REPORT TO THE CLIENT

By Angus Boyer, Gunit Singh

Group Members:

Student 1

Name: Angus Boyer

Student Number: 46415282

Student 2

Name: Gunit Singh

Student Number: 46425704

Please Note: Gunit Singh's Data has been used for the purposes of this collaboration.

MAY 3, 2022

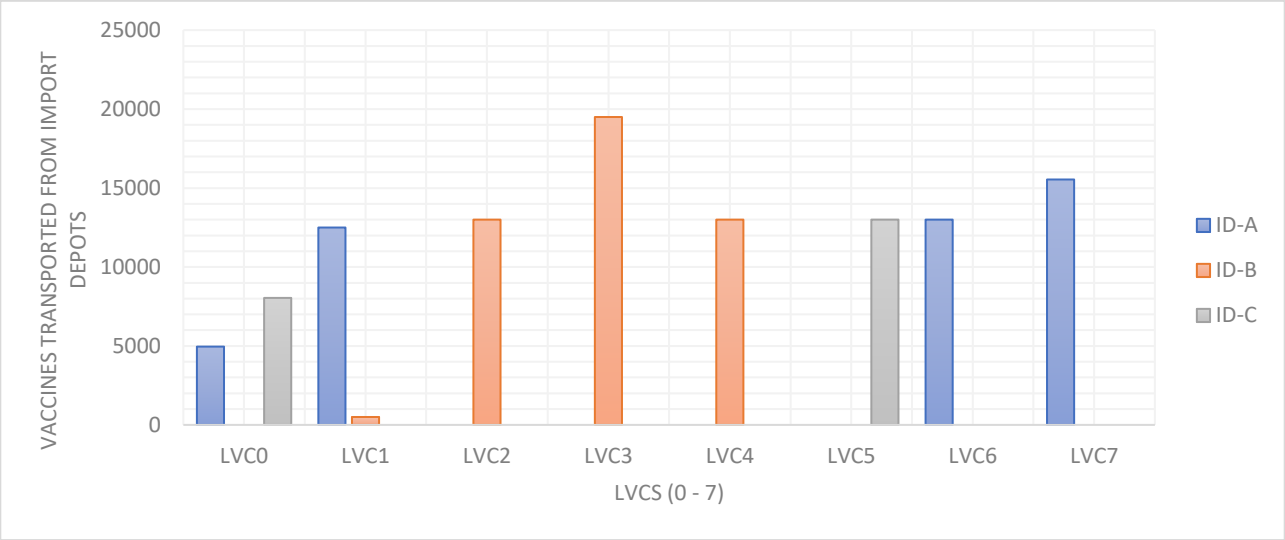
GUR-OBI PROJECT CONSULTANTS

CONTENTS

GRAPHS AND TABLES:

