APPENDIX

G STAGE 1 WASTEWATER CONVEYANCE OPTIONS

COMOX VALLEY REGIONAL DISTRICT

LIQUID WASTE MANAGEMENT PLAN
STAGE 1 – CONVEYANCE LONG LIST STUDY

MARCH 15, 2019

LIQUID WASTE MANAGEMENT PLAN

STAGE 1 CONVEYANCE LONG LIST STUDY

COMOX VALLEY REGIONAL DISTRICT

REV 1

PROJECT NO.: 18P-00276-00
DATE: MARCH 15, 2019

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10 CONVEYANCE OPTIONS

10.1 OVERVIEW

10.1.1 EXISTING INFRASTRUCTURE CAPACITY AND CONDITION

The existing large diameter sanitary system on the south side of the Comox Valley Sewerage System (CVSS) consists of three pump stations, namely Courtenay, Jane Place Pump Stations (PS) and K'omox First Nation Pump Station. Courtenay PS (CPS) is located on Comox Road, near the Highway 19A bridge that crosses the Puntledge River and services Courtenay. Jane Place PS (JPS) is located in Jane Place, near the Comox Valley Marina, and it services the south area of Comox. The K'omox FN pump station is relatively small and connects directly into the forcemain. A combined gravity and pressurized system serves the north sections of the CVSS. This system consists of various gravity trunks including the Hudson and Greenwood trunks, and the Canadian Forces Base (CFB) pump station and the associated alignment to convey the sewage to the treatment plant. Figure 10-1 presents the existing CVSS infrastructure.

Currently, sewage is conveyed from the Courtenay PS in a 750 mm ø reinforced concrete pipe (Hyperscon) eastward along Comox Road and Bayside Road before routing into the foreshore, where sewage from JPS ties directly into and the diameter increases to 860 mm ø. The force main makes a turn northward at Goose Pit by crossing Hawkins Road and continues in the foreshore along Willmar Bluffs to the Comox Valley Water Pollution Control Centre (CVWPCC).

In 2002, the Comox Valley Regional District (CVRD) discovered significant sections of the forcemain in the foreshore were exposed without the protective cover material due to changes in soil deposition patterns and erosion. This was confirmed by Northwest Hydraulic Consultants Ltd. (NHC) in 2003, which was again reaffirmed in a 2016 study, *Risk Analysis of CVRD Force main on Balmoral Beach*, NHC, 2016. A risk analysis of the forcemain along the Bluffs was prepared by NHC in 2016. It was concluded that risk of forcemain failure exists along the beach and estimated a minimum 24-hour response time is required to fix any major failures to the forcemain. The study recommended that the affected portion of the forcemain to be relocated off-the-beach. The existing forcemain has an estimated 12 years remaining in the design life. A forcemain re-alignment study was performed in 2005 to assess various options for re-routing the forcemain, allowing the section along Willemar Bluffs to be decommissioned. This LWMP process is intended to further develop and select a preferred alignment.

Figure 10-1: Existing Force Main Alignment

Courtenay PS has a wet well and dry well configuration with 3 service and 1 standby 200 HP pumps. The lead-lag-pumps-off elevation in the wet well is -4.25 m. Jane PS has a wet well configuration with 2 service and 1 standby 77 HP pumps. The lead-lag-pump off elevation in the wet well is -3.25 m. Both pump stations are currently pumping sewage to the CVWPCC that has an inlet invert elevation at 8 m. Currently, sewage is conveyed at 0 m elevation as the force main travels along the foreshore. The hydraulics of the existing systems are presented in Table 10-1.

Table 10-1: Hydraulics of Existing System

Parameter	Courtenay PS	Jane Place PS
Static Head to CVWPCC (m)	17	15
Line Losses (m)	12	7
Total Head (m)	29	22

The achievable pumping capacities at either of the pump stations declines with the flowrate of the other pump station. Such that Courtenay PS is only able to achieve 380 L/s when JPS is operating at Peak Wet Weather Flow (PWWF), and JPS is only able to achieve 120 L/s when Courtenay PS is operating at PWWF. Figure 10-2 was derived from the 2013 AECOM report, demonstrating the operating rate range between the two pump stations.

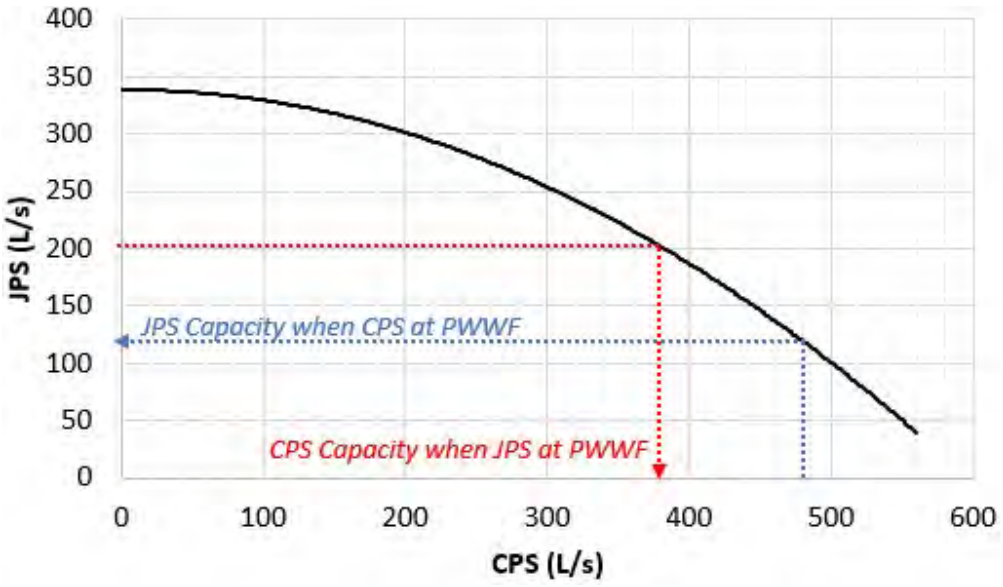


Figure 10-2: Existing System Performance

Given the current flow restrictions at either pump stations, upgrades to both pump stations are imminent in the near future to ensure management of the sanitary flows.

10.1.2 OPTIONS BOUNDARIES AND LIMITING FACTORS

The LWMP Stage 1 and Stage 2 studies are limited to the existing sewage conveyance systems between Courtenay, Comox and the CVWPCC. Consideration for future sewage from Area A's South Sewer project is not in this report but is addressed elsewhere. Furthermore, the current and future sewage that flows into the CFB Pump station via the Hudson and Greenwood trunk mains is not directly included in this evaluation. It is indirectly addressed through population growth off-sets where future loads to the foreshore system are adjusted to address sewage loads directed to through the CFB pump station.

10.2 STAGE 1 LWMP CONVEYANCE OPTIONS

The work team developed a preliminary long-list of options which could feasibly be used to convey sewerage from Courtenay, K'ómoks First Nation, and Comox to the CVWPCC. Options which were considered technically viable were carried forward to the Technical and Public Advisory Committees (TAC and PAC, respectively) for review and consideration. The option of a deep water marine alignment between the Courtenay PS and the CVWPCC was eliminated from further study by the team due to unacceptable fundamental technical and environmental issues. The remaining options were categorized as conveyance alignments and concepts and are described below:

1. Estuary Alignments – These alignments all include a section of forcemain in the estuary, specifically the inter-tidal zone. The objective of these options is to only eliminate the section of forcemain along Willmar Bluffs while minimizing impact of construction in the heavily populated and built-out sections of the CVRD.
2. Overland Alignments – These alignments are entirely overland and would generally follow existing road right-of-ways and be installed using traditional cut and cover trenching methods. These options minimize the need for construction in the estuary and allow for more conventional proven overland construction methods.
3. Tunnel Alignments – As a variation to overland options these alignments would incorporate a significant tunnelled section of pipe to off-set the hydraulic pressures necessary to overcome the natural topography between the CPS, JPS, and the CVWPCC.
4. North Side Concept – This option is a broad consideration for a conveyance system that includes an alignment which follows roads North of Comox Road between the CPS pump station and the CVWPCC, and a separate alignment conveying sanitary sewer directly from JPS to the CVWPCC.
5. Decentralized Treatment Concept – This option is a broad consideration which explores the idea that a portion of the sewage could be treated at a location at a wastewater treatment plant other than the CVWPCC rather than pumping the sewage to a common location. The effluent from this new wastewater treatment plant would then need to be conveyed to the location of the existing outfall at the CVWPCC.

The level of detail noted below is intended to broadly outline the above alignment and conveyance concepts. As such, detailed routings and facility locations are not included or discussed. Critical factors noted in the reviews include:

- General location and size of critical infrastructure such as pipes, pump stations, and treatment facilities;
- Technical challenges such as hydraulics, servicing capacity, and risks of construction and installation;
- Environmental considerations such as habitat impact, ecosystem impacts and proximity to known sensitive habitat;
- Archaeological considerations such as proximity to known sites;
- Operations and maintenance considerations including ability to isolate the system, shutdown operations, undertake repairs, flexibility, and complete spill management activities;
- Marine construction costs are carried at approximately double the terrestrial construction. This is based on historic comparison pricing along with the basis that working times are governed by tides which impact efficiency. Furthermore, excavation in the tidal zone is inefficient as the trench side slopes must be flatter due to sloughing of the saturated sands/mud soils;
- Land acquisition is not included in any price;
- Potential to expand the system to address future capacity; and
- Relative capital and operational costs.

With respect to cost estimates, the following is the basis of costing. Cost estimates are Class ‘D’ which can be defined as follows:

"A preliminary estimate which, due to little or no site information, indicates the approximate magnitude of cost of the proposed project, based on the client's broad requirements. This overall cost estimate may be derived from lump sum or unit costs for a similar project. It may be used in developing long term capital plans and for preliminary discussion of proposed capital projects." - EGBC Cost Estimate Definitions.

Furthermore, the following assumptions and criteria are incorporated into the cost estimates.

- Capital costs are based on the following:
  - Similar infrastructure installed in other communities, where available; and
  - Cost curves and project holistic unit rates.
- Operating costs are based on:
  - Estimated annual average power consumption for major equipment only;
  - Estimated relative labour effort between options; and
  - Asset renewal requirements.

The costs presented in this report do not include GST. These costs are only for the purpose of options comparison and discussion and are not suitable for budgeting. Detailed industry quotes, building sizing, layouts and such are not included or considered for this level of costing.

10.2.1 ESTUARY ALIGNMENTS

OPTION 1A – ESTUARY WITH LAZO HILL TUNNEL

Description:	The forcemain from CPS would continue directly to the CVWPCC along the estuary and across the peninsula, such that there is no in-line pump station; however, a tunnel through the Lazo Road hill would be used to reduce the required pressures in the system. Pending the tunnel elevation, a new pump station may be required in the general vicinity of the existing JPS. Detailed financial modelling of the tunnel length verses the pumping costs would need to be undertaken to optimize this option. In order to evaluate this option a tunnel elevation which does not result in a major pump station upgrade at CPS or JPS has been assumed. The existing JPS would be repurposed as a small subdivision pump station.
Advantages	» Subject to tunnel elevation, there may be potentially limited changes to existing pump stations hydraulics. » Maximizes useful life of estuary foreshore forcemain » Avoids construction of a forcemain through Comox. » Avoids the construction of additional large pump stations.
Disadvantages	» Involves work along and in the estuary, including environmentally and archaeologically sensitive areas. » Elevated maintenance and risk management needs due to proximity to marine environment. » Elevated construction and operational risk associated with a tunnel.
Technical Consideration	The system would be installed and operated very similar to the existing CVRD forcemain configuration. Required pumping head and pressure to convey sewage would be provided by separate pumping stations which would function nearly independently of each other. Any operational issues at any one station would be isolated in that collection zone. The hydraulic pressures can be reduced by tunnelling through the Lazo Road hill. The estimated system hydraulic operating pressure would be in the order of 40 to 50 meters. A significant technical challenge of this project is the inherent nature of the risks involved in tunnelling. As a result, a higher front-end effort may be required to map the geotechnical conditions along and around the proposed tunnelled alignment. Due to the uncertainty and risks surrounding tunnelling, a higher contingency would need to be accounted for during construction.
Environmental Considerations	Marsh habitat within the estuary area is recognized as major habitat for numerous water bird species. The estuary constitutes large intact salt marsh communities which have been noted as significant due to the increasing rarity on the east coast of Vancouver Island.
Archaeological Considerations	Significant sections of the pipe alignment would follow through existing archaeological sites, such as DkSf-4 and DkSf-44, however any estuary alignments should be assumed to encounter archeological sites.
Operational Considerations	Maintenance and repair of any inter-tidal section of pipe would be limited by tidal conditions. Furthermore, the ability to detect and control any leakage or sewage spilled due to a line break would be significantly limited and potentially improbable. As such the design of the system would have to recognize the risks associated with a failure and a higher material strength would have to be used to off-set this risk. Present day material standards for this application would utilize a continuously fused HDPE pipe retained below the seabed using concrete weights. As HDPE is susceptible to punctures due to boat anchors, additional concrete armouring would likely be required to protect the pipe from external damage. This configuration would add

significant costs to the project due to the relatively large diameter (~1,000 mm) and the resulting weight and size of a concrete collars. Furthermore, this protective armour would further limit any access to allow repair work to be completed in the future.

Subject to the methods used to install the tunnel section, repairs to any damaged section of pipe would not be possible as the system cannot be shut down or excavated to undertake repair work. A critical consideration during the tunnel design would be the choice of material used and if a carrier pipe arrangement is to be employed. The more cost-effective solution would utilize the same pipe to line the micro-tunnel as the fluid carrying pipe. However, this arrangement would not provide any indication of leakage or opportunity to repair the carrier pipe. An alternative arrangement is to utilize a separate casing and carrier pipe. This would result in a casing pipe with a diameter approximately 200 mm larger than the carrier pipe. This arrangement would provide containment should the carrier pipe leak and would permit replacement of the carrier pipe should alternative methods be available to temporarily convey the sewage around the tunnel during repairs.

Operational flexibility is provided by the independence of each of the pump stations. Future twinning of the alignment would be at elevated ri sks in the estuary as work would be completed in intertidal zones, similar to the initial construction. Future twinning of the tunnelled section would be at elevated risks as it would be installed parallel to the first tunnel section.

Infrastructure Elements

Description	Capital Cost	Investment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
New Courtenay - Moderate Pressure Increase	$10,500,000	2020	25	40%	625	3
Downgrade Jane	$2,362,500	2020	25	40%	25	0
New Jane - Moderate Pressure Increase	$3,850,000	2020	25	40%	250	3
Forcemain Tunnel through Lazo hill	$23,587,200	2020	60	100%	0	0
Estuary Courtenay to Lazo Hill	$38,133,480	2030	60	100%	0	0
Jane to forcemain	$1,108,800	2030	60	100%	0	0
Total Capital Cost	$79,541,980					

Cost Considerations

This option has an initial capital expenditure of around $80M which can be spread over a 10 year period as all components are not required simultaneously. , the majority of which accounts for the cost of the linear conveyance infrastructure between the CPS and the CVWPCC, particularly as construction must be partially completed in the foreshore conditions, leading to significantly higher construction costs.

Power requirements are low as the forcemain is maintained at a lower elevation. There are advantages based on operating cost for this option as it sustains a relatively low elevation throughout the length of the alignment.

Figures

Alignment is provided on Figure 10-3. Profile is provided on Figure 10-6.

