Verification and Validation Report: Software Engineering

Team 21, Alkalytics
Sumanya Gulati
Kate Min
Jennifer Ye
Jason Tran

March 4, 2025

1 Revision History

Date	Version	Notes
4 March 2025	1.0	Initial Draft
Date 2	1.1	Notes

2 Symbols, Abbreviations and Acronyms

symbol	description
CSV	Comma-Separated Values
FR	Functional Requirement
LFR	Look and Feel Requirement
MG	Module Guide
MSR	Maintainability and Support Requirement
NFR	Nonfunctional Requirement
OER	Operational and Environmental Requirement
PR	Performance Requirement
SR	Security Requirement
SRS	Software Requirements Specification
ST	System Test
UHR	Usability and Humanity Requirement
VnV	Verification and Validation
WCAG	Web Content Accessibility Guidelines

Contents

List of Tables

List of Figures

3 Overview

This document provides a comprehensive summary of the Verification and Validation (VnV) process for the Alkalytics project. It includes reports and analysis of system testing and unit testing results, along with traceability between test cases, the software modules in the Module Guide (MG), and the requirements outlined in the Software Requirements Specification (SRS). Additionally, it highlights changes made to the implementation based on testing outcomes and user feedback.

4 Functional Requirements Evaluation

4.1 Data Input and Storage

1. **FR-ST1**

   Control: Manual

   Initial State: Database is running and ready to intake data

   Input: `SAMPLE_.CSV_FILE`

   Expected Output: The inputted data is stored in the system with proper labels and without any data loss or errors

   Actual Output:

   Result: Pass OR Fail

2. **FR-ST1.1**

   Control: Manual

   Initial State: Database is running and ready to intake data

   Input: `SAMPLE_DATA_POINT`:

   Expected Output: The inputted data is stored in the system with proper labels and without any data loss or errors.

   Actual Output: The inputted data is stored in the system under the correct label and without any data loss or errors.

   Result: Pass

4.2 Data Querying and Results

1. **FR-ST2**

   Control: Manual

   Initial State: The system is not running any jobs, and the user interface is cleared.

   Input: `SAMPLE_PARAMETERS`: {}

   Expected Output: A human-readable and customizable visualization of correct results corresponding to the selected parameters from the input

   Actual Output:

   Result: Pass OR Fail

4.3 Data Analysis

1. **FR-ST3**

   Control: Manual

   Initial State: The application's cleared user interface which has not yet been used to query data, with no graph showing yet.

   Input: `SAMPLE_QUERY`: {}

   Expected Output: A small written human-readable paragraph explaining the input data.

   Actual Output:

   Result: Pass OR Fail

4.4 Data Hygiene

1. ~~**FR-ST4**~~ OUT OF SCOPE; Stretch Goal Requirement

   Control: Manual

   Initial State: The application's cleared user interface which has not yet been used to query data, with no graph showing yet.

Input: `SAMPLE_.CSV_FILE`

Expected Output: A log file documenting errors found in the input data and/or removals of missing data.

4.5 User Access

1. **FR-ST5**

   Control: Manual

   Initial State: User interface shows a login page, with no login credentials currently used

   Input: `SAMPLE_VALID_EMAIL, SAMPLE_VALID_PASSWORD`

   Expected Output: The page redirects to the page designated after login

   Actual Output: Once credentials are submitted, the page redirects to the main home page of the application.

   Result: Pass

4.6 Data Export

1. ~~**FR-ST6**~~ OUT OF SCOPE; Stretch Goal Requirement

   Control: Manual

   Initial State: User interface after multiple usages of data queries

   Input: `USER ACTION => BUTTON CLICK`

   Expected Output: Query report will be downloaded to the user's device

5 Nonfunctional Requirements Evaluation

5.1 Look and Feel

1. **NFR-LF1**

   Type: User Demo, Manual

Initial State: Fully functional application ready for user interaction, starting at the login page

Input/Condition: User engagement with application

Expected Output: 90% of responses in the Navigation and Ease of Use section of the usability survey are at least 'Neither easy nor difficult'; 85% of users navigate the entire application within 10 minutes.

Actual Output: `User's answers to usability survey, time taken to complete tasks or navigate site`

Result: Pass OR Fail

2. **NFR-LF2**

   Type: Manual

   Initial State: Application running on a 15" laptop, 24" monitor, standard smart phone and/or tablet

   Input/Condition: Manual tester's engagement with application

   Expected Output: Number of inconsistencies found across all devices ≤ 10.