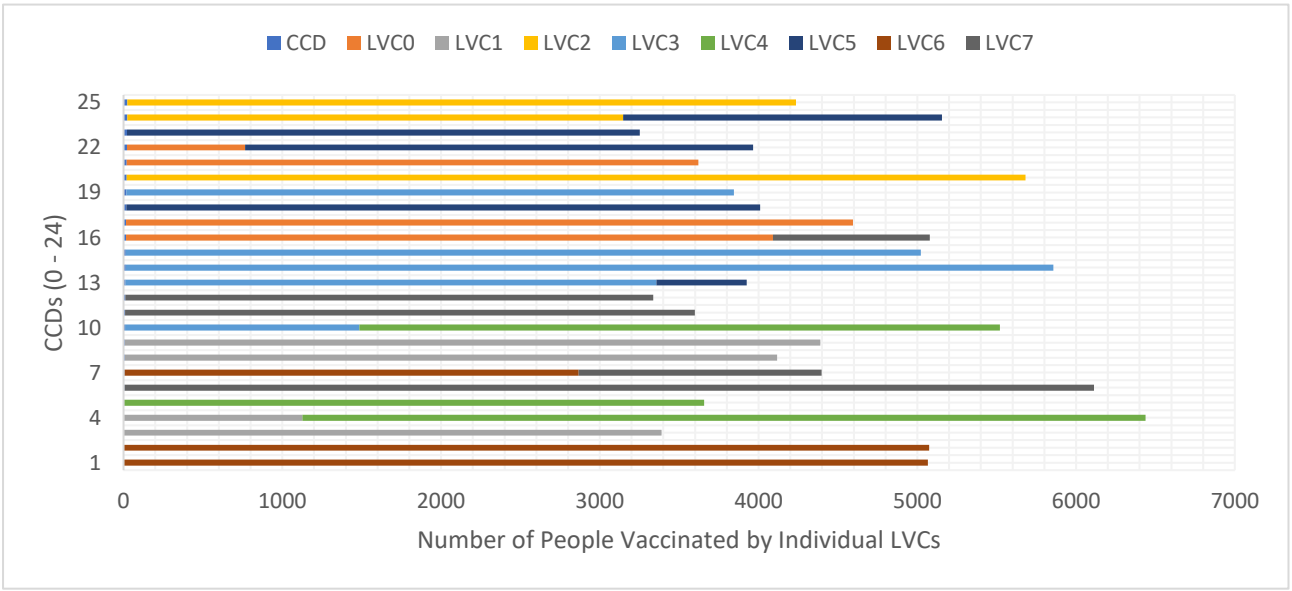
COMMUNICATION 6

Following the previous five communications, Pacific Paradise encountered a sudden refugee surge that was not reflected in the original CCD population numbers. Thus, a new vaccine distribution plan must be developed to best combat the spread of the disease in the region. To do this, it was suggested that each ID must have an increased capacity of 46,000 doses and some LVCs must be upgraded by 50% to ensure that there are enough vaccines for the connected CCDs. Through analysis of the problem, it was concluded that LVC3 and LVC7 should be upgraded as the populations of the CCDs connected to them are greater than the maximum capacity of an LVC. To upgrade these two LVCs, it would cost $2,168,000 but without this spending it would be impossible to meet the sudden increase in demand the new population of Pacific Paradise creates. Therefore, for the vaccine distribution plan, ID-A, ID-B and ID-C should have 46,000, 46,000 and 21042 doses imported to them respectively to then be transported to LVCs according to graph 1 and appendix table 1.



Graph 1 - Vaccine Transportation to Each LVC from all IDs for Communication 6

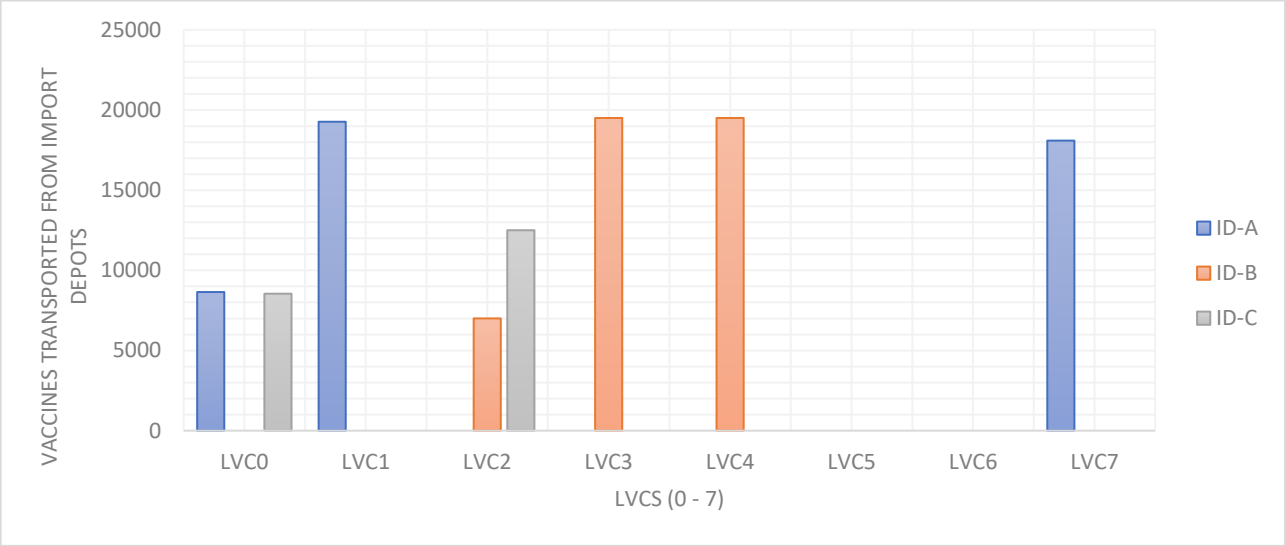
From here, the population of Pacific Paradise should be distributed to the LVC's such that they follow the prediction outlined in graph 2 and appendix table 2. By following this vaccine distribution plan, the whole operation is predicted to cost Pacific Paradise $19,319,005.72.