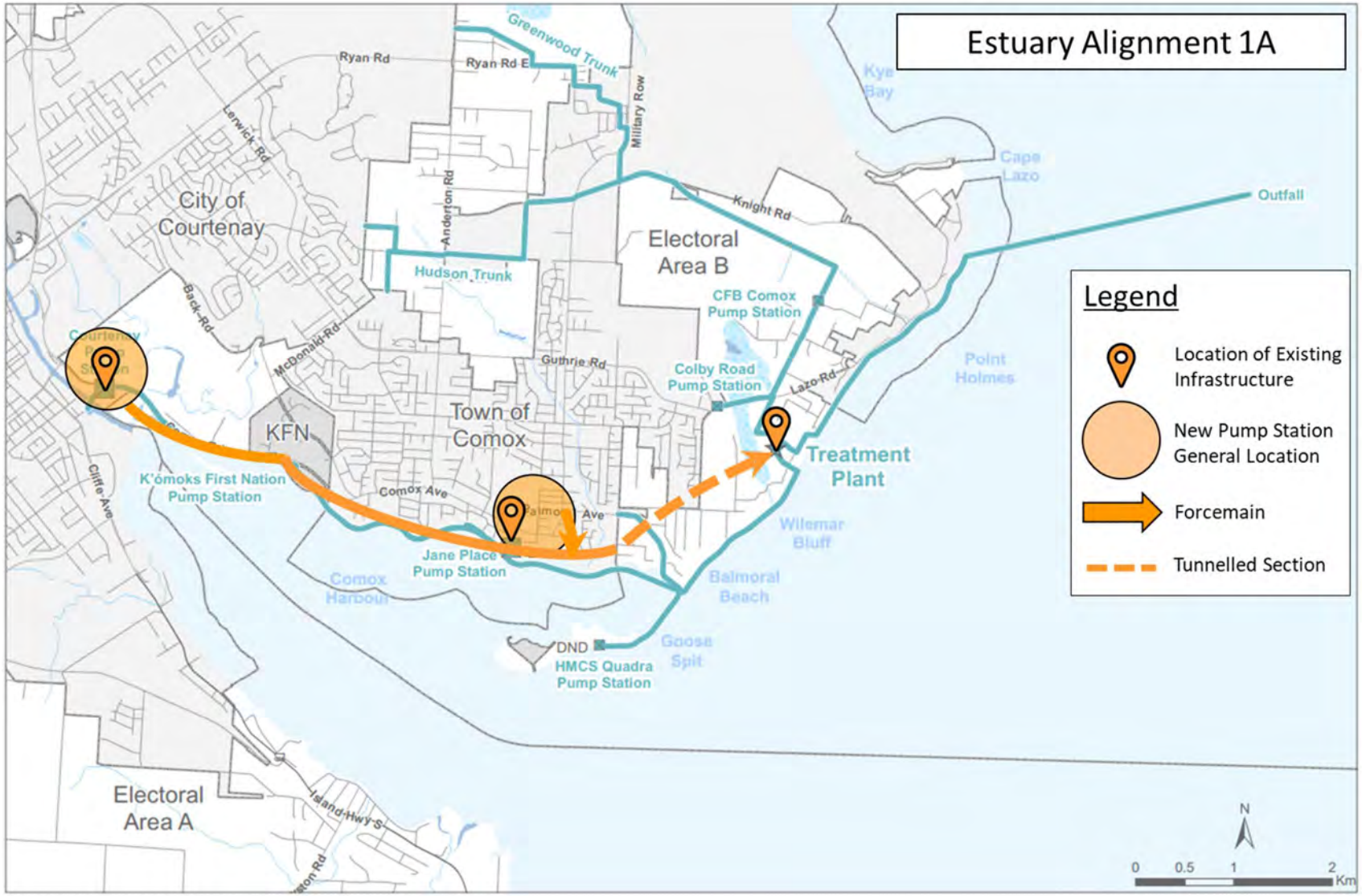


Figure 10-3: Estuary Alignment 1A

OPTION 1B – ESTUARY WITH LAZO HILL OVERLAND ROUTE	
Description:	The forcemain from CPS would continue directly to the CVWPCC in the estuary such that there is no in-line pump station. In order to overcome the Lazo Road hill, the CPS would be upgraded to provide sufficient forcemain pressure to overcome the height of land. As a result, the existing JPS would not be able to cope with this higher hydraulic requirement and therefore a new high head pump station would be required in the general vicinity of the existing JPS. This new facility would convey raw sewage into the forcemain between CPS and the CVWPCC. The existing JPS would be repurposed as a small subdivision pump station to convey sewage from the small catchments remaining outside of the service area of the new pump station.
Advantages	» Minimizes construction of a forcemain through Comox. » Only involves 2 large pump stations (JPS repurposed as local facility only).
Disadvantages	» Involves work along and in the estuary, including environmentally and archaeologically sensitive areas. » Elevated maintenance and risk management needed due to proximity to the marine environment.
Technical Consideration	The system would be installed and operated very similar to the existing CVRD forcemain configuration. Required pumping head and pressure to move sewage would be provided by separate pumping stations which would function nearly independently of each other. Any operational issues at any one station would be isolated in that collection zone. The required discharge pressures from the CPS would be in the order of 60 to 70 meters and be in excess of typical sanitary pumps. This would limit the available options for pumps or require a high pressure sanitary pump station configuration, specifically using two lower head pumps in direct series to achieve the necessary discharge pressures. The existing Jane Place property would not be large enough to accommodate a new pump station and as such a new property would be required to facilitate this new station. The existing JPS would still be required, albeit for a lower pumping capacity as it would only service the properties which would not gravity drain to the new pump station.
Environmental Considerations	Marsh habitat within the estuary area is recognized as major habitat for numerous water bird species. The estuary constitutes large intact salt marsh communities which have been noted as significant due to the increasing rarity on the east coast of Vancouver Island.
Archaeological Considerations	Significant sections of the pipe alignment would follow through existing archaeological sites, such as DkSf-4 and DkSf-44, however any estuary alignments should be assumed to encounter archeological sites.
Operational Considerations	Maintenance and repair of any inter-tidal section of pipe would be limited by tidal conditions. Furthermore, the ability to detect and control any leakage or sewage spilled due to a line break would be significantly limited and potentially improbable. As such the design of the system would have to recognize the risks associated with a failure and a higher material strength would have to be used to off-set this risk. Present day material standards for this application would utilize a continuously fused HDPE pipe retained below the seabed using concrete weights. As HDPE is susceptible to punctures due to boat anchors, additional concrete armouring would likely be required to protect the pipe from external damage. This configuration would add significant costs to the project due to the relatively large diameter (~1,000 mm) and the resulting weight and size of a concrete collars. Furthermore, this protective armour would further limit any access to allow repair work to be completed in the future.

The selection of a new property for the JPS provides an opportunity to consider future sea-level changes and increased resilience of this station to climate change.

Operational flexibility is provided by the independence of each of the pump stations. Future twinning of the alignment would be at elevated risks in the estuary as work would be completed in intertidal zones, similar to the initial construction. Excavation and installation of a twinned section of pipe in the overland portion would not be a significant challenge.

Infrastructure Elements

Description	Capital Cost	Investment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
New Courtenay - Moderate Pressure Increase	$10,500,000	2020	25	40%	1125	3
Downgrade Jane	$2,362,500	2020	25	40%	25	0
New Jane - Moderate Pressure Increase	$3,850,000	2020	25	40%	425	3
Overland Lazo Hill to CVWPCC	$5,913,600	2020	60	100%	0	0
Estuary Courtenay to Jane	$32,728,080	2020	60	100%	0	0
Jane to forcemain	$1,108,800	2020	60	100%	0	0
Old Jane to New Jane	$51,744	2020	60	100%	0	0
Total Capital Cost	$56,514,724					

Cost Considerations

This option has a capital cost of around $57M, a significant part of which accounts for the cost of the linear conveyance infrastructure between the CPS and the CVWPCC, particularly as construction must be partially completed in the foreshore conditions, leading to higher construction costs. There is also a need for the construction of a new moderate-pressure CPS and a new moderate-pressure JPS. This option requires the downgrading of the JPS and continued asset maintenance for a total of three pump stations, however the downgraded JPS will require minimal maintenance efforts.

Compared to alignment 1A, there are no advantages based on operating cost for this option as it has a higher pumping head requirement since the conveyance system needs to overcome the height of land at Lazo hill.

Figures

Alignment is provided on Figure 10-4. Profile is provided on Figure 10-6.

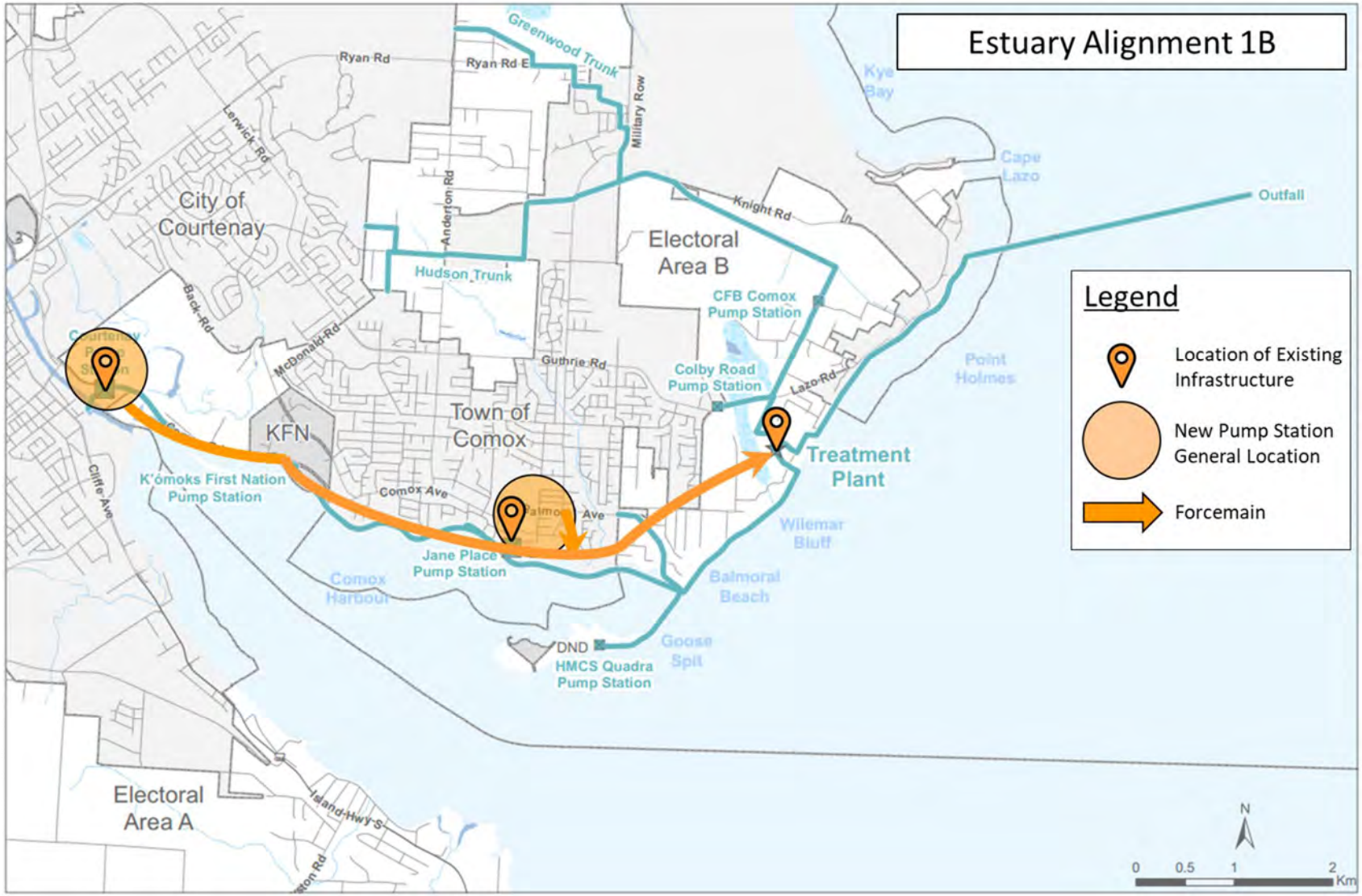


Figure 10-4: Estuary Alignment 1B

OPTION 1C – ESTUARY WITH A NEW IN-LINE PUMP STATION

Description:	This option includes the construction of a new pump station facility located between Comox and the Lazo Road hill, at the Beech Street property. This would be an inline facility which receives raw sewage from the CPS/JPS discharge forcemain. The new pump station would pump the sewage over the Lazo Road hill and the sewage would flow to the CVWPCC. The JPS would tie-in to the CPS discharge forcemain at a location upstream of the new pump station. The elevation of the new pump station would have to be low enough to permit the JPS to pressures at the forcemain connection.
Advantages	» Minimize hydraulic changes to existing CPS and JPS. » Maximize useful life of existing foreshore forcemain. » Avoids construction of a forcemain through Comox.
Disadvantages	» Pump stations in series and single point of complete failure of sewage conveyance system. » Involves operation and maintenance of 3 large pump station. » Involves work along and potentially in the estuary, including environmentally and archaeologically sensitive areas. » Elevated maintenance and risk management needs due to proximity to marine environment.
Technical Consideration	Unlike the existing CVRD pump station configuration, this station would be in-line with existing pump stations and all sewage would pass through this facility. Total capacity of this station would be the combined flow from CPS and JPS. To address the operational risks with this single point of operation, a very high level of system redundancy and operational flexibility would be required. This could include balancing storage or double redundancy on major systems such as power supply and piping systems. This arrangement limits the need to change the existing system pressure as the new station would be located to accommodate the existing CPS and JPS hydraulic operations. The discharge pressure required from this station would need to overcome the Lazo road hill of approximately 50m.
Environmental Considerations	Marsh habitat within the estuary area is recognized as major habitat for numerous water bird species. The estuary constitutes large intact salt marsh communities which has been noted as significant due to the increasing rarity on the east coast of Vancouver Island.
Archaeological Considerations	Significant section of the pipe alignment would follow through existing archaeological sites, such as DkSf-4 and DkSf-44.
Operational Considerations	Maintenance and repair of any inter-tidal section of pipe would be limited to tidal conditions. Furthermore, isolation and collection of leaking sewage would not be possible in intertidal zones. Repair and restoration of any damaged sections of pipe in the overland portions would be completed following common practices and could be completed quickly, with limited long-term impacts and completed using readily available local resources. Operation of the entire CVRD sewage system would be contingent on the operation of this new pump station. Overflows at this location would not be permitted and the provision of balancing storage would be strongly encouraged to provide an opportunity for maintenance activities or emergency responses to any faults.

Infrastructure Elements

Description	Capital Cost	Investment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
Upgrade Courtenay (Capacity and AM driven)	$4,200,000	2020	25	40%	375	3
Upgrade Jane (Capacity and AM driven)	$3,150,000	2020	25	40%	150	3
New In-line Pump Station	$12,040,000	2020	25	40%	1075	3
Overland Lazo Hill to CVWPCC	$5,913,600	2020	60	100%	0	0
Estuary Courtenay to Lazo Hill	$38,133,480	2030	60	100%	0	0
Jane to forcemain	$1,108,800	2030	60	100%	0	0
Total Capital Cost	$64,545,880					

Cost Considerations

This option has a moderate initial capital expenditure of around $65M, a significant part of which accounts for the cost of the linear conveyance infrastructure between the CPS and the CVWPCC, particularly as construction must partially be completed in the foreshore conditions, leading to significantly higher construction costs. There is also a need for the construction of a new in-line pump station west of the Lazo Road hill with sufficient capacity to convey all of Courtenay and Comox's sewage. This option requires the continued asset maintenance for a total of three pump stations.