   Actual Output: `# of inconsistencies found in the application's layout across devices, explanation of inconsistencies?`

   Result: Pass OR Fail

5.2 Usability

1. **NFR-UH1**

   Type: User Demo, Manual

   Initial State: Fully functional application ready for user interaction, starting at the login page

   Input/Condition: User engagement with application, set of tasks to complete

   Expected Output: 85% of users ask for help no more than 3 times; 90% of responses to the Learning section of the usability survey are at least

'Neither easy nor difficult'.

Actual Output: `User's answers to usability survey, # of times user asked usability test conductor for help`

Result: Pass OR Fail

2. **NFR-UH2**

   Type: Manual

   Initial State: Fully developed application, starting at the login page

   Input/Condition: Manual tester using application

   Expected Output: 0 language discrepancies found in the application.

   Actual Output: 0 language discrepancies found in the application.

   Result: Pass

3. **NFR-UH3**

   Type: Manual

   Initial State: Application ready to take in data

   Input/Condition: `SAMPLE_.CSV_FILE`

   Expected Output: Error logs from unrecognized characters, or successful upload

   Actual Output:

   Result: Pass OR Fail

4. **NFR-UH4**

   Type: Manual

   Initial State: Application ready for use

   Input/Condition: Tester engagement using third party tools

   Expected Output: List of accessibility issues in accordance to Web Content Accessibility Guidelines (WCAG), and checklists for if page is screen-readable

   Actual Output:

Result: Pass OR Fail

5.3 Performance

1. **NFR-P1**

   Type: Manual

   Initial State: Application navigated to upload page, ready to upload file

   Input/Condition: `SAMPLE_.CSV_FILE`

   Expected Output: Average upload duration $\leq$ `UPLOAD_TIME`

   `UPLOAD_TIME` = 60 seconds

   Actual Output:

   Result: Pass OR Fail

2. **NFR-P2**

   Type: Manual

   Initial State: Application navigated to querying page, ready to make query

   Input/Condition: `SAMPLE_QUERY`: {}

   Expected Output: Average query response duration $\leq$ `QUERY_TIME`

   `QUERY_TIME` = 3 seconds

   Actual Output:

   Result: Pass OR Fail

3. **NFR-P3**

   Type: Manual

   Initial State: Application ready to use

   Input/Condition: Tester engagement

   Expected Output: Average response time of buttons on website $\leq$ `RESPONSE_TIME`

`RESPONSE_TIME` = 2 seconds

Actual Output:

Result: Pass OR Fail

4. **NFR-P4**

   Type: Manual

   Initial State: Application navigated to graphs page, ready to make query to generate graphs

   Input/Condition: `SAMPLE_QUERY`: {}

   Expected Output: Average time taken to generate graphs/visualizations $\leq$ `GRAPH_TIME`

   `GRAPH_TIME`: 10 seconds

   Actual Output:

   Result: Pass OR Fail

5. **NFR-P5**

   Type: Manual

   Initial State: Application navigated to query page, ready to make query

   Input/Condition: `SAMPLE_QUERY`: {}

   Expected Output: A check for precision of numbers in different components of system

   Actual Output:

   Result: Pass OR Fail

6. **NFR-P6**

   Type: Manual

   Initial State: Application running as normal

   Input/Condition: Tester temporarily taking down back end

   Expected Output: Error messages properly displayed

Actual Output:

Result: Pass OR Fail

7. **NFR-P7**

   Type: Manual

   Initial State: Application running as normal

   Input/Condition: Tester temporarily disconnects internet connection

   Expected Output: Previously generated plots and previous queries still working

   Actual Output:

   Result: Pass OR Fail

8. **NFR-P8**

   Type: Manual

   Initial State: Three devices ready to run application

   Input/Condition: `SAMPLE_QUERY`: {}

   Expected Output: System response time while under load $\leq$ `RESPONSE_TIME_THRESHOLD`

   Actual Output:

   Result: Pass OR Fail

9. **NFR-P9**

   Type: Data Generation, Automated

   Initial State: A database with a known amount of experiment data

   Input/Condition: `DUMMY_DATA`

   Expected Output: Observations on system health after large payload

   Actual Output:

   Result: Pass OR Fail

5.4 Operational and Environmental

1. **NFR-OE1**

   Type: Manual

   Initial State: Application running on a windows device as a web application on a Chromium based browser.