Graph 2 - CCD Vaccination by LVCs for Communication 6

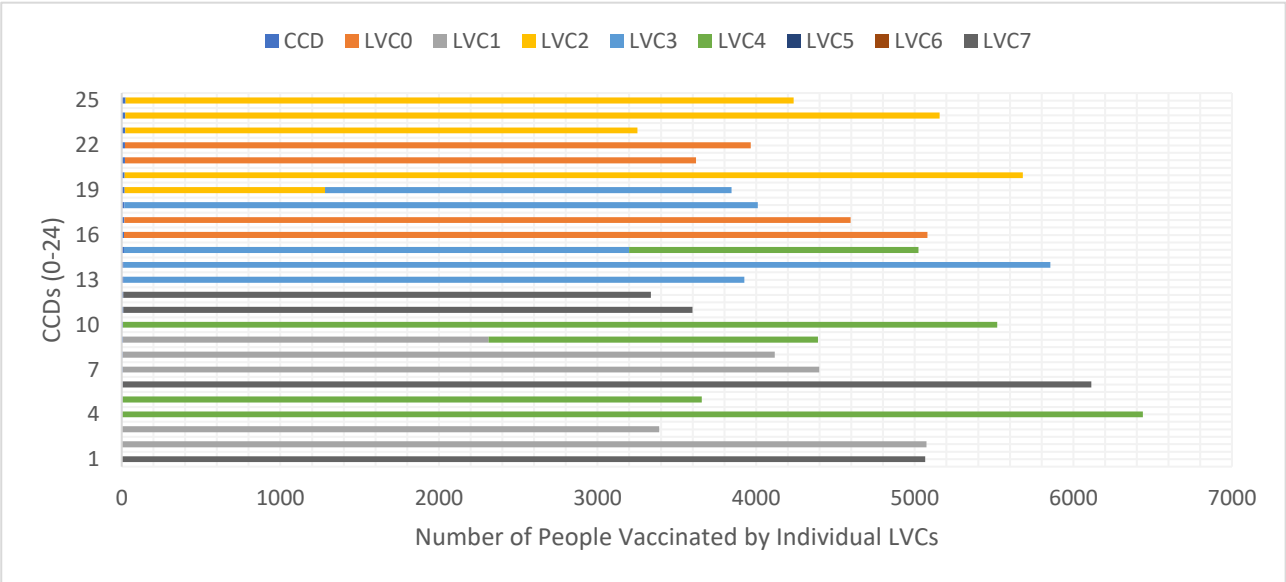
COMMUNICATION 7

Pacific Paradise realised that by closing one or more LVCs and upgrading one or more of the other LVCs, a tremendous amount of money for the vaccine distribution plan could be saved and requested that it be implemented into this version of the plan. Through GUROBI analysis, it was found that LVCs 0,1,2,3,4 and 7 should be upgraded while 5 and 6 should be closed. This action would result in a predicted total LVC upgrade cost of $8,070,000 with savings from closing LVC 5 and 6 being $9,628,000. Therefore, by closing down LVC 5 and 6 it was possible to pay for upgrades for all other LVCs while ensuring that the demands of all CCDs are met. Thus, to distribute the vaccines to Pacific Paradise each of the ID's will receive the same number of vaccines as in communication 6 (46,000, 46,000 and 21042 doses) but the number of vaccines delivered to each LVC will change. These ID to LVC changes is illustrated in graph 3 and appendix table 3.



Graph 3 - Vaccine Transportation to Each LVC from all IDs for Communication 7

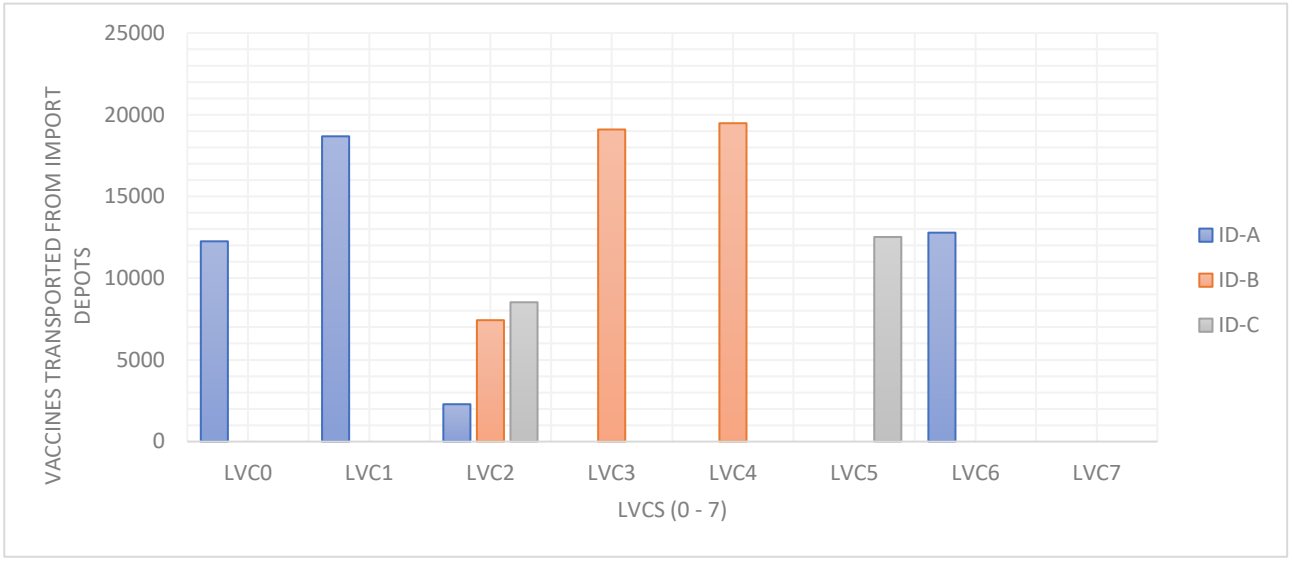
After transporting the vaccines to the LVCs from the IDs, all persons that were once allocated to LVC 5 and 6 are redirected to the other LVCs to ensure the populous does get vaccinated. This change in the number of people vaccinated at specific LVCs is depicted in graph 4 and appendix table 4. Interestingly, the only CCDs effected by this change are 0, 1, 6 ,12 ,17, 21, 22 and 23 with half of these CCDs already sharing LVCs for that population. Through this distribution plan, the cost of vaccinating all of Pacific Paradise decreases to $15,817,797.39.