Similar to option 1B, and compared to alignment 1A, there are no advantages based on operating cost for this option as it has a higher pumping head requirement since the conveyance system needs to overcome the height of land at Lazo Road hill.

Figures

Alignment is provided on Figure 10-5. Profile is provided on Figure 10-6.

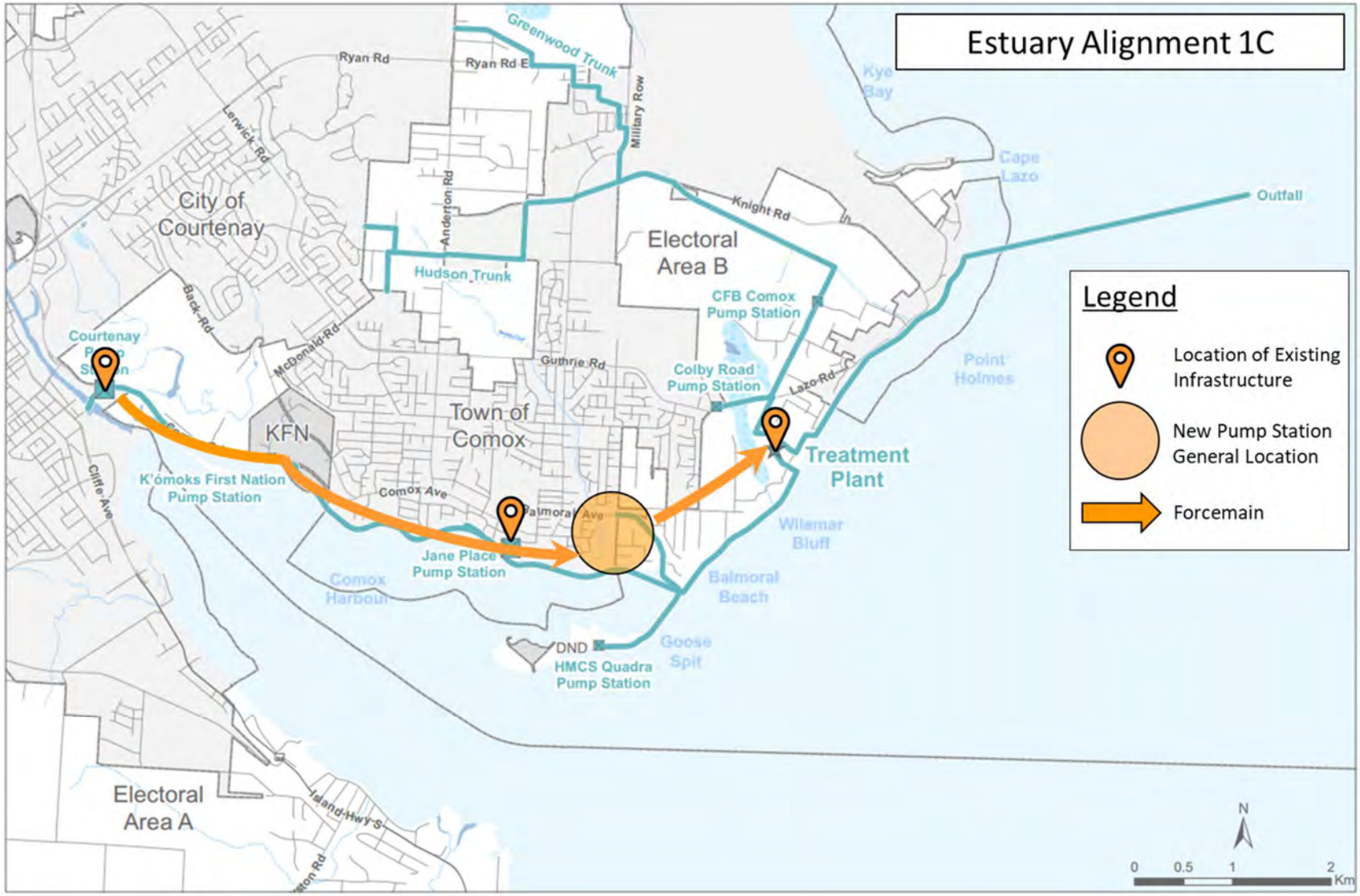
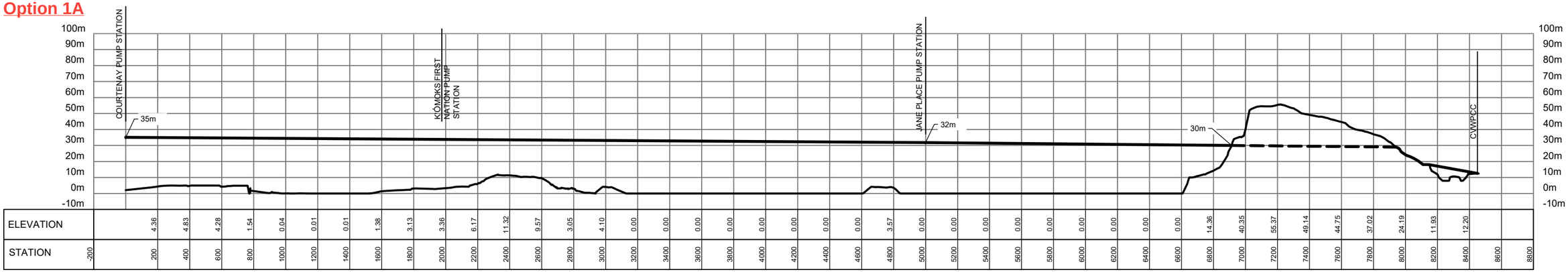


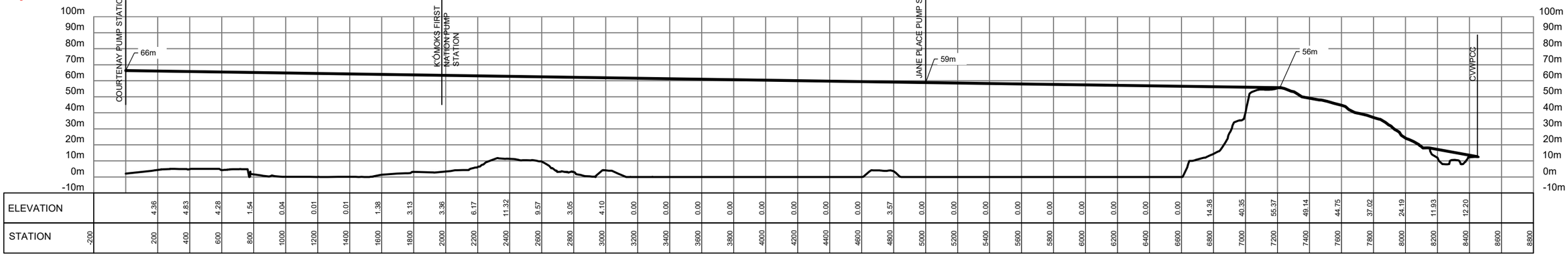
Figure 10-5: Estuary Alignment 1C

Option 1A



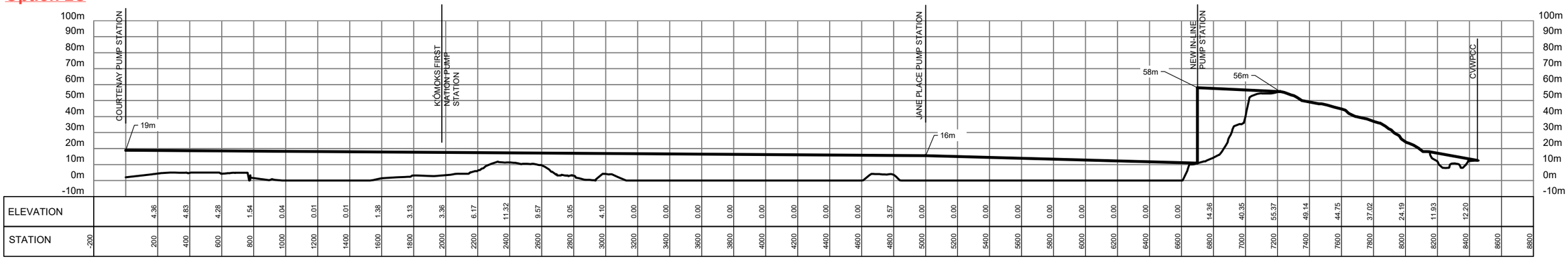
STATION	-200	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000	5200	5400	5600	5800	6000	6200	6400	6600	6800	7000	7200	7400	7600	7800	8000	8200	8400	8600	8800
ELEVATION		4.36	4.83	4.28	1.54	0.04	0.01	0.01	1.38	3.13	3.36	6.17	11.32	9.57	3.05	4.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.36	40.35	55.37	49.14	44.75	37.02	24.19	11.93	12.20		

Option 1B



STATION	-200	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000	5200	5400	5600	5800	6000	6200	6400	6600	6800	7000	7200	7400	7600	7800	8000	8200	8400	8600	8800
ELEVATION		4.36	4.83	4.28	1.54	0.04	0.01	0.01	1.38	3.13	3.36	6.17	11.32	9.57	3.05	4.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.36	40.35	55.37	49.14	44.75	37.02	24.19	11.93	12.20		

Option 1C



STATION	-200	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000	5200	5400	5600	5800	6000	6200	6400	6600	6800	7000	7200	7400	7600	7800	8000	8200	8400	8600	8800
ELEVATION		4.36	4.83	4.28	1.54	0.04	0.01	0.01	1.38	3.13	3.36	6.17	11.32	9.57	3.05	4.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.36	40.35	55.37	49.14	44.75	37.02	24.19	11.93	12.20		

OPTION 1
PROFILE BETWEEN CH: -200.00 AND 8800.00
1:12500(H) 1:1250(V) AT A1

1:12500 @ ANSI D 0 200
1:500 @ ANSI D 0 5 10 15 20 25 30 35 40 45 50 m

Original Sheet Size ANSI D [22"x34"]

Figure 10-6: Option 1 Hydraulic Profiles

10.2.2 OVERLAND ALIGNMENTS

OPTION 2A – OVERLAND FORCEMAIN

Description:	This alignment would involve installation of a new forcemain overland from the CPS towards the CVWPCC. This forcemain would pass over the Comox Road hill. Due to the change in discharge pressure, a significant upgrade or rebuild would be required at the CPS. The forcemain from CPS would continue directly to the CVWPCC such that there is no in-line pump station. In order to overcome both the Comox Road hill and the Lazo Road hill, the CPS would be upgraded to meet the necessary hydraulic pressure. As a result, the existing JPS would not be able to cope with this higher hydraulic requirement and therefore a new higher head pump station would be required in the general vicinity of the existing JPS. This new facility would convey raw sewage into the forcemain between CPS and the CVWPCC. The existing JPS would be repurposed as a small subdivision pump station to convey sewage from the small catchments remaining outside of the service area of the new pump station.
Advantages	» No pipe in the estuary mitigating environmental and archaeological risks. » All pipe and structures would be on-land to maximize maintenance accessibility. » Only involves 2 large pump stations (JPS repurposed as local facility only).
Disadvantages	» Significant hydraulic changes to the CPS and JPS. » Construction of new conveyance system through an area with significant existing infrastructure and high traffic.
Technical Consideration	The system would operate similar to the existing CVRD sewage system where a single forcemain conveys sewage directly to the CVWPCC. The two pump stations would operate independently of each other. The most significant variation from the existing system is that the forcemain would follow the natural topography of the land and therefore the pump station would need to be relatively high pressure in order to overcome the existing hills. As the flow rate through these stations is reasonably high, there are options available to provide the necessary discharge pressures, however the selection of options becomes reduced at these pressures, which are estimated to be in the order of 60 to 70 m of pressure. The overland forcemain would be installed using standard cut-and-cover installation methods with the general intention of following existing roadways. This approach is very common and as such, reasonably well established. Additional complexities would involve relocating existing utilities and restoration of surface roadways, sidewalks, and similar features. Due to the nature of sanitary systems, the depth of excavation would be set to be below the existing water systems.
Environmental Considerations	Overland portions routed along existing roadways would have limited environmental impacts. Areas with significant adjacent trees could be potentially damaged due to root damage.
Archaeological Considerations	The intention would be to remain within existing areas of disturbance, so no unique archaeological impacts are likely.

Operational Considerations	Maintenance of the higher head pump station would be similar to that of the existing facilities, however there is a reduced selection of pump options. In addition, a typical higher head sewage pump operates at reduced efficiency compared to lower head pumps. Maintenance and repair on the overland forcemain would be completed using well established repair methods based on open excavation. Should a pipe failure occur, standard methods of isolation and pumping off-site using a vacuum truck would be employed.

Infrastructure Elements

Description	Capital Cost	Investment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
New Courtenay - Moderate Pressure Increase	$10,500,000	2020	25	40%	1050	3
Downgrade Jane	$2,362,500	2020	25	40%	25	0
New Jane - Moderate Pressure Increase	$3,850,000	2020	25	40%	425	3
Overland Courtenay to Jane (New or Existing)	$16,493,400	2020	60	100%	0	0
Overland Jane to Lazo Hill	$4,851,000	2020	60	100%	0	0
Overland Lazo Hill to CVWPCC	$5,913,600	2020	60	100%	0	0
Jane to forcemain	$1,108,800	2020	60	100%	0	0
Total Capital Cost	$45,079,300					

Cost Considerations	This option has a relatively low initial capital expenditure at $45M, as construction of the linear conveyance infrastructure is mostly completed overland in already-disturbed areas, leading to lower construction costs. There is need for the construction or re-construction of two new pump stations. This option requires the continued asset maintenance for a total of three pump stations, however the downgraded JPS will require minimal maintenance efforts. There is no operating cost advantage to this option as it requires pumping of the raw sewage over the heights of land at both Comox Road and Lazo Road hills, resulting in significant financial operating costs.
Figures	Alignment is provided on Figure 10-7. Profile is provided on Figure 10-9.

