April 19, 2023

Charlie Gore
Manager of Capital Projects
Comox Valley Regional District
770 Harmston Ave.
Courtenay, BC
V9N 0G8

Dear Mr. Gore,

During the CVRD LWMP review, of options to convey raw sewage from the City of Courtenay, K'omox First Nation, and the Town of Comox, two options were advanced to the short list review. Namely Option 2A: Overland Forcemain (Cut and Cover installation) and Option 3: Optimal Tunnelling[1]. The community elected to advance with the optimal tunnelling option involving a horizontal directionally drilled (HDD) pipe through Lazo Hill to reduce the overall pumping head and system hydraulic pressures as the Courtenay and Comox pump stations. This design was used as the basis of the current Design-Build program. The concept was developed around the attached Figure 1, which graphically depicts the system hydraulic grade line. Given the required constraints around the HDD portion of the work and given perception of the drilling risks associated with the required alignment, the option of an overland alignment is being revisited.

Overland Option Development

The proposed overland alignment is provided in the attached Figure 2 and 3. Two scenarios were considered, one utilizing a standard depth of cover of 2m, resulting in a maximum static lift of approximately 48m. The other one uses a 10m depth of burial, resulting in a maximum static lift of 40m. The additional depth was evaluated as it reduces the required pumping head at the Courtenay Pump Station. Due to the alignment change, the project's length increases by about 350 m.

As a result of these changes, the required discharge pressure at the Courtenay Pump station increases as summarized in Table 1 below. Two pipe diameters were modelled, the current 32" nominal OD HDPE pipe and a larger 36" nominal OD HDPE pipe. For both options DR17 PE4710 pipe was used.

[1] WSP. 2020. Memo: CVRD LWMP Stage 2 – Conveyance Options Assessment – Final.

- 2100 PWWF FLOW; C=130 (Q = 1,150 L/s); 32m INVERT AT LAZO ROAD
- 2100 PWWF FLOW; C=130 (Q = 1,150 L/s); 24m INVERT AT LAZO ROAD
- 2060 PWWF FLOW; C=130 (Q = 930 L/s); 32m INVERT AT LAZO ROAD
- 2060 PWWF FLOW; C=130 (Q = 930 L/s); 24m INVERT AT LAZO ROAD
- STATIC; 32m INVERT AT LAZO ROAD
- STATIC; 24m INVERT AT LAZO ROAD