Graph 4 - CCD Vaccination by LVCs for Communication 7

COMMUNICATION 8

For this communication, Pacific paradise decided that implementing a simplified CCD to LVC arrangement would be desirable and requested that it be added to the model for analysis and price estimation. This simplification involved ensuring that each CCD had one and only one LVC that the population could attend for a vaccination. Through investigation of this addition through GUROBI it became known that LVCs 0,1,2 and 3 must be upgraded, LVCs 4,5 and 6 are to remain unchanged and LVC 7 is to be closed. Due to this change in LVC availability, the model for ID to LVC vaccine transportation must be altered. However, the number of vaccines imported to the IDs remain the same. From here, the current distribution plan from IDs to LVCs are visualised in graph 5 and appendix table 5.

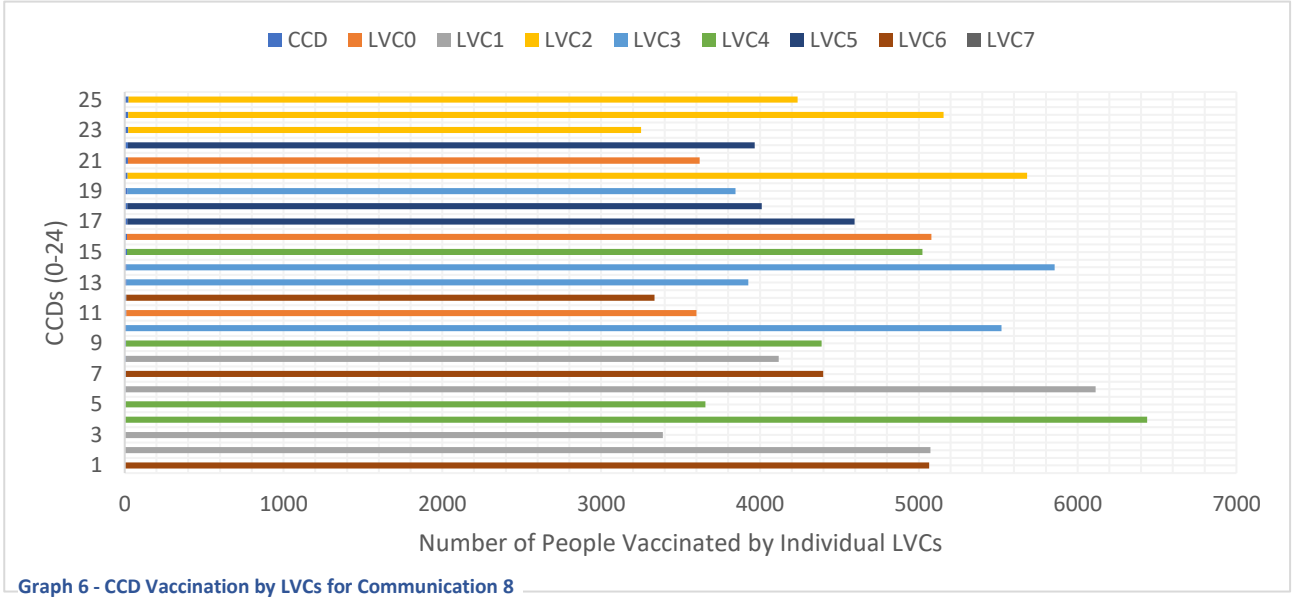


Graph 5 - Vaccine Transportation to Each LVC from all IDs for Communication 8

In terms of the plan from LVCs to CCDs, as the various CCD populations can no longer travel to many different LVCs, all CCDs go to only one LVC. Table 1 highlights the optimal CCD to LVC allocations to ensure the population of Pacific Paradise are vaccinated with the least cost. This allocation of CCDs to LVCs results in the following vaccination plan shown in graph 6 and appendix table 6 which would cost Pacific Paradise $17,967,286.28 to implement with $5,672,000 of this budget being used as upgrade costs of the LVCs and $5,113,000 being saved by closing LVC 7.