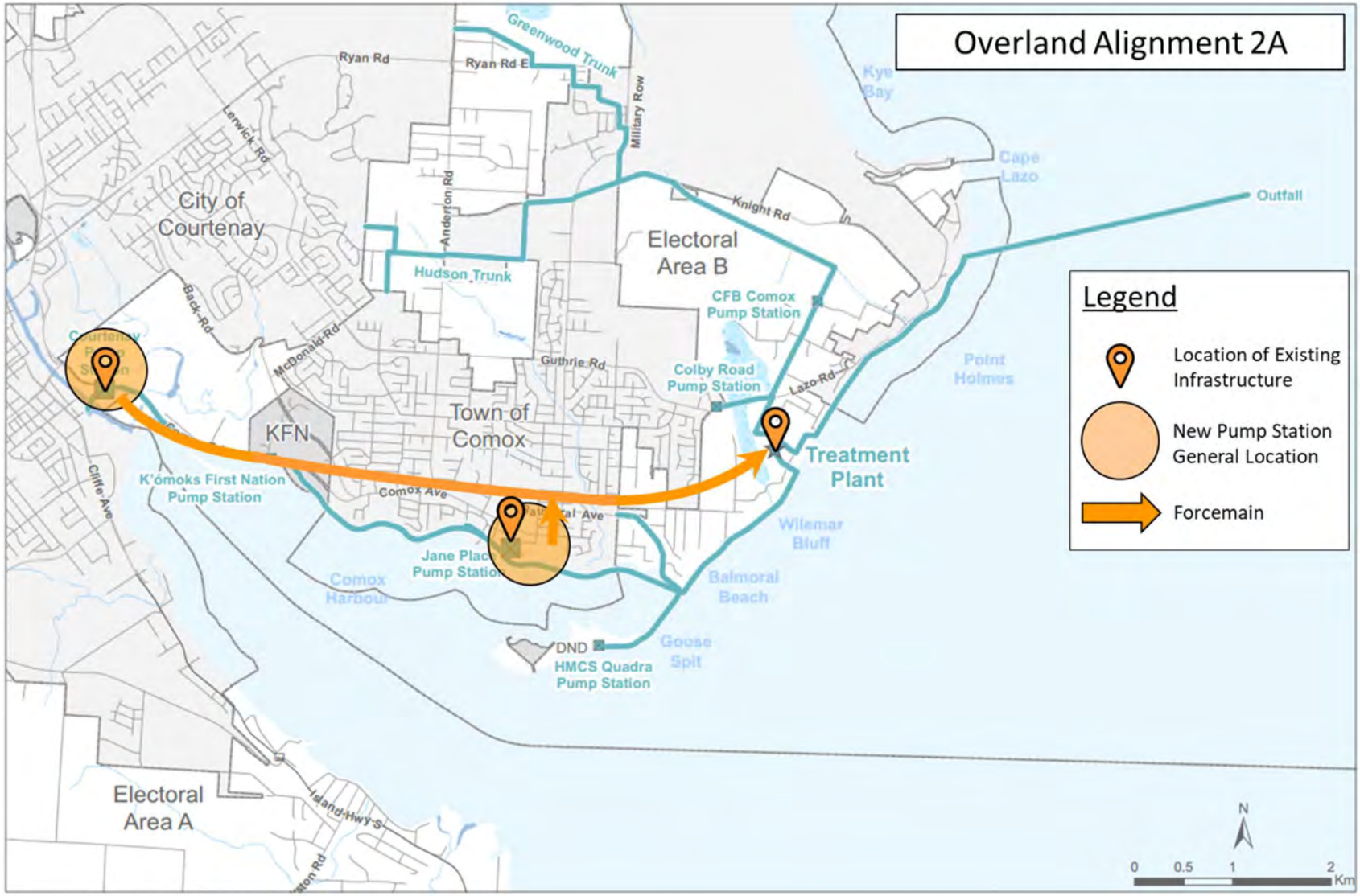


Figure 10-7: Overland Alignment 2A

OPTION 2B – OVERLAND FORCEMAIN WITH IN-LINE PUMP STATION

Description:	This alignment would involve installation of a new forcemain overland from CPS towards a new in-line pump station. The forcemain from CPS would convey raw sewage over the Comox Road hill and down into a new pump station, connected in series, between the JPS and Lazo Road heights of land, at the Beech Street property. The elevation of the new pump station would need to be at an elevation to suit the existing discharge pressures from the JPS. From the new pump station, the raw sewage would be conveyed over the Lazo Road hill to the CVWPCC.
Advantages	» No pipe in the estuary mitigating environmental and archaeological risks. » All pipe and structures would be on-land to maximize maintenance accessibility. » Minimize hydraulic changes to existing JPS.
Disadvantages	» Pump in series and single point of complete failure of sewage conveyance system. » Involves operation and maintenance of 3 large pump station, one of high criticality. » Significant hydraulic changes to the CPS. » Construction of new conveyance system through an area with significant existing infrastructure and high traffic.
Technical Consideration	Unlike the existing CVRD pump station configuration this new system would include an in-line pump station where all sewage would pass. Total capacity of this station would be the combined flow from CPS and JPS. To address the operational risks with this single point of operation a very high level of system redundancy and operational flexibility would be required. This could include balancing storage or double redundancy on major systems such as power supply and piping systems. This arrangement limits the need to change the existing JPS pressure as the new station would be located to accommodate the existing JPS hydraulic operations. The discharge pressure required from this station would need to overcome the Lazo road hill. The overland forcemain would be installed using standard cut-and-cover installation methods with the general intention of following existing roadways. This approach is very common and as such, reasonably well established. Additional complexities would involve relocating existing utilities and restoration of surface roadways, sidewalks and similar features. Due to the nature of sanitary systems the depth of excavation would be set to be below the existing water systems.
Environmental Considerations	Overland portions routed along existing roadways would have limited environmental impacts. Areas with significant adjacent trees could be potentially damaged due to root damage.
Archaeological Considerations	The intention would be to remain with existing areas of disturbance, so no unique archaeological impacts are likely.
Operational Considerations	Maintenance of the higher head pump station would be similar to that of the existing facilities, however there is a reduced selection of pump options. In addition, a typical higher head sewage pump operates at reduced efficiency compared to lower head pumps. Operation of the entire CVRD sewage system would be contingent on the operation of this new pump station. Overflows at this location would not be permitted and the provision of balancing storage would be strongly encouraged to provide an opportunity for maintenance activities or emergency responses to any faults.

Maintenance and repair on the overland forcemain would be completed using well established repair methods based on open excavation. Should a pipe failure occur standard methods of isolation and pumping off-site using a vacuum truck would be employed.

Infrastructure Elements

Description	Capital Cost	Investment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
New Courtenay - Moderate Pressure Increase	$10,500,000	2025	25	40%	750	3
Upgrade Jane (Capacity and AM driven)	$3,150,000	2020	25	40%	300	3
New In-line Pump Station	$12,040,000	2020	25	40%	1075	3
Overland Courtenay to Lazo Hill	$26,999,280	2030	60	100%	0	0
Overland Lazo Hill to CVWPCC	$5,913,600	2020	60	100%	0	0
Total Capital Cost	$58,602,880					

Cost Considerations

This option has moderate initial capital expenditure of $59M, as construction of the linear conveyance infrastructure is mostly completed overland in already-disturbed areas, leading to lower construction costs. There is need for the construction of a new CPS and a new in-line pump station west of the Lazo Road hill. This option requires the continued asset maintenance for a total of three pump stations.

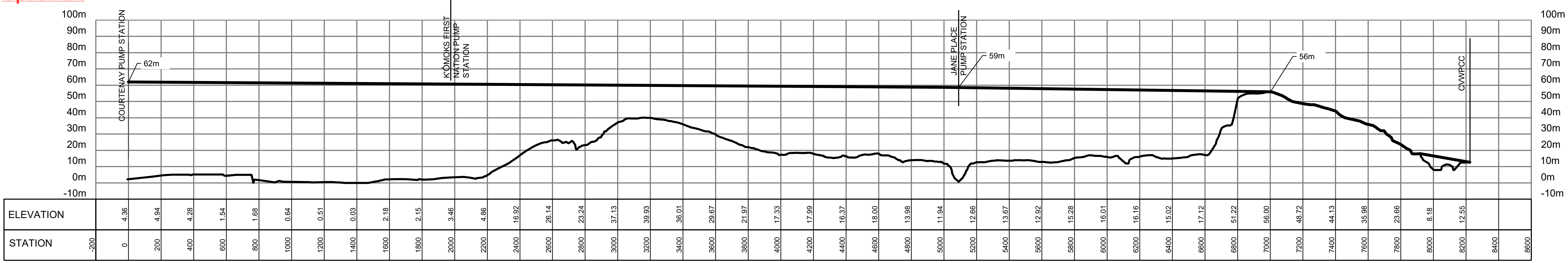
There are operating cost disadvantages to this option as it requires pumping of the raw sewage over the height of land at Comox Road hill, breaking head at the location of the new in-line pump station, and again pumping over the height of land at the Lazo Road hill, resulting in significant financial operating costs.

Figures

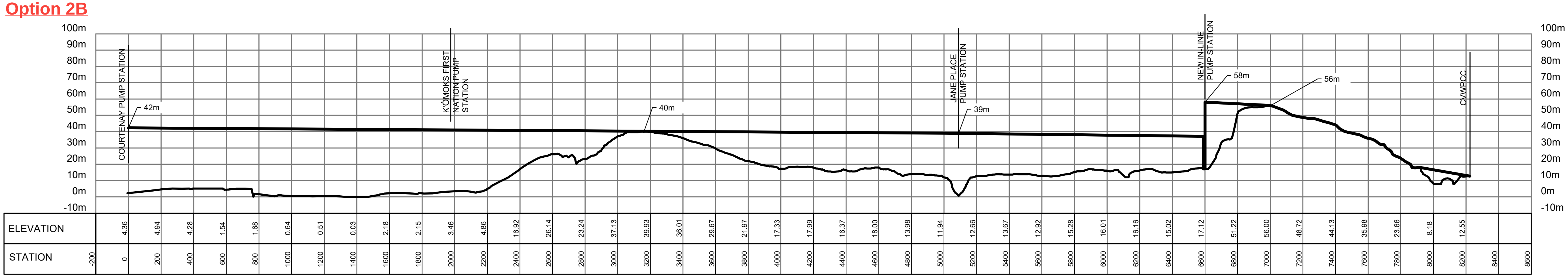
Alignment is provided on Figure 10-8. Profile is provided on Figure 10-9.

Figure 10-8: Overland Alignment 2B

Option 2A



Option 2B



OPTION 2
PROFILE BETWEEN CH: -200.00 AND 8600.00
1:12500(H) 1:1250(V) AT A1

1:12500 @ ANSI D 0 200
1:500 @ ANSI D 0 5 10 15 20 25 30 35 40 45 50 m

Original Sheet Size ANSI D [22"x34"]

Figure 10-9: Option 2 Hydraulic Profiles

10.2.3 TUNNELLING ALIGNMENTS

OPTION 3A – TUNNEL THROUGH COMOX RD HILL AND LAZO RD HILL

Description:	This alignment would involve installation of a combination of new forcemains installed using open cut methods and micro-tunnel methods in order to minimize pumping requirements. The primary areas where tunnelling would be appropriate are under the Comox Rd. and Lazo Rd hills. Sewage would be pumped from the CPS to an elevation where a tunnel would be constructed through the Comox Road hill. The forcemain would transition to an open cut installation through Comox and back to a tunnel to pass under the Lazo Road hill and down to the CVWPCC. The JPS could connect to the forcemain. To avoid major modifications to the JPS the tunnel elevations would have to be selected to suit the existing hydraulics of the JPS. The tunnel through the Comox Road hill would be around a 30-meter elevation and be in the 800 to 1,000 m length. To pass through the Lazo Road hill, while maintain an elevation suitable to limit upgrades at the JPS it is likely that 1,200 to 1,500 m tunnel would be required. This would necessitate an intermediate shaft and add cost and complexity to the project as this has the potential to penetrate the groundwater in the area. Following construction this shaft would be removed. Alternative routing would need to be explored to evaluate options to avoid this shaft. The overland forcemain would be installed using standard cut-and-cover installation methods with the general intention of following existing roadways. This approach is very common and as such, reasonably well established. Additional complexities would involve relocating existing utilities and restoration of surface roadways, sidewalks, and similar features. Due to the nature of sanitary systems the depth of excavation would be set to be below the existing water systems.
Advantages	» No pipe in the estuary mitigating environmental and archaeological risks. » All overland pipes and structures will maximize maintenance accessibility. » Alleviates some of the high head requirements as compared to other overland options.
Disadvantages	» Construction of new conveyance system through an area with significant existing infrastructure. » High risk tunnel installation and a potential construction shaft located along the Lazo Road hill section. » Limited maintenance accessibility for the tunnelled sections of alignment.
Technical Consideration	This system would operate similar to the existing configuration where a single forcemain connects the CPS with the CVWPCC and the JPS connects into the forcemain. To avoid significant changes to the existing pump stations a micro-tunnel would be used to pass through the two heights of land. The length of the micro-tunnel would be limited to 800 to 1,000 m between access shafts. Tunnel sections would need to be reviewed for the financial benefit of installing a twinned system during initial construction. Risks to future expansion and tunnelling adjacent a critical forcemain would need to be factored into the decision making during preliminary design. The design of the tunnel forcemain would likely utilize materials not commonly used in Western Canada for sewage infrastructure as the pipe would have to be designed for the installation conditions and the exposure to sewage.

Environmental Considerations	Overland portions routed along existing roadways would have limited environmental impacts. Areas where there are significant adjacent trees could be potentially damaged due to root damage. The deeper tunnel options would likely involve dewatering during installation and construction which may temporarily impact local groundwater wells.
Archaeological Considerations	The intention would be to remain with existing areas of disturbance so no unique archaeological impacts are likely.
Operational Considerations	Maintenance of the pump stations would be similar to that of the existing facilities. Maintenance and repair on the overland forcemain would be completed using well established repair methods based on open excavation. Should a pipe failure occur standard methods of isolation and pumping off-site using a vacuum truck would be employed. There would be no opportunity to undertake maintenance on the tunnel section of pipe and any damage would require a cured-in-place repair technology. This repair cannot be completed while the system is in operation and therefore would necessitate a significant by-pass design to permit the tunnel to be taken off-line.

Infrastructure Elements

Description	Capital Cost	Investment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
New Courtenay - Moderate Pressure Increase	$10,500,000	2020	25	40%	625	3
Downgrade Jane	$2,362,500	2020	25	40%	25	0
New Jane - Moderate Pressure Increase	$3,850,000	2020	25	40%	250	3
Forcemain Tunnel through Lazo hill	$23,587,200	2020	60	100%	0	0
Forcemain Tunnel through Comox hill	$11,734,800	2020	60	100%	0	0
Overland from Comox hill to Lazo hill	$10,977,120	2020	60	100%	0	0
Jane to forcemain	$1,108,800	2020	60	100%	0	0
Overland Courtenay to CVWPCC (Excl. Tunnel Sections)	$15,846,600	2020	60	100%	0	0
Total Capital Cost	$79,967,020					

Cost Considerations	This option has moderate initial capital expenditure of $80M, as construction of tunnelled sections caries additional cost compared to open-cut installation of linear infrastructure. However, the remainder of the alignment construction is mostly completed overland in already-disturbed areas. This option requires the continued asset maintenance for a total of the two existing CPS and JPS. There are significant advantages based on operating cost for this option as it sustains a relatively low elevation by tunnelling through the heights of land at the Comox Road and Lazo Road hills.
Figures	Alignment is provided on Figure 10-10. Profile is provided on Figure 10-13.