Comox Valley Regional District

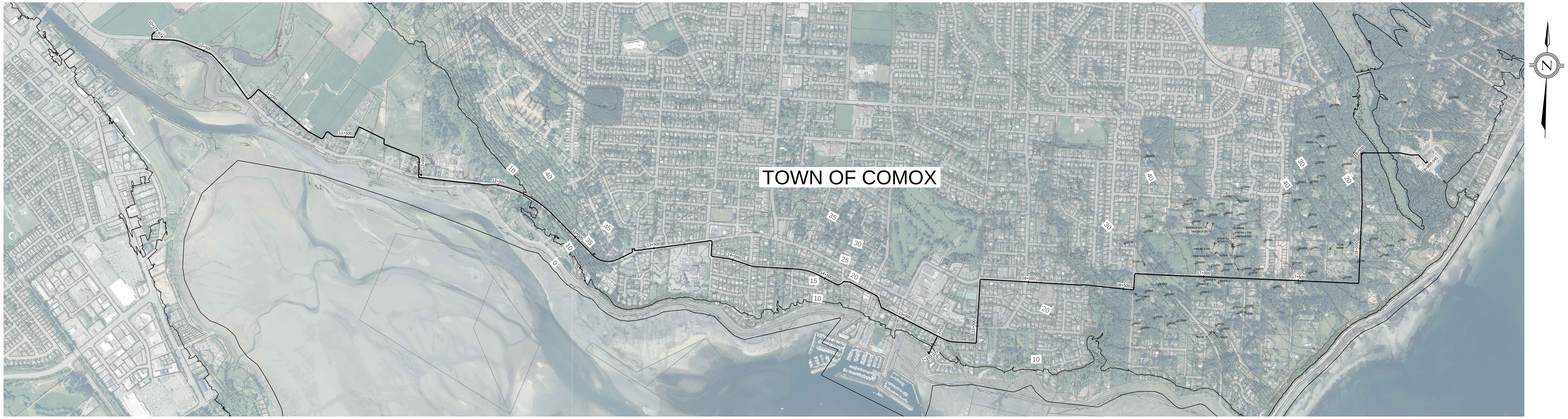
Comox Valley Regional District

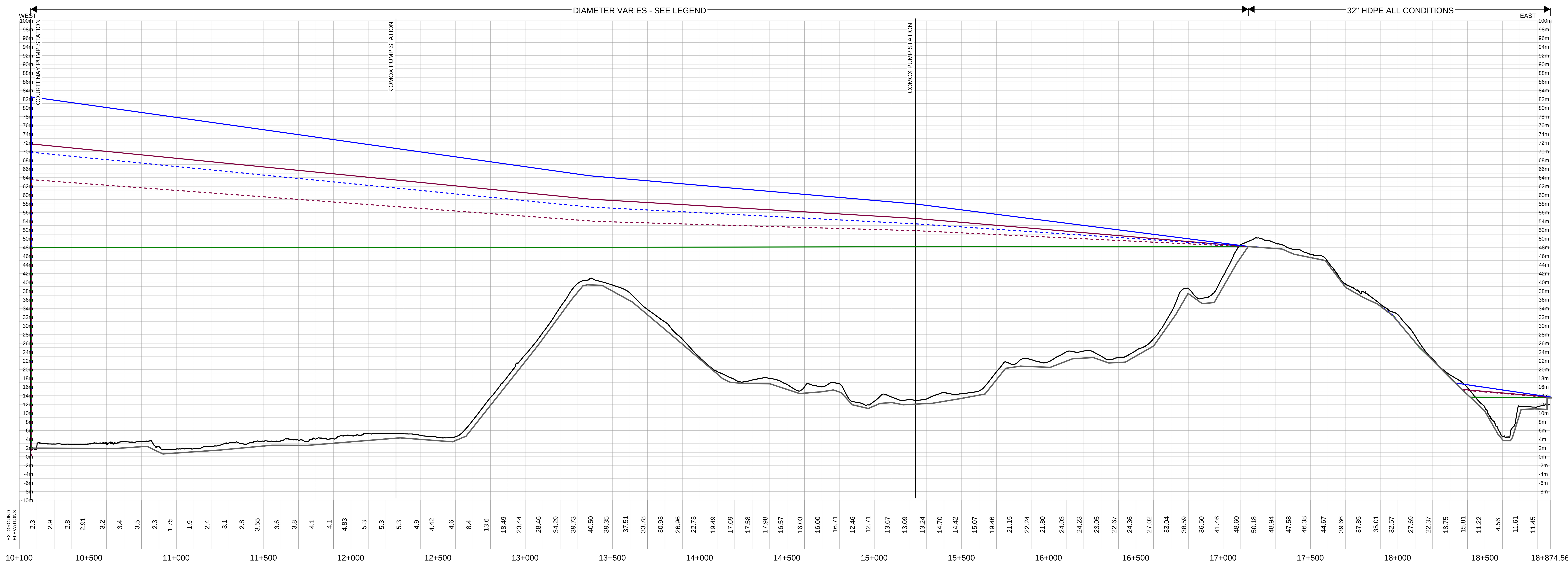
Indicative Design HDD Alignment

Hydraulic Profile

JOB NUMBER	10308968
DATE	JAN 19 2022
SCALE	H 1:10,000 V 1:400

FIGURE 1





HDR

LEGEND
32" HDPE AT 2100 PWWF
32" HDPE AT 2060 PWWF
36" HDPE AT 2100 PWWF
36" HDPE AT 2060 PWWF
STATIC

Comox Valley REGIONAL DISTRICT

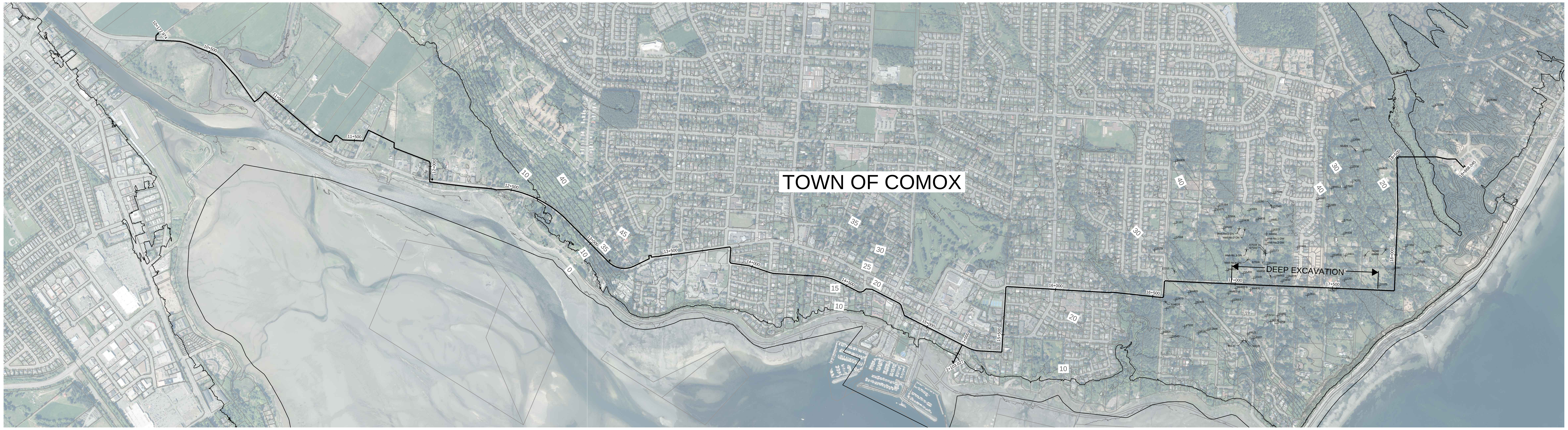
Comox Valley Regional District

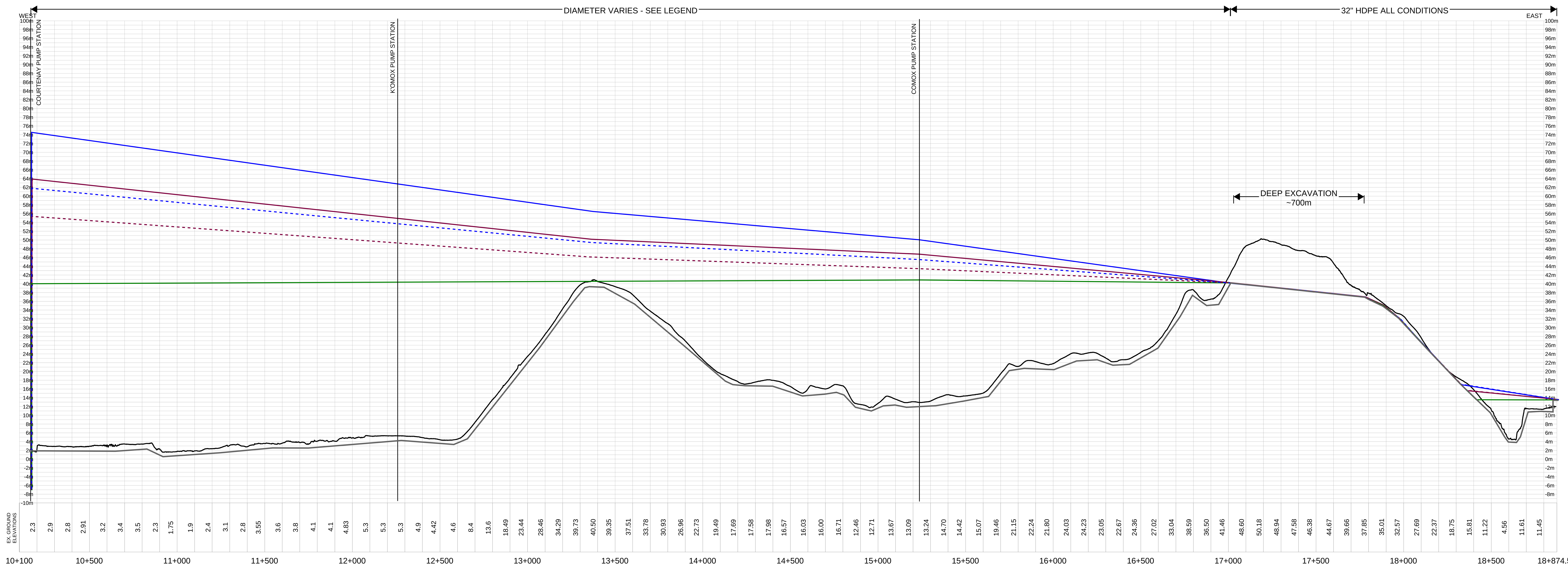
Overland Alignment - No Deep Excavation

Hydraulic Profilele

JOB NUMBER	10308968
DATE	APR 06 2023
SCALE	H 1:10,000 V 1:400

FIGURE 2





LEGEND

- 32" HDPE AT 2100 PWWF
- 32" HDPE AT 2060 PWWF
- 36" HDPE AT 2100 PWWF
- 36" HDPE AT 2060 PWWF
- STATIC

HDR

Comox Valley Regional District

Comox Valley Regional District

Overland Alignment - Deep Excavation

Hydraulic Profile

JOB NUMBER	10308968
DATE	APR 06 2023
SCALE	H 1:10,000 V 1:400

FIGURE 3

Table 1. Estimated Discharge Pressure at the Courtenay Pump Station