LVC	0	1	2	3	4	5	6	7
CCDs	10,15,20	1,2,5,7	19,22,23,24	9,12,13,18	3,4,8,14	16,17,21	0,6,11	N/A

Table 1 - CCD to LVC Allocations for Communication 8



Graph 6 - CCD Vaccination by LVCs for Communication 8

COMMUNICATION 9

With communication 9, Pacific Paradise requested that we analyse the potential use of other vaccine distribution strategies such that the virus may be eradicated from the community. Each of these strategies have their own probabilities for success with an associated cost, ranging from 95% to 99.5% effective. In order for a 'best' strategy to be chosen, the overall probability of eradicating the disease must be greater than 80% while also being cost effective for Pacific Paradise. After examination of the problem, it was confirmed that the best way to utilize the various strategies would be to use as many high probability cheap options as possible and then iterate through the other solutions until a cost effective, high probability assortment of strategies is found. The solution to this communication is represented below in table 2:

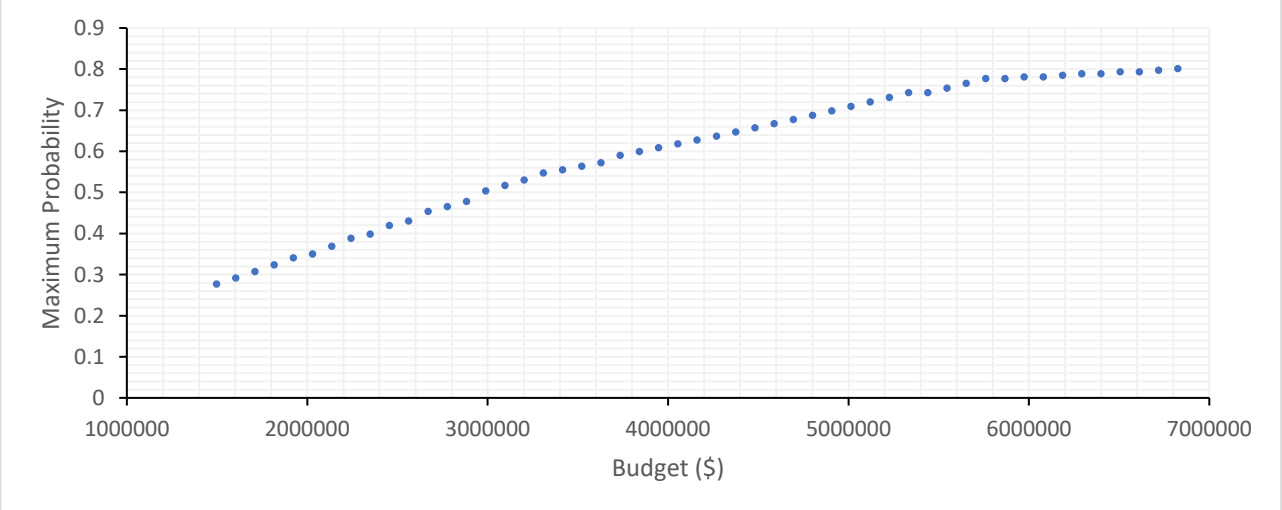
Probability	0.95	0.975	0.99	0.995
CCDs	N/A	N/A	0,1,2,3,4,5,6,7,10,11, 12,13,15,16,17,20,22, 23,24	8,9,14,18,19,21

Table 2 - Strategy Selected for Each CCD

This assortment of probabilities results in the cheapest possible vaccine distribution strategy, costing $6,825,000 and having an overall probability of virus eradication of 80.169%.

COMMUNICATION 10

For this communication, Pacific Paradise requested to know the maximum overall probability of eradication for a range of lower budgets and to be supplied with multiple options that would result in the highest probability of eradication from these lower budgets. The solution to this request was to determine a range of supposed probabilities for virus eradication and their associated costs from the total 4^{25} ways to allocate eradication methods to CCDs. From these choices, a significant amount would be probabilities larger than the previous 0.8 and thus be more expensive than the previous option. Therefore, these probabilities would be neglected as a potential choice along with any other probability that is outside the range of the various proposed budgets. The analysis found 50 different possible options with a range of different eradication probabilities and costs to implement to Pacific Paradise starting with the known uncommittable solution of 80% down to the lowest probability chance at ~27.74% and $1,496,000. To illustrate the range of options across the 50 budgets, graph 7 was created between the maximum probability and cost from communication 9 and the lowest probability and cost from taking the 0.95 eradication option for each CCD.