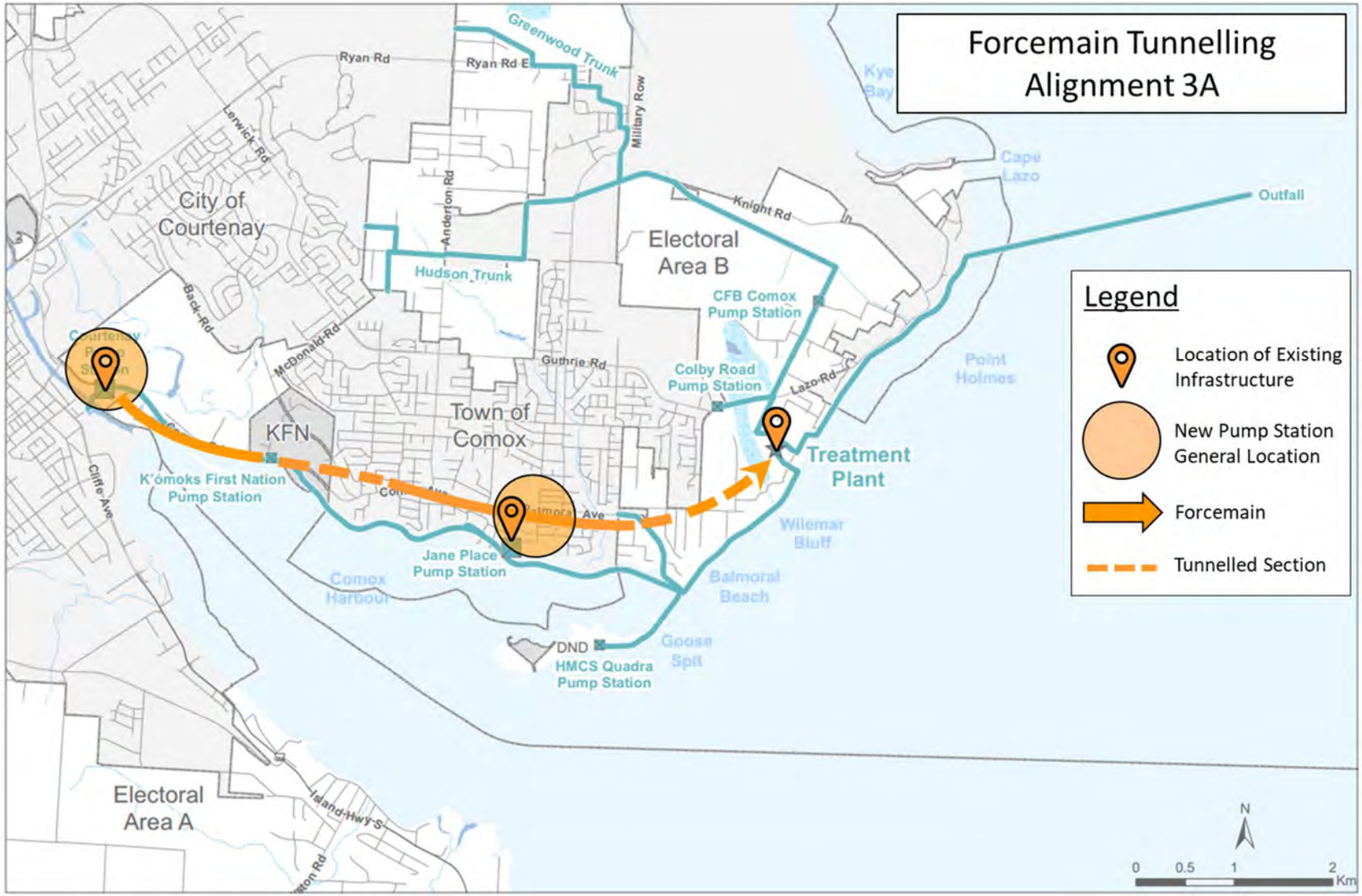


Figure 10-10: Forcemain Tunnelling Alignment 3A

OPTION 3B – TUNNEL THROUGH LAZO RD HILL

Description:	A new open cut forcemain would be installed from CPS and would continue directly to the CVWPCC with a tunnel through the Lazo Road Hill. The existing JPS would likely not be able to cope with this higher hydraulic requirement and therefore a new high head pump station would be required in the general vicinity of the existing JPS. This new facility would convey raw sewage into the forcemain between CPS and the CVWPCC. The existing JPS would be repurposed as a small subdivision pump station. If the tunnel elevation is sufficiently low, the existing JPS would be suitable. Assuming a new JPS the tunnel through Lazo Road hill would be approximately 800 to 1,000 m long. The overland forcemain would be installed using standard cut-and-cover installation methods with the general intention of following existing roadways. This approach is very common and as such, reasonably well established. Additional complexities would involve relocating existing utilities and restoration of surface roadways, sidewalks and similar features. Due to the nature of sanitary systems the depth of excavation would be set to be below the existing water systems.
Advantages	» No pipe in the estuary mitigating environmental and archaeological risks. » All pipe and structures on-land to maximize maintenance accessibility. » Alleviates some of the high head requirements as compared to other overland options.
Disadvantages	» Construction of new conveyance system through an area with significant existing infrastructure. » Higher upgrade requirements at the CPS and JPS.
Technical Consideration	This system would operate similar to the existing configuration where a single forcemain connects the CPS with the CVWPCC and the JPS connects into the forcemain. As the flow rate through these stations is reasonably high there are options available to provide the necessary discharge pressures, however the selection of options becomes reduced at these pressures, which are estimated to be in the order of 50 to 60 m of pressure. Tunnel sections would need to be reviewed for the financial benefit of installing a twinned system during construction. Risks to future expansion and tunnelling adjacent a critical forcemain would need to be factored into the decision making at the project on-ste. The design of the tunnel forcemain would likely utilize materials not commonly used in Western Canada for sewage infrastructure as the pipe would have to be designed for the installation conditions and the exposure to sewage.
Environmental Considerations	Overland portions routed along existing roadways would have limited environmental impacts. Areas where there are significant adjacent trees could be potentially damaged due to root damage. The deeper tunnel options would likely involve dewatering during installation/construction which may temporarily impact local groundwater wells.
Archaeological Considerations	The intention would be to remain with existing areas of disturbance so no unique archaeological impacts are likely.

Operational Considerations	Maintenance of the higher head pump station would be similar to that of the existing facilities, however there is a reduced selection of pump options. In addition, a typical higher head sewage pump operates at reduced efficiency compared to lower head pumps. Maintenance and repair on the overland forcemain would be completed using well established repair methods based on open excavation. Should a pipe failure occur standard methods of isolation and pumping off-site using a vacuum truck would be employed. There would be no opportunity to undertake maintenance on the tunnel section of pipe and any damage would require a cured-in-place repair technology. This repair cannot be completed while the system is in operation and therefore would necessitate a significant by-pass design to permit the tunnel to be taken off-line.

Infrastructure Elements

Description	Capital Cost	Ivestment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
New Courtenay - Moderate Pressure Increase	$10,500,000	2020	25	40%	750	3
Downgrade Jane	$2,362,500	2020	25	40%	25	0
New Jane - Moderate Pressure Increase	$3,850,000	2020	25	40%	275	3
Forcemain Tunnel through Lazo hill	$23,587,200	2020	60	100%	0	0
Overland Courtenay to Lazo Hill	$26,999,280	2020	60	100%	0	0
Old Jane to New Jane	$51,744	2020	60	100%	0	0
Overland Lazo Tunnel to CVWPCC	$1,617,000	2020	60	100%	0	0
Total Capital Cost	$68,967,724					

Cost Considerations	This option has moderate initial capital expenditure of $69M, as construction of tunnelled sections caries additional cost as compared to open-cut installation of linear infrastructure. However, the remainder of the alignment construction is mostly completed overland in already-disturbed areas. This option requires the downgrading of the JPS and continued asset maintenance for a total of three pump stations, however the downgraded JPS will require minimal maintenance efforts. There are advantages based on operating cost for this option compared to overland options as it sustains a lower elevation by tunnelling through the height of land at the Lazo Road hills.
Figures	Alignment is provided on Figure 11. Profile is provided on Figure 10-13.

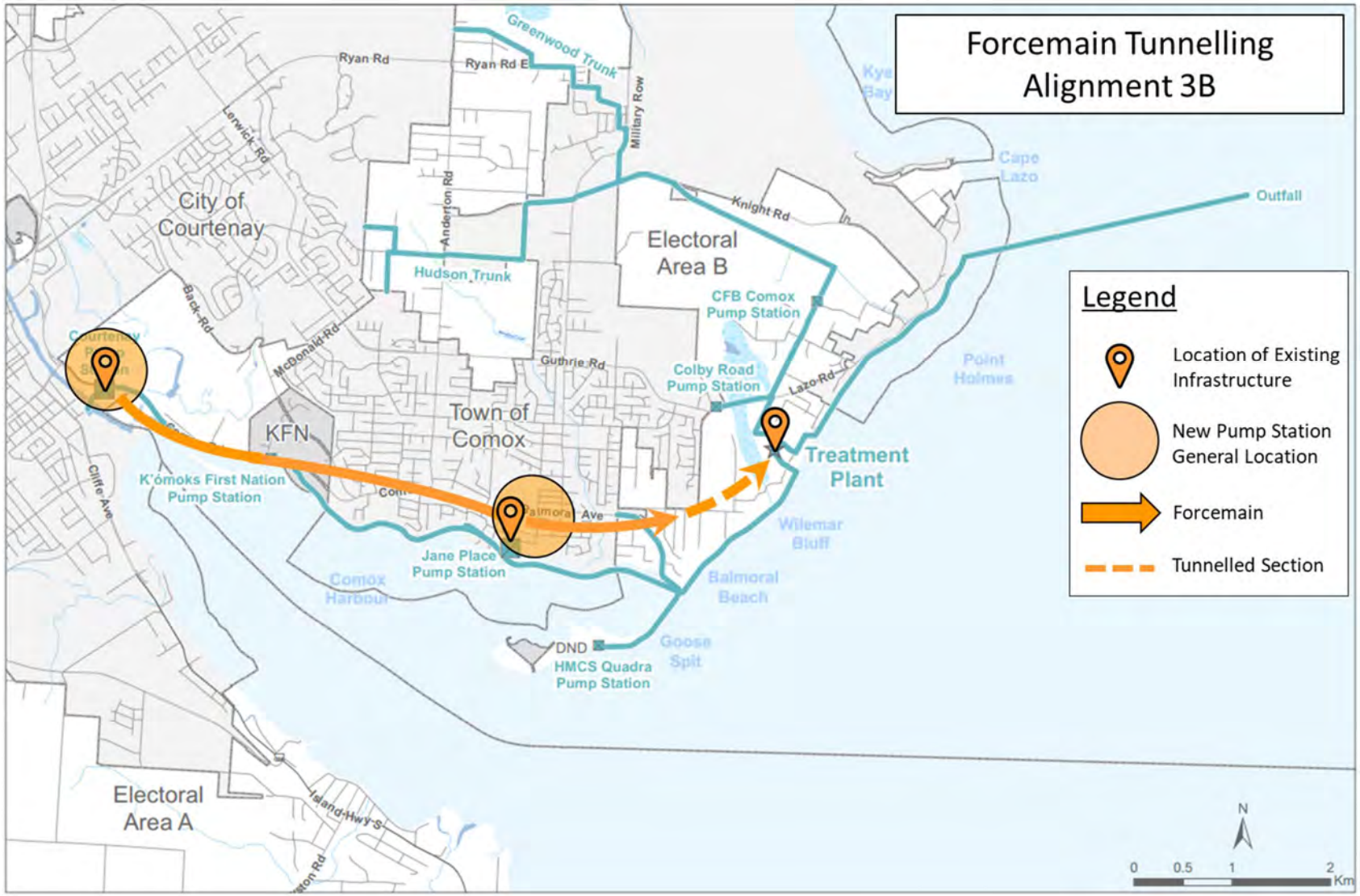


Figure 10-11: Forcemain Tunnelling Alignment 3B

OPTION 3C – GRAVITY TUNNEL FROM COMOX TO THE CVWPCC

Description:	A new open cut forcemain would be installed from CPS and would continue directly to the CVWPCC such that there is no in-line pump station. To reduce pressures a gravity sewer main tunnel would be used to pass through the Lazo Road height of land. Depending on the tunnel elevation the existing JPS may not require replacement to a high head pump station. The alignment options for the gravity sewer main would be restricted to those which accommodate the required slope. The JPS would connect to the gravity sewer main through a new forcemain. The tie-in location would be governed by the gravity sewer main alignment. In order to maintain the existing JPS hydraulic conditions a tunnel length of around 2,300 m would be required. It is likely that this would necessitate 2 access shafts during construction. Each shaft would be in the order of 15 m and 25 m deep. Detailed analysis during preliminary design would be required to determine the benefit of a minor hydraulic upgrade at the JPS as compared to a tunnel of around 1,500 m with only one access shaft. The overland forcemain would be installed using standard cut-and-cover installation methods with the general intention of following existing roadways. This approach is very common and as such, reasonably well established. Additional complexities would involve relocating existing utilities and restoration of surface roadways, sidewalks and similar features. Due to the nature of sanitary systems the depth of excavation would be set to be below the existing water systems.
Advantages	» No pipe in the estuary mitigating environmental and archaeological risks. » All pipe and structures on-land to maximize maintenance accessibility. » Alleviates some of the high head requirements for the CPS and most of the high head requirements for the JPS as compared to other overland options. » Part of the JPS catchment and the HMCS Quadra outlet could potentially be tied directly into the gravity tunnel.
Disadvantages	» Construction of new conveyance system through an area with significant existing infrastructure. » Gravity sewer main alignment must follow a specific slope which is dependent on the topography. » Gravity sewer mains are nominally larger diameter as compared to forcemains for the same flow.
Technical Consideration	This system would operate similar to the existing configuration where a single forcemain connects the CPS with the CVWPCC and the JPS connects into the forcemain. Significant upgrades to the CPS would be required to overcome the hydraulic pressure of the Comox Road Hill. Between Comox and the Lazo Road Hill the forcemain would transition to a gravity sewer which would connect to the CVWPCC. Design of the gravity sewer would require a minimum slope which can be relatively low due to the large diameter of the pipe, potentially as low as 0.5%. The elevation of the CVWPCC is approximately 12 meters and therefore a 2,300-m gravity sewer would require a tunnel elevation of around 24 meters. Subject to pump selection review, it is possible that the JPS could be upgraded to meet this new discharge pressure within the existing site. The design of the tunnel gravity sewer would likely utilize materials not commonly used in Western Canada for sewage infrastructure as the pipe would have to be designed for the installation conditions and the exposure to sewage.

Environmental Considerations	Overland portions routed along existing roadways would have limited environmental impacts. Areas where there are significant adjacent trees could be potentially damaged due to root damage. The deeper tunnel options would likely involve dewatering during installation/construction which may temporarily impact local groundwater wells.
Archaeological Considerations	The intention would be to remain with existing areas of disturbance, so no unique archaeological impacts are likely.
Operational Considerations	Maintenance of the higher head pump station would be similar to that of the existing facilities, however there is a reduced selection of pump options. In addition, a typical higher head sewage pump operates at reduced efficiency compared to lower head pumps. Maintenance and repair on the overland forcemain would be completed using well established repair methods based on open excavation. Should a pipe failure occur standard methods of isolation and pumping off-site using a vacuum truck would be employed. The gravity tunnel pipe could potentially be repaired using cured-in-place technologies which would utilize robotic tooling to inspect and prepare repair patches. As the gravity pipe has storage capacity very short-term shutdowns could be accommodated in low flow seasons.

Infrastructure Elements

Description	Capital Cost	Investment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
New Courtenay - Moderate Pressure Increase	$10,500,000	2020	25	40%	750	3
Upgrade Jane (Capacity and AM driven)	$3,150,000	2020	25	40%	275	3
Gravity Tunnel through Lazo hill	$27,800,640	2020	60	100%	0	0
Overland Courtenay to Jane (New or Existing)	$16,493,400	2020	60	100%	0	0
Overland Jane to Lazo Hill	$4,851,000	2020	60	100%	0	0
Jane to forcemain	$1,108,800	2020	60	100%	0	0
Overland Lazo Tunnel to CVWPCC	$1,617,000	2020	60	100%	0	0
Total Capital Cost	$65,520,840					

Cost Considerations	This option has moderate initial capital expenditure of $66M, as construction of tunnelled sections caries additional cost compared to open-cut installation of linear infrastructure. However, the remainder of the alignment construction is mostly completed overland in already-disturbed areas. This option requires the continued asset maintenance for the two existing CPS and JPS. There are advantages based on operating cost for this option as it sustains a relatively low elevation by tunnelling through the height of land at the Lazo Road hills.
Figures	Alignment is provided on Figure 12. Profile is provided on Figure 10-13.

