabase() in database.py	High	Verify that currentWaterLevelData is updated to the 'waterLevelForNotify' database. If the update is successful, return a success message; otherwise, return an error message.	Data from a variable named currentWaterLevelData	The data in the 'waterLevelForNotify' database is updated and a success message is printed.	Pass [Jidapa 18/04/2024 14:00]
49	sendLineNotify() in main.py	High	Verify that the notification message can be successfully sent to Line Notify through the API endpoint https://notify-api.line.me/api/notify using the POST method.	A message and https://notify-api.line.me/api/notify	The message is successfully sent to Line Notify.	Pass [Jidapa 18/04/2024 14:30]

Table 4.22 Notification system unit test cases from ID 50 to 53

ID	Function	Priority	Description	Inputs	Actual output	Test result
2. CCTV ID 1 (Khlong Tha Yai)						
50	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 1, previous zone is 0, current zone is 1, and current water level is 3, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 1, previous zone is 0, current zone is 1, and current water level is 3.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 10:10]
51	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 1, previous zone is 1, current zone is 2, and current water level is 6, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 1, previous zone is 1, current zone is 2, and current water level is 6.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 10:20]
52	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 1, previous zone is 2, and current zone is 1, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 1, previous zone is 2, and current zone is 1.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 10:30]
53	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 1, previous zone is 1, and current zone is 0, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 1, previous zone is 1, and current zone is 0.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 10:40]

Table 4.23 Notification system unit test cases from ID 54 to 57

ID	Function	Priority	Description	Inputs	Actual output	Test result
3. CCTV ID 2 (Khlong Na Muang)						
54	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 2, previous zone is 0, current zone is 1, and current water level is 4, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 2, previous zone is 0, current zone is 1, and current water level is 4.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 10:50]
55	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 2, previous zone is 1, current zone is 2, and current water level is 7, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 2, previous zone is 1, current zone is 2, and current water level is 7.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 11:00]
56	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 2, previous zone is 2, and current zone is 1, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 2, previous zone is 2, and current zone is 1.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 11:10]
57	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 2, previous zone is 1, and current zone is 0, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 2, previous zone is 1, and current zone is 0.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 11:20]

Table 4.24 Notification system unit test cases from ID 58 to 61

ID	Function	Priority	Description	Inputs	Actual output	Test result
4. CCTV ID 3 (Khlong Liap Thang Rot Fai)						
58	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 3, previous zone is 0, and current zone is 1, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 3, previous zone is 0, and current zone is 1.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 11:30]
59	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 3, previous zone is 1, and current zone is 2, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 3, previous zone is 1, and current zone is 2.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 11:40]
60	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 3, previous zone is 2, and current zone is 1, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 3, previous zone is 2, and current zone is 1.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 11:50]
61	criteriaForNotify() in main.py	High	Verify that if the CCTV ID is 3, previous zone is 1, and current zone is 0, then a message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	CCTV ID is 3, previous zone is 1, and current zone is 0.	A message is sent to sendLineNotify(), and currentWaterLevelData is sent to updateDatabase().	Pass [Jidapa 18/04/2024 12:00]

After conducting unit testing on the three modules—water level estimation algorithm (from tables 4.8, 4.9, 4.10, and 4.11), web application (including front-end testing from tables 4.12, 4.13, 4.14, 4.15, and 4.16, and API testing from tables 4.17 and 4.18), and the notification system (from tables 4.19, 4.20, 4.21, 4.22, 4.23, 4.24, and 4.26)—we found that each test case successfully returned the expected values and each module is ready for integration testing.

4.6.2 Integration Testing

We conduct integration testing with each module in three parts: water level estimation algorithm with the database, front-end with API connections, and notification system with the database. The details are shown in the table below.

4.6.2.1 The water level estimation algorithm and database connection testing

Table 4.25 The water level estimation algorithm and database integration test cases from ID 62 to 63

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
1. Water level estimation algorithm - Database							
62	Insert water level data to the database	High	Verify that new water level data can be inserted to the database.	New water level data	All new water level data is successfully inserted into the database.	All new water level data is successfully inserted into the database.	Pass [Jidapa 12/05/ 2024 10:30]
63	Update water level data in the database	High	Verify that water level data can be updated with new data in the database.	New water level data	Water level data is successfully updated with new data in the database.	Water level data is successfully updated with new data in the database.	Pass [Jidapa 12/05/ 2024 10:40]

4.6.2.2 The front-end and APIs connection testing

Table 4.26 The front-end and APIs integration test cases from ID 64 to 66

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
2. Front-end - APIs							
64	Fetch water level data from an API	High	Verify that the front-end can fetch water level data from an API, which in turn retrieves data from the database, and then displays the water level data on the web application.	http://27.254.145.207:8000/waterLevel/latest	Display the latest water level data on the web application.	Display the latest water level data on the web application.	Pass [Jidapa 12/05/2024 10:50]
65	Send selected CCTV ID and year to an API	High	Verify that the front-end can send selected CCTV ID and year from dropdown options to an API.	http://27.254.145.207:8000/download/selectedCCTVID/selectedYear , Given selectedCCTVID = 1 and selectedYear = 2024	http://27.254.145.207:8000/download/1/2024	http://27.254.145.207:8000/download/1/2024	Pass [Jidapa 12/05/2024 11:00]
66	Water level data download	High	Verify that the front-end can request water level data download from an API and successfully download the file to the device.	http://27.254.145.207:8000/download/1/2024	The Excel file containing water level data within a selected year range and CCTV ID should be successfully downloaded to my device. It should comprise five columns: CCTV ID, CCTV camera name, date and time, water level, and zone.	The Excel file containing water level data within a selected year range and CCTV ID is successfully downloaded to my device. It comprises five columns: CCTV ID, CCTV camera name, date and time, water level, and zone.	Pass [Jidapa 12/05/2024 11:10]

4.6.2.3 The notification system and database connection testing

Table 4.27 The notification system and database integration test case for ID 67

ID	Function	Priority	Description	Inputs	Expected output	Actual output	Test result
3. Notification system - Database							
67	Retrieve water level data from the database	High	Get water level data from the database	SELECT * FROM depa-smartcity-thailand.waterlevel.waterLevel-Record WHERE cctvID = 1 ORDER BY dateTime DESC LIMIT 5;	[“cctvID”: “1”, “dateTime”: “2024-05-12 11:48:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-05-12 11:46:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-05-12 11:44:01.000000 UTC”, “waterLevel”: “1”, “zone”: ”0” , ”cctvID”: ”1”, ”dateTime”: ”2024-05-12 11:42:01.000000 UTC”, ”waterLevel”: ”1”, ”zone”: ”0” , ”cctvID”: ”1”, ”dateTime”: ”2024-05-12 11:40:01.000000 UTC”, ”waterLevel”: ”1”, ”zone”: “0”]	[“cctvID”: “1”, “dateTime”: “2024-05-12 11:48:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-05-12 11:46:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-05-12 11:44:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-05-12 11:42:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0” , “cctvID”: “1”, “dateTime”: “2024-05-12 11:40:01.000000 UTC”, “waterLevel”: “1”, “zone”: “0”]	Pass [Jidapa 12/05/2024 11:49]