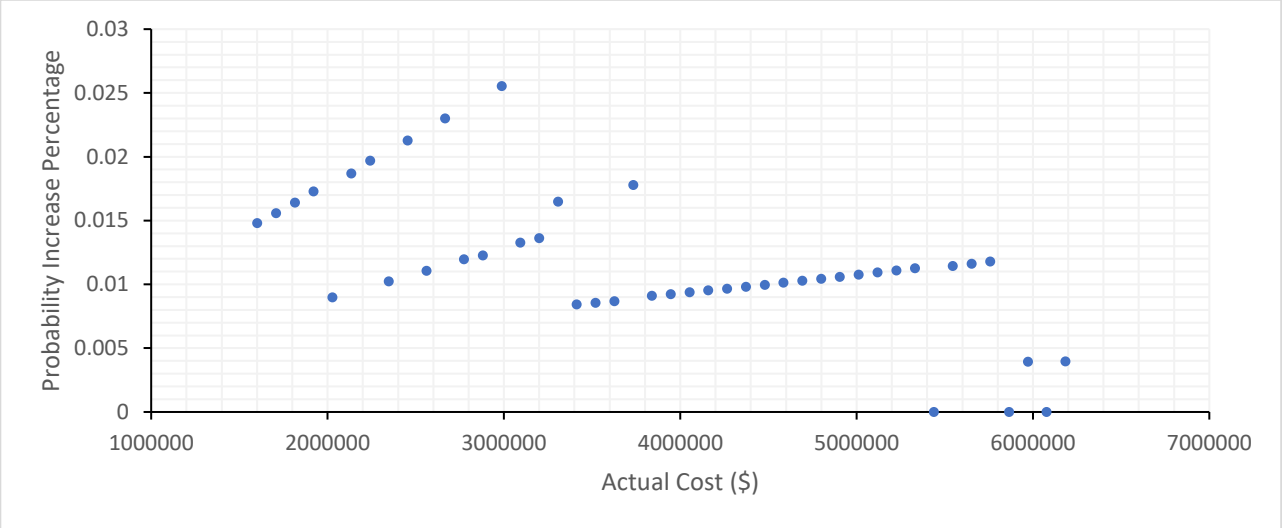
Graph 7 - Maximum Probability Against Budget

To create this graph, a multitude of budgets were formulated between $6,825,000 and $1,496,000 with a $106,580 price step increase. From this, the highest probabilities within a 0.1 probability range step for the various budget steps were chosen and are represented in table 3 as potential choices across the range.

Budget ($)	1,602,580	2,348,640	2,881,540	3,734,180	4,906,560	6,825,000
Probability	0.2923	0.3990	0.4786	0.5909	0.6990	0.8017

Table 3 - Chosen Budgets and their Associated Probabilities

However, this alone is not enough to adequately identify which budget should be chosen due to the logarithmic nature of the probabilities. This is indicated by the observed trend that as the probabilities increase, the cost for purchasing higher tier eradication methods does not necessarily return a much higher probability. Thus, there is an aspect of diminishing return as the probabilities approach 0.8. Therefore, graph 8 – which plots percentage probability increase against the budgets – was created to better understand which selection of budgets should be taken into consideration.



Graph 8 – Percentage Probability Increase Against Budget

From the graph it is clear that a high probability change for a low increase in budget is desirable as it implies that the money spent has higher value while also maintaining a high virus eradication probability relative to the cost. Clearly, this observation leads to a new selection of budget options seen in table 4 as only the budgets with the largest change in probability percentage for the least cost should be options for implementation into Pacific Paradise.

Budget ($)	2,135,480	2,455,220	2,668,380	2,988,120	3,734,180	5,546,040	5,759,200
Probability	0.3691	0.4203	0.4544	0.5041	0.5909	0.7544	0.7778

Table 4 – New Chosen Budgets and their Associated Probabilities

However, these proposed probabilities do not exemplify the actual cost that purchasing these eradication plans would entail. Therefore, extra analysis was undertaken to determine the true costs of all the purchasing methods. These actual budgets are detailed in table 5 with a graph that describes the actual cost against probability being found in the appendix.

Budget ($)	2,105,000	2,446,000	2,666,000	2,979,000	3,717,000	5,511,000	5,736,000
Probability	0.3691	0.4203	0.4544	0.5041	0.5909	0.7544	0.7778

Table 5 - Actual Budgets and their Associated Probabilities

Therefore, any of these eradication plan implementations could be chosen as they minimise the effects of logarithmic diminishing return. But Gur-Obi Project Consultants heavily suggests that the 0.7778, $5,736,000 option be chosen for implementation in Pacific Paradise due to the method having the highest probability before significant cost increases.

