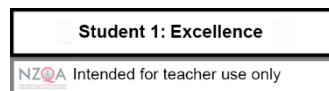Background information, method, and results were included

in the report.

Method:

After the standardisation has been completed, the quantitative analysis of the estuary samples can begin. By using Mohr's method of titration we can determine the concentration of Cl^- ions in the estuary samples. As silver nitrate is added to the sample, the Ag^+ ions react with the chloride ions in the seawater to form the white precipitate AgCl, similar to the standardisation experiment:

$Ag^+ + Cl^- \rightarrow AgCl$

The silver ions can also react with the chromate ions in the indicator ($Cr_2O_7^{2-}$) to form chromate, which presents as a red pigment: $2 Ag^+ + Cr_2O_7^{2-} \rightarrow Ag_2Cr_2O_7$

①

When silver nitrate is titrated against the sample, the silver cations bond to the chloride anions to form the white precipitate. When there are no more chloride ions left to react with, the silver ions begin bonding to the chromate ions to form the potassium chromate indicator, turning the solution a reddish colour. The titrations depict 'how much' silver ions are required to react with all of the chloride ions in the sample. Therefore, when the solution goes red, it means that there are no longer chloride ions for the silver ions to bond with and therefore means the titration is complete.

Conclusion:

The results show an average declining trend for the concentration of chloride in the estuary as you move from the sea towards the river, as shown on the graph above. The chloride concentration was high at 0.538 mol L^{-1} on the seaside of the estuary (460 m from the sea) and gradually decreasing to a concentration of 0.254molL^{-1} near the river mouth (2340 m from the sea). The average trend shows that as the distance from the sea increases, the chloride concentration in the estuary decreases. We retrieved a single outlying result (sample 4: 1810 m from the sea) that does not follow the trend line that our other results follow. Omitting this result from the graph shows a clear linear trend line.

②

Discussion:

NaCl salt, when dissolved, separates into individual respective ions Na^+ and Cl^-. Water molecules surround the individual ions, arranged so the positive and negative dipoles of the H2O molecules attract to the oppositely charged ions. The more salt dissolved in water results in more of these ions present in the solution and therefore will present a higher concentration of Cl-, which means water with a higher salinity will have a higher chloride concentration. As outlined in the background information, seawater generally has a high chloride concentration due to its high amount of dissolved salts. Freshwater has little to no salt content and therefore a very low chloride ion concentration. The collision of fresh river water and seawater from the ocean in the estuary causes a gradient of chloride concentration, where seawater-dense areas in the river have higher concentrations of chloride and gradually decrease to little or no chloride in the river side. Our results display a clear trend line from a high chloride concentration of 0.538 mol L^{-1} only 460 m from the ocean opening to a low concentration of 0.254 mol L^{-1} 2.34 km from the ocean (very close to the river).

③

The independent variable ranges used was 460 m, 550 m, 810 m, 1810 m and 2340 m from the opening of the Gulf. These points were the most spread out data points possible, taking into account water accessibility (which was a limiting factor in where we collected our data). The dependent variable, chloride concentration, was measured using Mohr's Method of titration. We used images of our titrations to compare the orange colour between sets of

titrations to ensure we had a consistent end point between each titration, making the end point a variable we had to control. The chloride concentration of the samples is not affected by exposure to heat, sunlight or other environmental factors and does not denature over time. We stored them in clear, rinsed plastic bottles to avoid contamination from the bottle. We used the same concentration of silver nitrate throughout the investigation, and monitored this by standardising the silver nitrate solution before and after the investigation to show that the concentration stayed the same. We also collected the samples on the same day. This ensured variables such as weather were controlled and didn't affect the result. This could be a major source of error as variability of wind and precipitation could change the chloride concentration levels. Due to the differing densities of fresh and salt water, they do not mix readily. "*Wind is frequently the most important mixing tool for the fresh and saltwater*" (USEPA, 2013). The estuary is heavily influenced by wind for the brackish water mixing. Wind becomes an important factor into how well the two mix, so collecting samples on different days could alter the mixing of the two and therefore affect the results. Rain increases the freshwater in the estuary which decreases the average chloride concentration. It did not rain during our sample collection and therefore did not factor into our results, however, if we did not keep it controlled this would become a major error in case of precipitation differences. "In shallow, bar-built estuaries, direct rainfall […] may be as important to the water balance of the area as river and stream flow" (Pfafflin, J.R.). Therefore, the precipitation was controlled as throughout our sample collection there was no rainfall that would interfere with the results.

We took accuracy improving measures to ensure that validity of the data. Measuring all volumes at eye level using the bottom of the meniscus to reduce parallax error. If we didn't measure the volumes accurately then this would change the amount of substance we were adding which would then has a flow on effect to the titres we would record. This would mean that our final concentration of chloride ions in the sample would not be accurate. We had separate flasks for separate solutions to ensure none of the solutions used got contaminated or affected as this could cause the solutions to react before we wanted them to and therefore affect our results. We also made sure that we rinsed all the equipment with distilled water and then the solution we were adding to it to make sure that there were no contaminants in the glassware as these could react with our solutions and again affect our titres.

To ensure reliability of the data, we repeated the titrations for each sample at least four times and averaged to get a final, more accurate titre value. For standardisation titrations, we continued titrations until we got 3 concordant results (within 0.1 mL of each other). By repeating and averaging we ensured our results were reliable and not just a 'one-off' result. We had to modify the given method slightly in order to carry out the investigation. The method suggests using a 10:40 dilution of sample to distilled water, however, when we tried this method, the titre value was too high to get an accurate value from the burette, we decreased the dilution to 10:90 in order to be able to get a titre values low enough to complete with the given equipment. This was done to every sample to ensure that the titre values were not too small which would increase the margin of error of the titre samples and also so they weren't too large which would require us to refill the burette and therefore introduce another source of error.

A few limitations were encountered during sample collection and the investigation. We could not control the plant growth surrounding sample sites. As mentioned earlier, surrounding flora and fauna such as mangroves can affect the chloride concentrations in the estuary water. We could not select specific sites each with similar growth patterns due to the accessibility of each point.