   Input/Condition: Tester engagement

   Expected Output: A list of all discovered issues with the application that arise due to environment compatibility

   Actual Output:

   Result: Pass OR Fail

2. **NFR-OE2**

   Type: Manual, User Demo

   Initial State: Application running and ready for use on home screen

   Input/Condition: User engagement

   Expected Output: Survey results depicting subjective complexity of onboarding process

   Actual Output:

   Result: Pass OR Fail

5.5 Maintainability and Support

1. **NFR-MS1**

   Type: Manual, User Demo

   Initial State: Application running, ready for use

   Input/Condition: User engagement

   Expected Output: Observations on user's ability to complete tasks without support

   Actual Output:

Result: Pass OR Fail

2. **NFR-MS2**

   Type: Manual

   Initial State: Multiple Chromium-based web browsers open

   Input/Condition: Tester Engagement

   Expected Output: All abnormal behaviour of web pages observed on each different web browser

   Actual Output:

   Result: Pass OR Fail

5.6 Security

1. **NFR-SR1**

   Type: Manual

   Initial State: Application login page is displayed.

   Input/Condition: `SAMPLE_VALID_CREDENTIALS, SAMPLE_INVALID_CREDENTIALS`

   Expected Output: Access is granted or denied based on the validity of the credentials provided.

   Actual Output: Access is granted for the `SAMPLE_VALID_CREDENTIALS`, which consisted of a registered email and correct password, and consistently denied for the `SAMPLE_INVALID_CREDENTIALS`, which consisted of the following test inputs:

   - Registered email, incorrect password
   - Unregistered email, correct password
   - Unregistered email, incorrect password

   Result: Pass

2. **NFR-SR2**

   Type: Manual

Initial State: Application logged in with multiple user roles (e.g., admin, researcher, research assistant).

Input/Condition: Tester interacts with the application using on different user roles.

Expected Output: Access to query or modify data and perform sensitive operations is restricted according to user roles.

Actual Output: Only admin and researchers were able to modify data and these operations were not available to users with the role of research assistant.

Result: Pass

3. **NFR-SR3**

   Type: Manual

   Initial State: User is logged into the application.

   Input/Condition: User remains inactive for a specified period.

   Expected Output: User is automatically logged out after a predefined period of inactivity.

   Actual Output: The user was not logged out after 15 minutes of inactivity.

   Result: Fail

4. **NFR-SR4**

   Type: Manual

   Initial State: Application is open, ready for data entry and CSV upload.

   Input/Condition: `VALID_DATA, INVALID_DATA, CORRUPTED_DATA`

   Expected Output: All invalid inputs and CSV uploads are rejected, and only valid data entries are processed.

   Actual Output:

   Result: Pass OR Fail

5. **NFR-SR5**

Type: Manual

Initial State: Application database contains a set of unique, validated records. Application interface is open for data entry, processing, and transfer actions

Input/Condition: `SAMPLE_DUPLICATE_RECORD`

Expected Output: Duplicate records are detected and prevented, and data accuracy is maintained during all transfer operations.

Actual Output:

Result: Pass OR Fail

6. ~~**NFR-SR6**~~ OUT OF SCOPE

   Type: Manual/Automated

   Initial State: Database is operational, with storage capacity at or below normal usage. Alert system is configured, and the administrator contact information is set up to receive notifications.

   Input/Condition: Tester simulates increasing database storage usage to exceed the `STORAGE_THRESHOLD`.

   Expected Output: System successfully detects when storage usage exceeds `STORAGE_THRESHOLD` and sends a timely alert to administrators.

7. ~~**NFR-SR7**~~ OUT OF SCOPE

   Type: Manual/Automated

   Initial State: The application is operational, with logging features configured and permissions for accessing logs assigned to administrators only.

   Input/Condition: Tester performs various access and modification actions within the application, then attempts to access the audit logs with both authorized and unauthorized user accounts.

   Expected Output: All actions are logged with timestamps and user identities, and audit logs are accessible only to authorized users, with proper encryption.

8. ~~**NFR-SR8**~~ OUT OF SCOPE

   Type: Manual

   Initial State: Application login screen is open. Administrator contact information is configured to receive security alerts.

   Input/Condition: Tester attempts multiple failed logins to trigger the suspicious activity detection mechanism.

   Expected Output: Application detects and blocks access after three failed attempts, sends an alert to administrators, and locks out the user temporarily.

9. ~~**NFR-SR9**~~ OUT OF SCOPE

   Type: Automated/Manual

   Initial State: Application is running under typical workload conditions. Monitoring tools and alerts for CPU and memory usage are enabled.

   Input/Condition: Tester simulates a high workload to approach system resource limits, observing the system's monitoring and optimization response.

   Expected Output: The system actively manages CPU and memory usage, preventing overload and maintaining performance stability.

6 Comparison to Existing Implementation

This section will not be appropriate for every project.