APPENDIX:

COMMUNICATION 6:

	LVC0	LVC1	LVC2	LVC3	LVC4	LVC5	LVC6	LVC7
ID-A	4958	12500	0	0	0	0	13000	15542
ID-B	0	500	13000	19500	13000	0	0	0
ID-C	8042	0	0	0	0	13000	0	0

Appendix Tables 1 - ID to LVC Transport amounts

CCD	LVC0	LVC1	LVC2	LVC3	LVC4	LVC5	LVC6	LVC7
0	0	0	0	0	0	0	5066	0
1	0	0	0	0	0	0	5073	0
2	0	3386	0	0	0	0	0	0
3	0	1123	0	0	5312	0	0	0
4	0	0	0	0	3653	0	0	0
5	0	0	0	0	0	0	0	6109
6	0	0	0	0	0	0	2861	1531
7	0	4110	0	0	0	0	0	0
8	0	4381	0	0	0	0	0	0
9	0	0	0	1476	4035	0	0	0
10	0	0	0	0	0	0	0	3589
11	0	0	0	0	0	0	0	3325
12	0	0	0	3345	0	569	0	0
13	0	0	0	5843	0	0	0	0
14	0	0	0	5009	0	0	0	0
15	4075	0	0	0	0	0	0	988
16	4579	0	0	0	0	0	0	0
17	0	0	0	0	0	3994	0	0
18	0	0	0	3827	0	0	0	0
19	0	0	5663	0	0	0	0	0
20	3600	0	0	0	0	0	0	0
21	745	0	0	0	0	3200	0	0
22	0	0	0	0	0	3229	0	0
23	0	0	3125	0	0	2008	0	0
24	0	0	4212	0	0	0	0	0

Appendix Tables 2 - Amount of People that get Vaccinated at each LVC from Specific CCDs

COMMUNICATION 7:

	LVC0	LVC1	LVC2	LVC3	LVC4	LVC5	LVC6	LVC7
ID-A	8646	19265	0	0	0	0	0	18089
ID-B	0	0	7000	19500	19500	0	0	0
ID-C	8542	0	12500	0	0	0	0	0

Appendix Tables 3 - ID to LVC Transport amounts

CCD	LVC0	LVC1	LVC2	LVC3	LVC4	LVC5	LVC6	LVC7
0	0	0	0	0	0	0	0	5066
1	0	5073	0	0	0	0	0	0
2	0	3386	0	0	0	0	0	0
3	0	0	0	0	6435	0	0	0
4	0	0	0	0	3653	0	0	0
5	0	0	0	0	0	0	0	6109
6	0	4392	0	0	0	0	0	0
7	0	4110	0	0	0	0	0	0
8	0	2304	0	0	2077	0	0	0
9	0	0	0	0	5511	0	0	0
10	0	0	0	0	0	0	0	3589
11	0	0	0	0	0	0	0	3325
12	0	0	0	3914	0	0	0	0
13	0	0	0	5843	0	0	0	0
14	0	0	0	3185	1824	0	0	0
15	5064	0	0	0	0	0	0	0
16	4579	0	0	0	0	0	0	0
17	0	0	0	3994	0	0	0	0
18	0	0	1263	2564	0	0	0	0
19	0	0	5663	0	0	0	0	0
20	3600	0	0	0	0	0	0	0
21	3945	0	0	0	0	0	0	0
22	0	0	3229	0	0	0	0	0
23	0	0	5133	0	0	0	0	0
24	0	0	4212	0	0	0	0	0

Appendix Tables 4 - Amount of People that get Vaccinated at each LVC from Specific CCDs

COMMUNICATION 8:

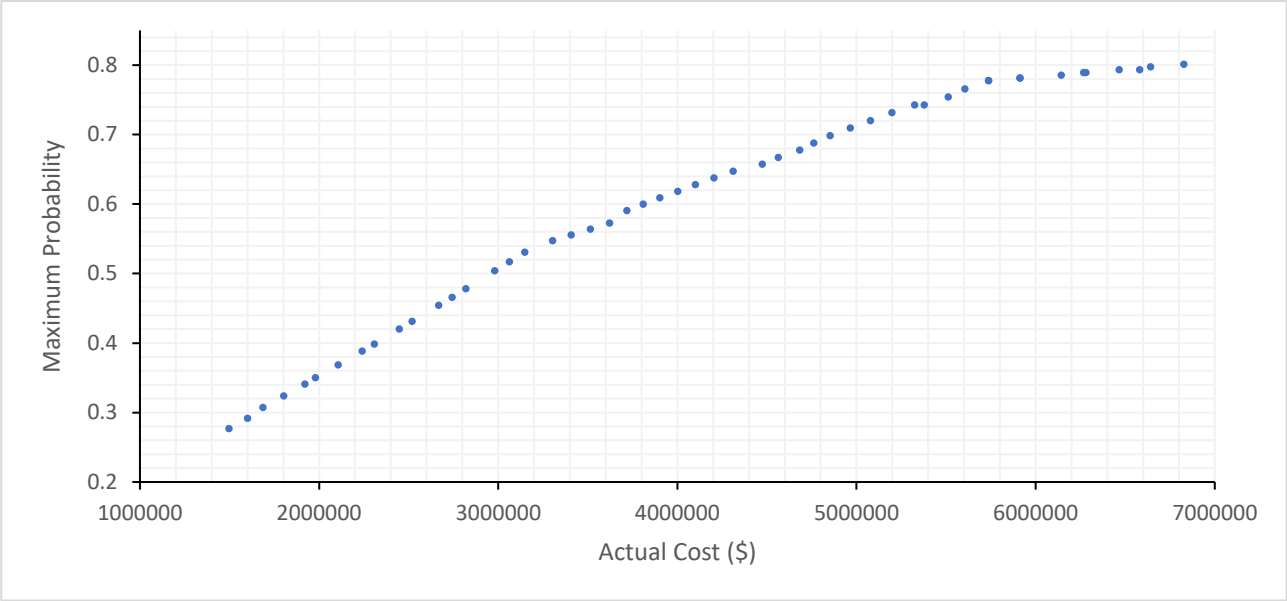
	LVC0	LVC1	LVC2	LVC3	LVC4	LVC5	LVC6	LVC7
ID-A	12253	18678	2286	0	0	0	12783	0
ID-B	0	0	7427	19095	19478	0	0	0
ID-C	0	0	8524	0	0	12518	0	0