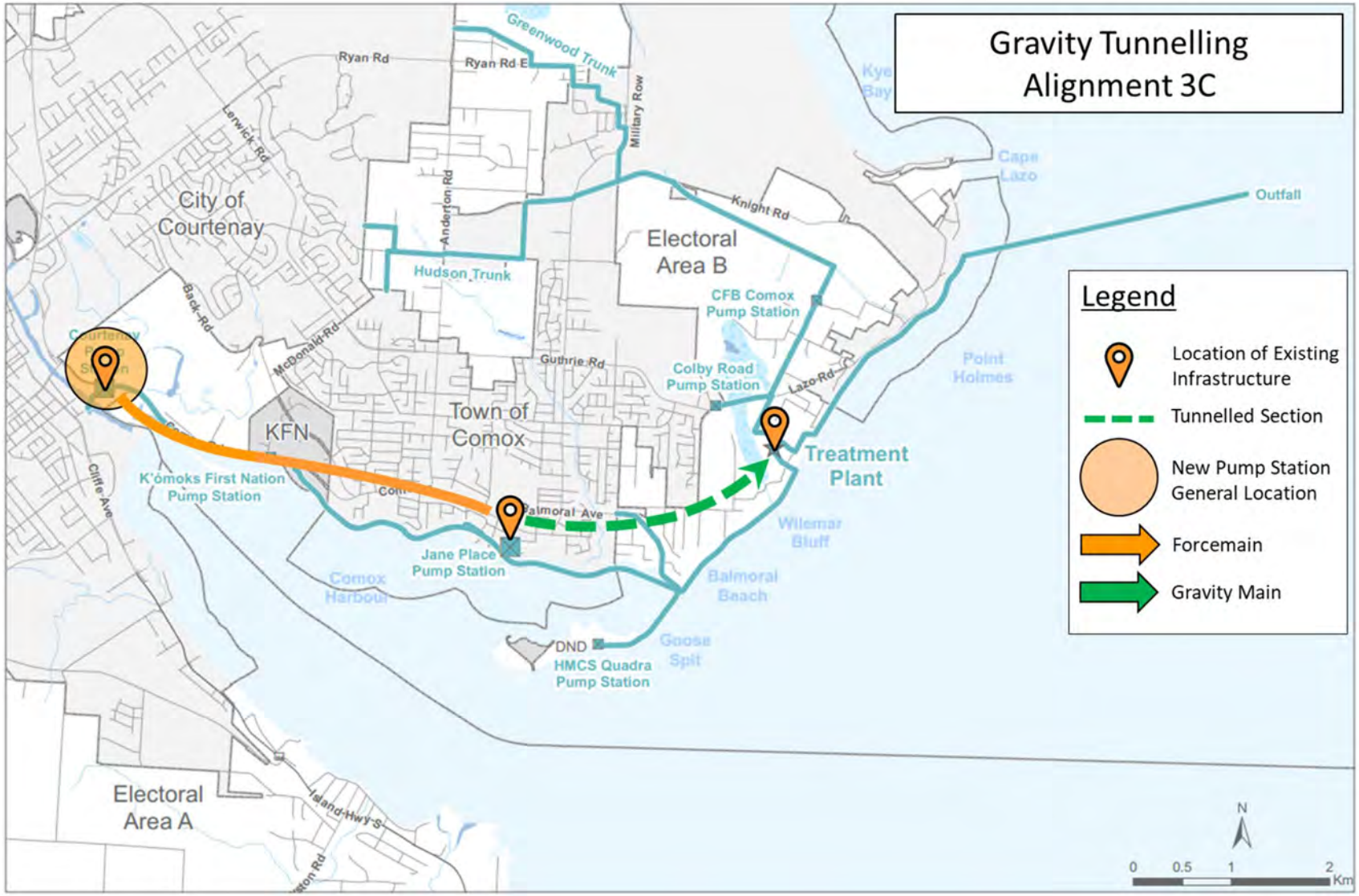
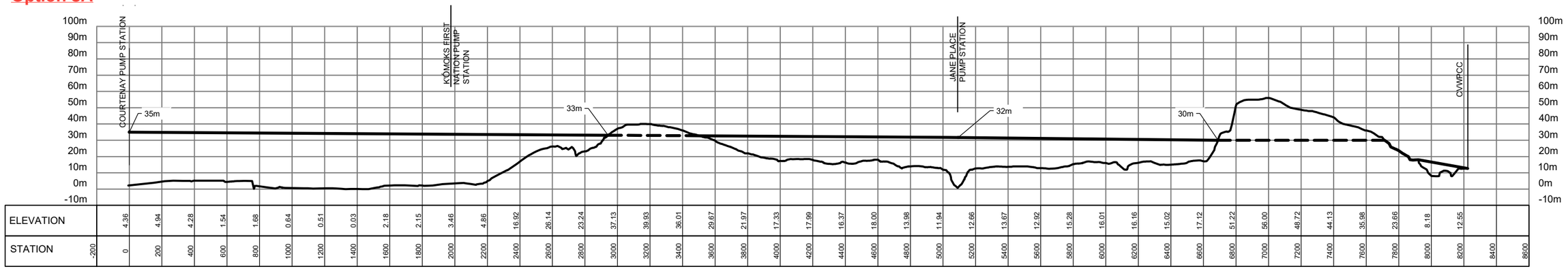


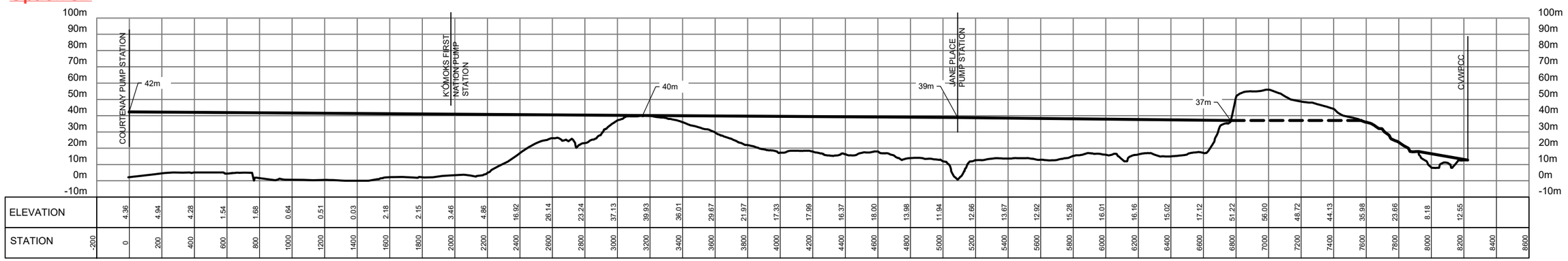
Figure 10-12: Gravity Tunnelling Alignment 3C

Option 3A



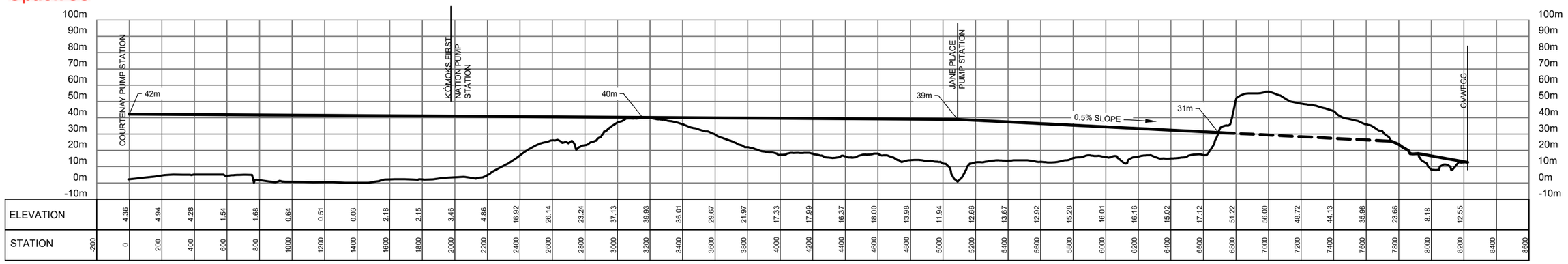
ELEVATION	4.36	4.94	4.28	1.54	1.68	0.64	0.51	0.03	2.18	2.15	3.46	4.86	16.92	26.14	23.24	37.13	39.93	36.01	29.67	21.97	17.33	17.99	16.37	18.00	13.98	11.94	12.66	13.67	12.92	15.28	16.01	16.16	15.02	17.12	51.22	56.00	48.72	44.13	35.98	23.66	8.18	12.55		
STATION -200	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000	5200	5400	5600	5800	6000	6200	6400	6600	6800	7000	7200	7400	7600	7800	8000	8200	8400	8600

Option 3B



ELEVATION	4.36	4.94	4.28	1.54	1.68	0.64	0.51	0.03	2.18	2.15	3.46	4.86	16.92	26.14	23.24	37.13	39.93	36.01	29.67	21.97	17.33	17.99	16.37	18.00	13.98	11.94	12.66	13.67	12.92	15.28	16.01	16.16	15.02	17.12	51.22	56.00	48.72	44.13	35.98	23.66	8.18	12.55		
STATION -200	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000	5200	5400	5600	5800	6000	6200	6400	6600	6800	7000	7200	7400	7600	7800	8000	8200	8400	8600

Option 3C



ELEVATION	4.36	4.94	4.28	1.54	1.68	0.64	0.51	0.03	2.18	2.15	3.46	4.86	16.92	26.14	23.24	37.13	39.93	36.01	29.67	21.97	17.33	17.99	16.37	18.00	13.98	11.94	12.66	13.67	12.92	15.28	16.01	16.16	15.02	17.12	51.22	56.00	48.72	44.13	35.98	23.66	8.18	12.55		
STATION -200	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000	5200	5400	5600	5800	6000	6200	6400	6600	6800	7000	7200	7400	7600	7800	8000	8200	8400	8600

OPTION 3
PROFILE BETWEEN CH: -200.00 AND 8600.00
1:12500(H) 1:1250(V) AT A1

1:12500 @ ANSI D 0 200
1:500 @ ANSI D 0 5 10 15 20 25 30 35 40 45 50 m

Original Sheet Size ANSI D [22"x34"]

Figure 10-13: Option 3 Hydraulic Profiles

10.2.4 NORTH SIDE CONCEPTS

OPTION 4A – NORTH SIDE FORCEMAIN CONCEPT	
Description:	In this concept, raw sewage would be pumped from the location of the existing CPS along the north side of the Comox to the CVWPCC. Sewage from the JPS would be conveyed to this north side forcemain at a location west of the Lazo Road hill. A joint forcemain would convey the combined flows from the CPS and JPS to the CVWPCC. CPS would potentially be required to pump sewage to the CVWPCC over the highest elevation of Glacier View Drive hill (El. 73 m) in a forcemain. JPS would be required to pump sewage to the new forcemain between Courtenay and the CVWPCC which would have a hydraulic grade of around 50 to 60 m. The combined forcemain would continue to the CVWPCC along existing roadways or right-of-ways. This option would trigger a high head upgrade at both the CPS and JPS, leading to the requirement for a rebuild of both pump stations. The overland forcemain would be installed using standard cut-and-cover installation methods with the general intention of following existing roadways. This approach is very common and as such, reasonably well established. Additional complexities would involve relocating existing utilities and restoration of surface roadways, sidewalks and similar features. Due to the nature of sanitary systems the depth of excavation would be set to be below the existing water systems.
Advantages	» Only involves 2 large pump stations (JPS repurposed as local facility only) » Pump Stations operating in parallels as opposed to in series, minimizing need for a sophisticated control system. » Avoids construction in the downtown core area, limiting construction impact to areas with less infrastructure development as compared to the downtown core. » No pipe in the estuary mitigating environmental and archaeological risks. » All pipe and structures on-land to maximize maintenance accessibility.
Disadvantages	» Construction for the linear assets required along two separate alignments within the CVSS, increasing construction disturbance. » Operating two partially separate high pressure forcemain networks. » The North Side of Glacier View Drive is at a significant higher elevation than that of the South Side (73 m vs 39 m).
Technical Consideration	The system would operate as two independent systems. The Courtenay pump station would be a high head pump station, in the order of 80 to 100 m pressure, and would likely require a two stage pump configuration which utilizes two standard sewage pumps configured immediately in-line with each other. This approach to sewage conveyance is relatively unique in this market, but not unheard-of. A new right-of-way would be required through the ALR and up to existing roadways. It is unlikely that this system could transition to a gravity system as there is a high point at near the crossing of Prichard Rd. The forcemain from the JPS could be routed up Prithcard Rd to intersect with the Courtenay forcemain or be routed directly to the CVWPCC, with the short alignment likely a connection to the forcemain from Courtenay. Either way the JPS would require a significant upgrade to increase the discharge pressure to around 50 to 60 m hydraulic pressure.

Environmental Considerations	Overland portions routed along existing roadways would have limited environmental impacts. Areas where there are significant adjacent trees could be potentially damaged due to root damage.
Archaeological Considerations	The intention would be to remain with existing areas of disturbance, so no unique archaeological impacts are likely.
Operational Considerations	Maintenance of the higher head pump station would be similar to that of the existing facilities, however there is a reduced selection of pump options. In addition, a typical higher head sewage pump operates at reduced efficiency compared to lower head pumps. Although there would only be 2 pump stations in the system, the Courtenay facility would effectively be two stations in one. Pumps and electrical equipment would be provided in duplicate as two pumps would be operating in-series to meet the operational pressures. As such, the number of pumps and associated equipment in the system would increase from the existing. Maintenance and repair on the overland forcemain would be completed using well established repair methods based on open excavation. Should a pipe failure occur standard methods of isolation and pumping off-site using a vacuum truck would be employed. A benefit of this arrangement is the opportunity to route the new infrastructure along roadways which are not as constrained by traffic and existing infrastructure as would be expected within the higher density areas of Comox.

Infrastructure Elements

Description	Capital Cost	Investment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
New Courtenay - High Pressure Increase	$29,400,000	2020	25	40%	1250	3
Downgrade Jane	$2,362,500	2020	25	40%	25	0
New Jane - Moderate Pressure Increase	$3,850,000	2020	25	40%	425	3
Overland Jane to connect to FM (Long Distance to North)	$4,804,800	2020	60	100%	0	0
Overland Forcemain North from Courtenay to CVWPCC	$27,489,000	2020	60	100%	0	0
Old Jane to New Jane	$51,744	2020	60	100%	0	0
KFN Pump Station and FM to Courtenay	$616,000	2020	60	100%	0	0
Total Capital Cost	$68,574,044					

Cost Considerations	This option has a moderate initial capital expenditure of $69M as it includes an overall alignment from the CPS to the CVPWCC on the north side, and another alignment from the JPS to the above forcemain. There is also a need for the construction of a new high-pressure CPS and a new moderate-pressure JPS. This option requires the downgrading of the JPS and continued asset maintenance for a total of three pump stations, however the downgraded JPS will require minimal maintenance efforts. There is no operating cost advantage to this option as is requires pumping a significant portion of the Courtenay sewage over the height of land, resulting in significant financial operating costs.
Figures	Concept alignment is provided on Figure 14. Profile is provided on Figure 10-15.