7 Unit Testing

7.1 Data Storage Module

7.2 Data Retrieval Module

7.3 Visualization Module

7.4 User Management Module

8 Changes Due to Testing

8.1 Changes Due to Supervisor Feedback

Our supervisor suggested the current data visualization form intake could be improved by allowing the user to filter the experiment data by additional parameters, rather than only by the date it was performed. This feature will be added to the final product.

They have also requested to add a new feature that was not originally part of the requirements. This feature allows the user to compute a variety of efficiency factors related to the data, measuring the efficiencies of the membrane used in the experiment. This feature will be added to the final product, but thorough validation testing will be limited due to time constraints.

[This section should highlight how feedback from the users and from the supervisor (when one exists) shaped the final product. In particular the feedback from the Rev 0 demo to the supervisor (or to potential users) should be highlighted. —SS]

8.2 Changes Due to Failed Tests

8.2.1 NFR-S3

The system did not automatically log out the user after a period of inactivity. This was due to the lack of a session timeout manager, which will be implemented in the final product.

9 Automated Testing

Pytest was used as the automated testing framework for Python. Unit test suites were written and executed using Pytest, which supports fixtures, parameterization, and code coverage metrics, making automated testing more efficient and flexible.

10 Trace to Requirements

Test ID	FR-ST1	FR-ST1.1	FR-ST2	FR-ST3	FR-ST4	FR-ST5	FR-ST6
FR-1	X	X					
FR-2	X	X					
FR-3	X	X					
FR-4	X	X					
FR-5			X				
FR-6			X				
FR-7			X				
FR-8			X				
FR-9			X				
FR-10				X			
FR-11				X			
FR-12					X		
FR-13					X		
FR-14						X	
FR-15							X

Table 1: Traceability Matrix for Test Cases and Functional Requirements

Test ID {NFR-}	LF1	LF2	UH1	UH2	UH3	UH4	OE1	OE2	MSR1	MSR2
LFR-1	X									
LFR-2		X								
LFR-3	X									
LFR-4	X									
LFR-5	X									
LFR-6	X									
LFR-7	X									
UHR-1			X							
UHR-2				X						
UHR-3					X					
UHR-4			X							
UHR-5			X							
UHR-6						X				
OER-2							X			
OER-3							X			
OER-4							X			
OER-5								X		
MSR-4									X	
MSR-6										X

Table 2: Traceability Matrix for Test Cases and Nonfunctional Requirements (Part 1)

Test ID {NFR-}	P1	P2	P3	P4	P5	P6	P7	P8	P9
PR-1	X								
PR-2		X							
PR-3			X						
PR-4		X							
PR-5				X					
PR-6					X				
PR-7					X				
PR-8					X				
PR-9						X			
PR-10							X		
PR-11								X	
PR-12									X

Table 3: Traceability Matrix for Test Cases and Nonfunctional Requirements (Part 2)

Test ID {NFR-}	SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8	SR9
SR-1	X								
SR-2		X							
SR-3		X							
SR-4			X						
SR-5				X					
SR-6					X				
SR-7					X				
SR-8					X				
SR-9				X					
SR-12						X			
SR-13							X		
SR-14							X		
SR-15							X		
SR-16								X	
SR-17									X

Table 4: Traceability Matrix for Test Cases and Nonfunctional Requirements (Part 3)

11 Trace to Modules

Test ID	FR-ST1	FR-ST1.1	FR-ST2	FR-ST3	FR-ST4	FR-ST5	FR-ST6
M1							
M2							
M3							
M4							
M5							
M6							
M7							
M8							
M9							
M10							
M11							
M12							
M13							

Table 5: Traceability Matrix for Test Cases and Modules

12 Code Coverage Metrics

Appendix — Reflection

1. **What went well while writing this deliverable?**

   Writing the general structure of the report was straightforward as we could refer back to the tests we had written in the VnV Plan (cont. later)

2. **What pain points did you experience during this deliverable, and how did you resolve them?**

   Constructing and executing all of our tests was the biggest challenge. Due to time constraints, (cont. later)

3. **Which parts of this document stemmed from speaking to your client(s) or a proxy (e.g. your peers)? Which ones were not, and why?**

4. **In what ways was the Verification and Validation (VnV) Plan different from the activities that were actually conducted for VnV? If there were differences, what changes required the modification in the plan? Why did these changes occur? Would you be able to anticipate these changes in future projects? If there weren't any differences, how was your team able to clearly predict a feasible amount of effort and the right tasks needed to build the evidence that demonstrates the required quality? (It is expected that most teams will have had to deviate from their original VnV Plan.)**