Appendix Tables 5 - ID to LVC Transport amounts

CCD	LVC0	LVC1	LVC2	LVC3	LVC4	LVC5	LVC6	LVC7
0	0	0	0	0	0	0	5066	0
1	0	5073	0	0	0	0	0	0
2	0	3386	0	0	0	0	0	0
3	0	0	0	0	6435	0	0	0
4	0	0	0	0	3653	0	0	0
5	0	6109	0	0	0	0	0	0
6	0	0	0	0	0	0	4392	0
7	0	4110	0	0	0	0	0	0
8	0	0	0	0	4381	0	0	0
9	0	0	0	5511	0	0	0	0
10	3589	0	0	0	0	0	0	0
11	0	0	0	0	0	0	3325	0
12	0	0	0	3914	0	0	0	0
13	0	0	0	5843	0	0	0	0
14	0	0	0	0	5009	0	0	0
15	5064	0	0	0	0	0	0	0
16	0	0	0	0	0	4579	0	0
17	0	0	0	0	0	3994	0	0
18	0	0	0	3827	0	0	0	0
19	0	0	5663	0	0	0	0	0
20	3600	0	0	0	0	0	0	0
21	0	0	0	0	0	3945	0	0
22	0	0	3229	0	0	0	0	0
23	0	0	5133	0	0	0	0	0
24	0	0	4212	0	0	0	0	0

Appendix Tables 6 - Amount of People that get Vaccinated at each LVC from Specific CCDs

COMMUNICATION 10:



Appendix Graph 1 - Maximum Probability Against Actual Cost of Eradication Plan

Budget Set	Actual Cost (New budget)	Max Probability
1496000	1496000	0.277389573
1602580	1599000	0.292181122
1709160	1685000	0.307761418
1815740	1801000	0.324172518
1922320	1918000	0.341458726
2028900	1978000	0.350444482
2135480	2105000	0.369131618
2242060	2239000	0.38881523
2348640	2307000	0.399047209
2455220	2446000	0.420326042
2561800	2518000	0.431387254
2668380	2666000	0.454390591
2774960	2741000	0.466348238
2881540	2817000	0.47862056
2988120	2979000	0.504142571
3094700	3061000	0.517409481
3201280	3147000	0.531025519
3307860	3302000	0.547490453
3414440	3406000	0.555913383
3521020	3513000	0.564465896
3627600	3620000	0.573149987
3734180	3717000	0.590921028
3840760	3808000	0.600012121
3947340	3900000	0.609243077
4053920	4001000	0.618616047
4160500	4099000	0.628133217
4267080	4203000	0.637796805
4373660	4309000	0.647609063
4480240	4473000	0.65757228
4586820	4562000	0.667688776

4693400	4682000	0.677960911
4799980	4760000	0.688391079
4906560	4851000	0.698981711
5013140	4963000	0.709735276
5119720	5076000	0.72065428
5226300	5196000	0.731741269
5332880	5322000	0.742998827
5439460	5376000	0.742998827
5546040	5511000	0.754429578
5652620	5603000	0.766036187
5759200	5736000	0.777821359
5865780	5736000	0.777821359
5972360	5910000	0.78174975
6078940	5910000	0.78174975
6185520	6141000	0.785697981
6292100	6267000	0.789666153
6398680	6278000	0.789666153
6505260	6465000	0.793654366
6611840	6579000	0.793654366
6718420	6639000	0.797662721
6825000	6825000	0.801691321

Appendix Tables 7 - Budget Set, Actual Cost and Max Probability of all Options Found Through Gurobi