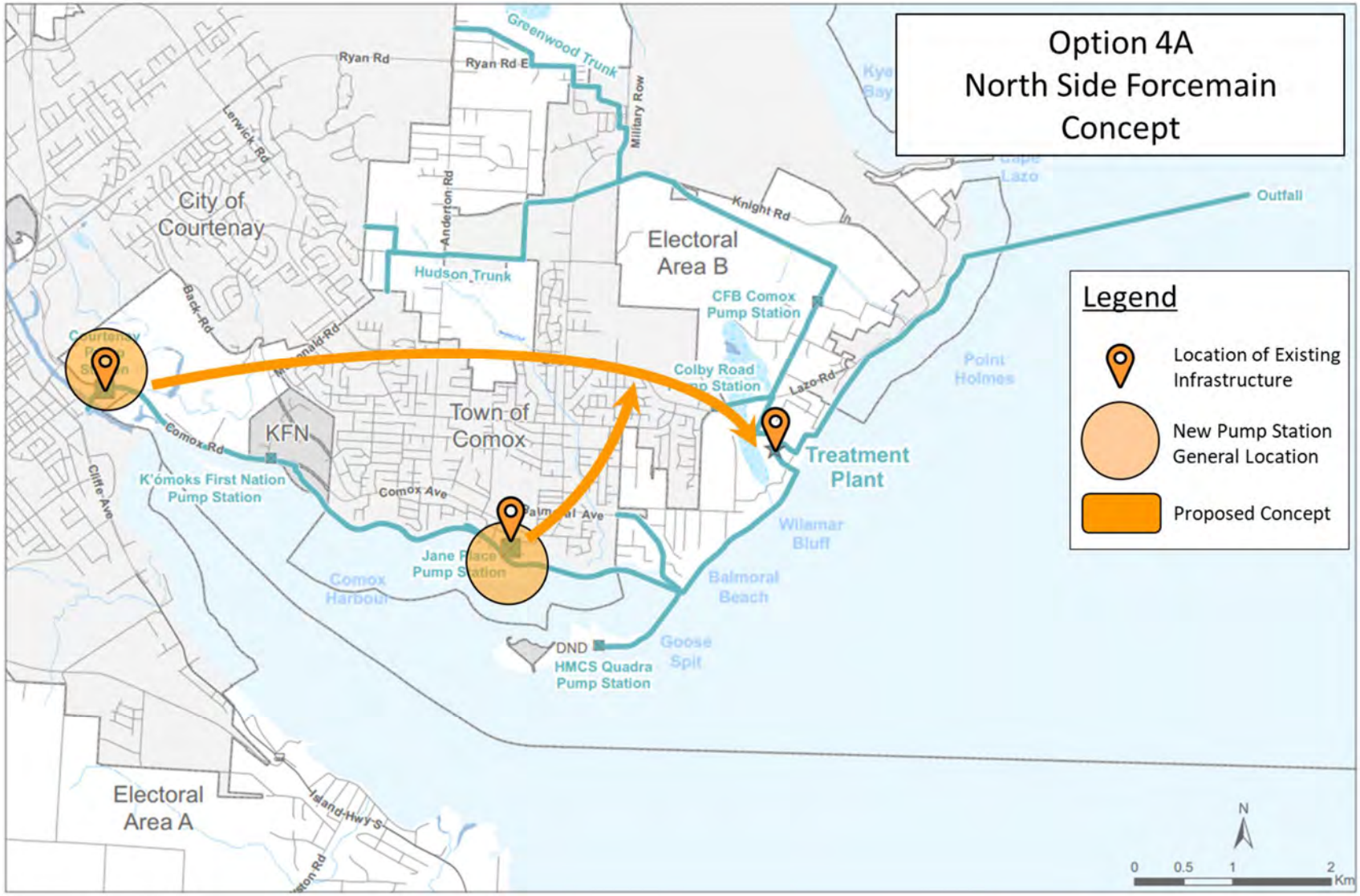
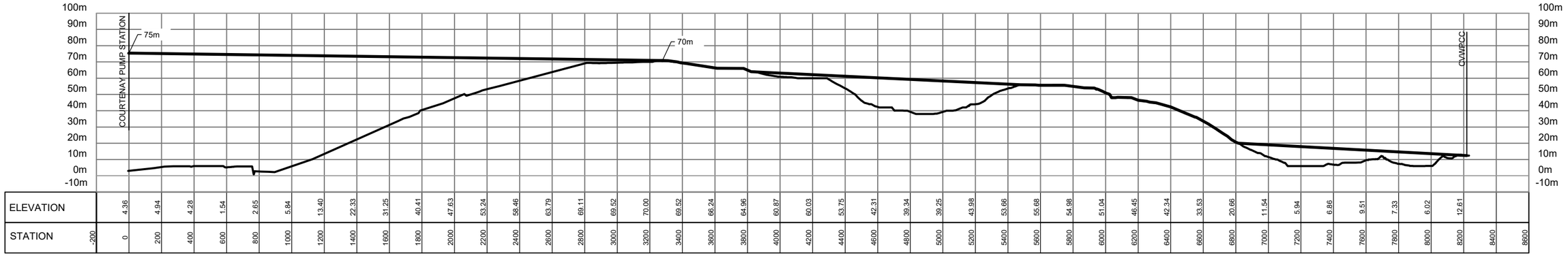
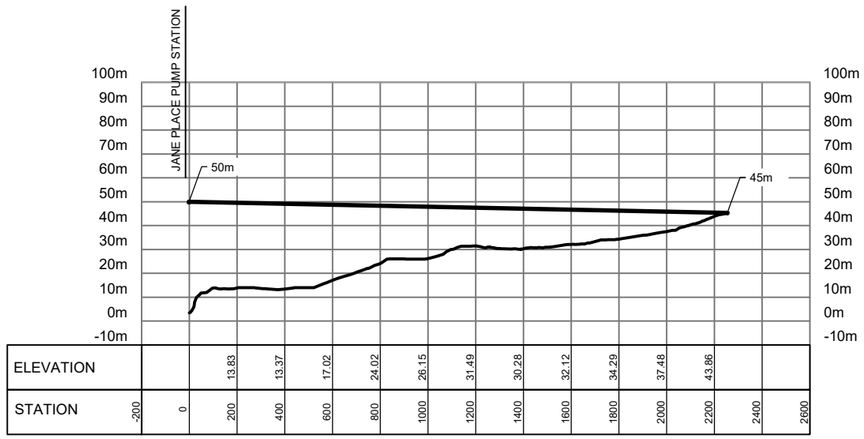


Figure 10-14: North Side Forcemain Concept 4A

Option 4A - North Section



Option 4A - South Section



OPTION 4A
PROFILE BETWEEN CH: -200.00 AND 8600.00
PROFILE BETWEEN CH: -200.00 AND 2600.00
1:12500(H) 1:1250(V) AT A1

1:12500 @ ANSI D 0 200
1:500 @ ANSI D 0 5 10 15 20 25 30 35 40 45 50 m

Original Sheet Size ANSI D [22"x34"]

Figure 10-15: Option 4A Hydraulic Profiles

OPTION 4B – NORTH SIDE GRAVITY CONCEPT

Description:	In this concept, raw sewage would be pumped from the location of the existing CPS along the north side of the Comox to an alignment parallel with the Hudson Gravity Sewer System. Sewage would gravity flow along this route to the existing CFB pump station. As the CFB pump station does not have adequate capacity to accommodate the CPS flows a new significantly larger facility would be required at this location. From the CFB pump station the sewage would be conveyed to the CVWPCC. CPS would be required to pump sewage to the CVWPCC over the highest elevation of Glacier View Dr hill (El. 73 m) to reach the height of land where it can gravity flow to the CFB pump station. JPS would be required to pump sewage directly to the CVWPCC over Lazo Hill which would have a hydraulic grade of around 50 to 60 m. This option would trigger a high head upgrade at both the CPS and a moderate head upgrade at the JPS, leading to the requirement for a rebuild of both pump stations. The overland forcemain would be installed using standard cut-and-cover installation methods with the general intention of following existing roadways. This approach is very common and as such, reasonable well established. Additional complexities would involve relocating existing utilities and restoration of surface roadways, sidewalks and similar features. Due to the nature of sanitary systems the depth of excavation would be set to be below the existing water systems.
Advantages	» Pump Stations operating independently from each other. » Avoids construction in the downtown core area, limiting construction impact to areas with less infrastructure development as compared to the downtown core. » No pipe in the estuary mitigating environmental and archaeological risks. » All pipe and structures on-land to maximize maintenance accessibility.
Disadvantages	» Construction for the linear assets required along two separate alignments within the CVSS, increasing construction disturbance. » Operating two partially separate high pressure forcemain networks. » The North Side of Glacier View Drive is at a significant higher elevation than that of the South Side (73 m vs 39 m). » A very long conveyance upgrade is required. » Requires a significant upgrade to the CFB pump station and results in 3 large pump stations in the conveyance. CFB is in-line with CPS pump station and would be a significant point of failure.
Technical Consideration	The CPS and JPS system would operate as two independent systems. The Courtenay pump station would be a high head pump station, in the order of 80 to 100 m pressure, and would likely require a two stage pump configuration which utilizes two standard sewage pumps configured immediately in-line with each other. This approach to sewage conveyance is relatively unique in this market, but not unheard-of. A new right-of-way would be required through the ALR and up to existing roadways. It is unlikely that this system could transition to a gravity system as there is a high point at near the crossing of Prichard Rd. The CPS would pump to the CFB pump station which would be in-series and as such would be a risk should the CFB pump station be off-line as it would restrict flow from CPS and the existing Hudson/Greenwood gravity collection system. The forcemain from the JPS could be routed directly to the CVWPCC over Lazo Hill The JPS would require a significant upgrade to increase the discharge pressure to around 50 to 60 m hydraulic pressure.

Environmental Considerations	Overland portions routed along existing roadways would have limited environmental impacts. Areas where there are significant adjacent trees could be potentially damaged due to root damage.
Archaeological Considerations	The intention would be to remain with existing areas of disturbance, so no unique archaeological impacts are likely.
Operational Considerations	Maintenance of the higher head pump station would be similar to that of the existing facilities, however there is a reduced selection of pump options. In addition, a typical higher head sewage pump operates at reduced efficiency compared to lower head pumps. Although there would only be 2 pump stations in the system, the Courtenay facility would effectively be two stations in one. Pumps and electrical equipment would be provided in duplicate as two pumps would be operating in-series to meet the operational pressures. As such, the number of pumps and associated equipment in the system would increase from the existing. Maintenance and repair on the overland forcemain would be completed using well established repair methods based on open excavation. Should a pipe failure occur standard methods of isolation and pumping off-site using a vacuum truck would be employed. A benefit of this arrangement is the opportunity to route the new infrastructure along roadways which are not as constrained by traffic and existing infrastructure as would be expected within the higher density areas of Comox.

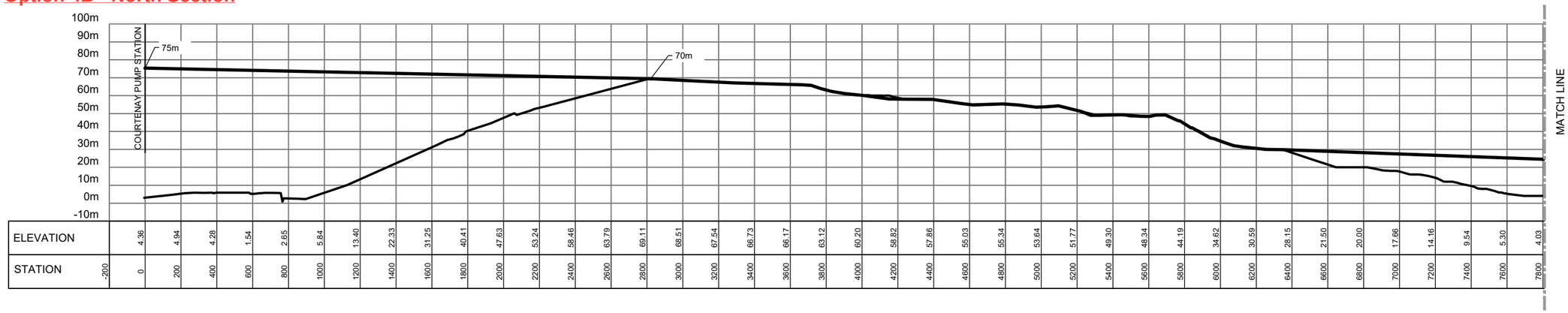
Infrastructure Elements

Description	Capital Cost	Investment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
New Courtenay - High Pressure Increase	$29,400,000	2020	25	40%	1250	3
Downgrade Jane	$2,362,500	2020	25	40%	25	0
New Jane - Moderate Pressure Increase	$3,850,000	2020	25	40%	425	3
Overland Jane to connect to FM (Long Distance to North)	$4,804,800	2020	60	100%	0	0
Overland Gravity North from Courtenay to CVWPCC	$38,962,000	2020	60	100%	0	0
Old Jane to New Jane	$51,744	2020	60	100%	0	0
KFN Pump Station and FM to Courtenay	$616,000	2020	25	40%	25	0
New CFB Pump Station	$3,920,000	2020	25	40%	225	2
Total Capital Cost	$83,967,044					

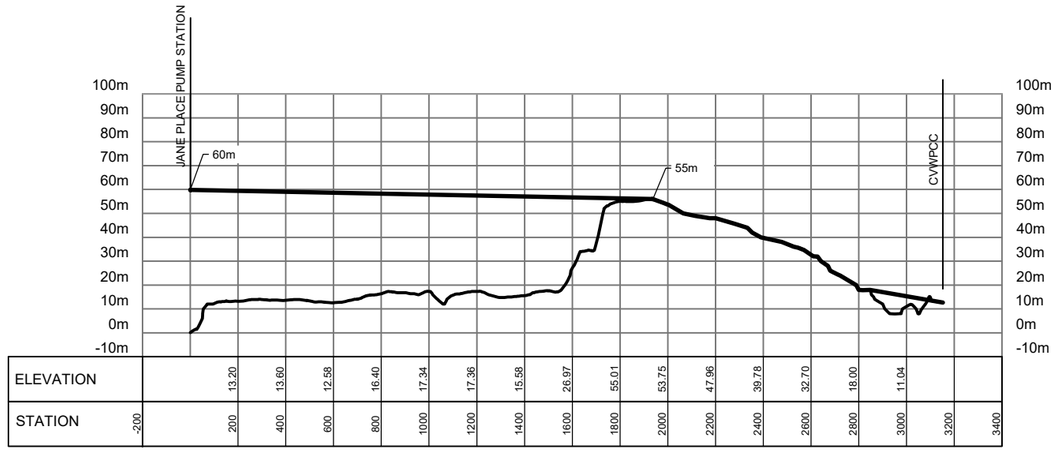
Cost Considerations	This option has a significant initial capital expenditure of $84M as it follows the longest conveyance route between the CPS and the CVWPCC. In addition, it requires the CFB Pump station to be upgraded to pass the CPS flows, resulting in a 3rd large pump station. The Hudson and Greenwood collection system is not sized to accommodate all the Courtenay flows and therefore would need to be twinned. There is no operating cost advantage to this option as is requires pumping a significant portion of the Courtenay sewage over the height of land, resulting in significant financial operating costs. Furthermore, all the CPS flows are re-pumped at the CFB pump station.
Figures	Concept alignment is provided on Figure 16. Profile is provided on Figure 10-17.

Figure 10-16: North Side Gravity Concept 4B

Option 4B - North Section



Option 4B - South Section



OPTION 4B

PROFILE BETWEEN CH: -200.00 AND 11400.00

PROFILE BETWEEN CH: -200.00 AND 3400.00

1:12500(H) 1:1250(V) AT A1

1:12500 @ ANSI D 0 200

1:500 @ ANSI D 0 5 10 15 20 25 30 35 40 45 50 m

Original Sheet Size ANSI D [22"x34"]

Figure 10-17: Option 4B Hydraulic Profiles

10.2.5 DECENTRALIZED TREATMENT CONCEPT

OPTION 5 – DECENTRALIZED TREATMENT

Description:	In this option, an additional wastewater treatment plant would be constructed in close proximity to the location of the existing Courtenay PS to treat the sewage collected and currently conveyed by the Courtenay PS. Due to the location of the outfall, the effluent of a decentralized wastewater treatment plant would have to be conveyed to the location of the existing outfall for discharge. Alignments for the conveyance of the effluent discharge are similar to those discussed within Options 1, 2, 3 and 4, and include estuary, overland, tunnelled, and north side alignments. The sewage collected at the JPS will be conveyed to the existing CVWPCC for treatment using an overland or tunnelled option. Overland options would still require a new pump station for the JPS, and subject to the length and depth of the tunnelled option a new pump station in Comox maybe required.
Advantages	» Eliminates the need for conveyance of Courtenay's raw sewage through the CVSS to the CVWPCC » Alleviate capacity-driven upgrade requirements at the CVWPCC.
Disadvantages	» Requires the need for conveyance of the decentralized Wastewater Treatment Plant (WWTP) effluent to the outfall using a new pumping and conveyance system. » Significant operational burden with two wastewater treatment plants. » Significant cost associated with the construction of a new wastewater treatment plant, and maintenance and operation of two plants. » Still requires conveyance of raw sewage overland from Comox.
Technical Consideration	Even following treatment of the sewage, the effluent would need to be discharged to the existing outfall as it is not an option to discharge treated effluent within the embayed waters around Comox. As a result, an effluent pipe would have to be routed from the CPS to the CVWPCC. This effluent would be a unique fluid (i.e.: not potable water, storm water or sewage) and as such could not be integrated with any existing system in the Comox area. Once the effluent is at the CVWPCC site it would by-pass the treatment plant and combine with the CVWPCC effluent. By removing a major portion of the sewage from the existing CVWPCC the existing plant would likely be rendered oversized and could result in a reduction in treatment efficiency and performance. Locating a new treatment plant in the general area of the CPS would be a significant challenge as this would have a very large footprint and need to be designed to address all future sewage flows in the catchment area. Once the effluent has been treated a high pressure effluent pump station would be required to convey the effluent. The ground elevation at a potential WWTP site would potentially be exposed to sea-level rise and storm surges.

Environmental Considerations	Overland portions routed along existing roadways would have limited environmental impacts. Areas where there are significant adjacent trees could be potentially damaged due to root damage. Depending on the exact location, new WWTP would result in a loss of land around the ALR and the associated habitat in the area.
Archaeological Considerations	Depending on the exact location of the new WWTP, and the alignment associated with the effluent conveyance, there can moderate to high potential of encountering known or unknown archeological sites in this general area. Construction of new infrastructure along existing areas of disturbance will minimize risk of archaeological impacts.
Operational Considerations	Operation of a second CVWPCC would be required and would not be suitable for overlap of many operational resources. Staff would be required at both sites and treatment systems would be duplicated, resulting a loss of efficiency associated with system maintenance. Solids handling and disposal would have to occur at two locations, rather than at one centralized site. There would be limited reduction in overall power requirements as a pump station is still required to convey treated effluent to the CVWPCC. A minor increase in pump efficiency would be achieved as a pump suitable for treated effluent will be more efficient than a raw sewage pump.

Infrastructure Elements

Description	Capital Cost	Investment Year	Renewal Frequency	Renewal %	Total Power (kW)	Labour hrs/day
New Courtenay - High Pressure Increase	$29,400,000	2020	25	40%	900	3
Downgrade Jane	$2,362,500	2020	25	40%	25	0
New Jane - Moderate Pressure Increase	$3,850,000	2020	25	40%	425	3
Overland Jane to connect to FM (Long Distance to North)	$4,804,800	2020	60	100%	0	0
Overland Forcemain North from Courtenay to CVWPCC	$27,489,000	2020	60	100%	0	0
New Courtenay WWTP	$105,000,000	2020	100	100%	2000	24
Old Jane to New Jane	$51,744	2020	60	100%	0	0
KFN Pump Station and FM to Courtenay	$616,000	2020	60	100%	0	0
Total Capital Cost	$173,574,044					

Note that Total Power for the New Courtenay WWTP is not necessarily representative of the expected total power required for the facility. The value of 2000 kW has been used such that it accounts for a number of various Operations and Maintenance cost categories that are not built into the cost model and are difficult to individually account for.

Cost Considerations	This option has a significant initial capital expenditure of $174M, approximately double the average capital cost for all other options considered. This cost is driven by the need for construction of an additional WWTP in Courtenay. There is no operating cost advantage to this option as is requires the operation of an additional WWTP, including additional power requirements and labor. Also, depending on the alignment for the effluent conveyance (assumed a North side alignment similar to 4A in this case), the high pumping head requirement for conveyance of effluent can result in significant financial operating costs.
Figures	Concept alignment is provided on Figure 18. Profiles are not provided as the alignment will follow a combination of the alignments presented under one of options 1,2, 3, or 4.

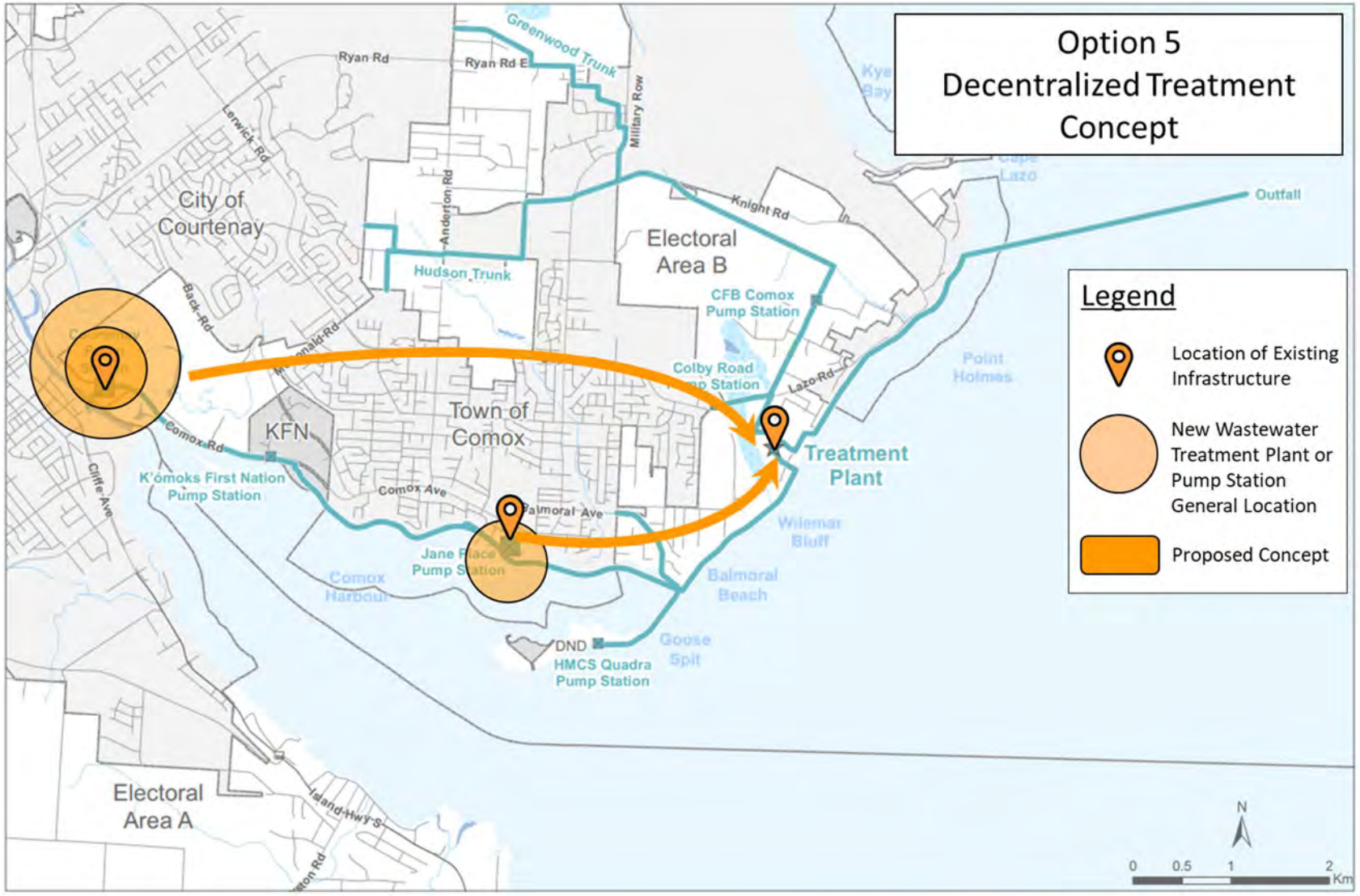


Figure 10-18: Decentralized Treatment Concept 5

10.2.6 OPTIONS FINANCIAL SUMMARY

Table 10-2 shows the summary of the infrastructure components that are applicable to each of the alignment and concept options presented in this section, as well as the approximate capital cost associated with each item. The costs presented in this report do not include GST. These costs are only for the purpose of options comparison and discussion and are not suitable for budgeting.

Table 10-2: Infrastructure Components' Capital Cost

Description	Class 'D' Cost 2019$ 40% Contingency	Alignments and Conveyance Concepts									
		1A	1B	1C	2A	2B	3A	3B	3C	4A	4B	5
Upgrade Courtenay (Capacity and AM driven)	$ 4,200,000			•								
New Courtenay - Moderate Pressure Increase	$ 10,500,000	•	•		•	•	•	•	•			
New Courtenay - High Pressure Increase	$ 29,400,000									•	•	•
Upgrade Jane (Capacity and AM driven)	$ 3,150,000			•		•			•			
New Jane - Moderate Pressure Increase	$ 3,850,000	•	•		•		•	•		•	•	•
Downgrade Jane	$ 2,363,000	•	•		•		•	•		•	•	•
New In-line Pump Station	$ 12,040,000			•		•						
Forcemain Tunnel through Lazo hill	$ 23,587,000	•					•	•				
Forcemain Tunnel through Comox hill	$ 11,735,000						•					
Gravity Tunnel through Lazo hill	$ 27,801,000								•			
Overland from Comox hill to Lazo hill	$ 10,977,000						•					
Overland Courtenay to Lazo Hill	$ 26,999,000					•		•				
Overland Courtenay to Jane (New or Existing)	$ 16,493,000				•				•			
Overland Jane to Lazo Hill	$ 4,851,000				•				•			
Overland Jane to connect to FM (Long Distance to North)	$ 4,805,000									•	•	•
Overland Lazo Hill to CVWPCC	$ 5,914,000		•	•	•	•						
Overland Forcemain North from Courtenay to CVWPCC	$ 27,489,000									•		•
Overland Gravity North from Courtenay to CVWPCC	$ 38,962,000										•	
Estuary Courtenay to Jane	$ 32,728,000		•									
Estuary Courtenay to Lazo Hill	$ 38,133,000	•		•								
New Courtenay WWTP	$ 105,000,000											•
Jane to forcemain	$ 1,109,000	•	•	•	•		•		•			
Old Jane to New Jane	$ 52,000		•					•		•	•	•
Overland Courtenay to CVWPCC (Excl. Tunnel Sections)	$ 15,847,000						•					
Overland Lazo Tunnel to CVWPCC	$ 1,617,000							•	•			
KFN Pump Station and FM to Courtenay	$ 616,000									•	•	•
New CFB Pump Station	$ 3,920,000										•	

Table 10-4 on the following page shows the 30, 50, and 100-year Net Present value (NPV) for all alignments options and conveyance concepts discussed in this report. The NPV is representative of the capital cost, asset management cost, and operations and maintenance costs (inclusive of power and labour). The parameters used in calculating the NPV are shown in Table 10-3.

Table 10-3: NPV Calculations Parameters

Parameter	Value	Unit
15-yr Municipal Finance Authority (MFA) Long-Term Lending Rate	3.05	%
15-yr Engineering News-Record (ENR) Construction Index	3.02	%
Starting Power Cost	11.21	$/kW-hr
Power Rate Increase	5	%
Operating hrs/day	12	hr
Variable Rate	0.055	$/kW-hr
Labour Rate	100,000	$/yr
Labour Inflation	3	%

Table 10-4: Options Net Present Value

Option ID	Options Description	Initial Capital Cost	30-Year			50-Year			100-Year		
			Capital	O&M	Total	Capital	O&M	Total	Capital	O&M	Total
1A	Estuary With Lazo Hill Tunnel	$ 79.5	$ 86.1	$ 14.9	$ 100.9	$ 92.7	$ 29.4	$ 122.1	$ 167.4	$ 97.4	$ 264.8
1B	Estuary with Lazo Hill Overland Route	$ 56.5	$ 63.2	$ 24.3	$ 87.5	$ 69.8	$ 48.5	$ 118.3	$ 121.9	$ 164.9	$ 286.8
1C	Estuary with a New In-Line Pump Station	$ 64.5	$ 72.1	$ 25.8	$ 97.9	$ 79.8	$ 51.1	$ 130.9	$ 139.2	$ 171.1	$ 310.3
2A	Overland Forcemain	$ 45.1	$ 51.7	$ 23.3	$ 75.0	$ 58.4	$ 46.4	$ 104.8	$ 99.3	$ 157.4	$ 256.7
2B	Overland Forcemain with In-Line Pump Station	$ 58.6	$ 68.7	$ 33.1	$ 101.8	$ 74.7	$ 66.0	$ 140.7	$ 127.1	$ 223.5	$ 350.6
3A	Tunnel Through Comox Hill and Lazo Hill	$ 80.0	$ 86.6	$ 14.9	$ 101.5	$ 93.2	$ 29.4	$ 122.6	$ 168.4	$ 97.4	$ 265.8
3B	Tunnel Through Lazo Hill	$ 69.0	$ 75.6	$ 17.0	$ 92.6	$ 82.2	$ 33.6	$ 115.8	$ 146.6	$ 112.4	$ 259.0
3C	Gravity Tunnel From Comox to the CVWPCC	$ 65.5	$ 70.9	$ 16.6	$ 87.6	$ 76.4	$ 32.9	$ 109.3	$ 138.0	$ 109.9	$ 247.9
4A	North Side Forcemain Concept	$ 68.6	$ 82.7	$ 26.0	$ 108.8	$ 96.8	$ 52.1	$ 148.9	$ 157.0	$ 177.4	$ 334.4
4B	North Side Gravity Concept	$ 84.0	$ 99.9	$ 30.3	$ 130.2	$ 115.8	$ 60.4	$ 176.2	$ 190.2	$ 204.8	$ 395.0
5	Decentralized Treatment Concept	$ 173.6	$ 187.7	$ 58.3	$ 246.0	$ 201.8	$ 114.0	$ 315.8	$ 364.0	$ 371.9	$ 735.9

For ease of comparison, the following colour gradient has been used in Table 10-4. The highest cost in each column is shown in red (right of the color gradient), and the lowest cost in each column is shown in green (left of the colour gradient), with the in-between values shown in the respective colour along the gradient.