Design Number	Design Configuration	2060 Courtenay Discharge TDH	2100 Courtenay Discharge TDH	Static Head
1	32” HDPE Forcemain 2 m burial depth at Lazo Height of Land 2100 PWWF Design	73 m	83 m	48m
2	32” HDPE Forcemain 10 m burial depth at Lazo Height of Land 2100 PWWF Design	65 m	75 m	40m
3	36” HDPE Forcemain 2 m burial depth at Lazo Height of Land 2100 PWWF Design	64 m	70 m	48m
4	36” HDPE Forcemain 10 m burial depth at Lazo Height of Land 2100 PWWF Design	56 m	62 m	40m
Notes: 1. Modelled at C=130; total length 8.5km; 32” pipe diameter from top of Lazo hill to CVWPCC 2. Assumed low wet well levels at CPS of -4.0m and CXPS of -5.2m				

The estimated total discharge head was used to select Xylem (Flygt) sewage pumps at the Courtenay design flow 700 L/s PWWF condition, while Comox Pump station was operating at 303 L/s, which correspond to the 2100 system flow forecasts prepared for the CVRD. The selected pumps were also compared to the 2060 design operating condition of 559 L/s at PWWF and average day operating conditions, plus Comox Pump Station flows of 244 L/s.

Given the CVRD’s past experience, support and operational knowledge, pump options were limited to available submersible Xylem non-clog series pumps in a wet well configuration. Custom N-series pumps, C-series pumps and other pump manufactures have not been reviewed at this time.

The only pump suitable to meet the required operating condition and specified N-Series (non-clog) impeller is the N-3312 in either the 565mm impeller or 585mm impeller. The results are summarized in Table 2 below. No pumps were identified in the Xylem standard selection which could accommodate the 32” diameter pipe for the 2100 PWWF design event.

Table 2. Reviewed Pump Design Variations

Design Number	Impeller	Motor (hp)	Single Pump Flow	Maximum Station Flow With 3 online pumps	Comments
1	No available options for 2100 PWWF				
2					
3A (36"θ @ 2m Burial)	565mm	470	200 to 430 L/s	650 L/s	Motor overloads at approximately 650 L/s, outside of pump & system curve operating range
3B (36"θ @ 2m Burial)	585mm	470	200 to 400 L/s	730 L/s	Motor overloads at approximately 500 L/s, within pump operating range, but outside the normal operating range. Typically, this would require PLC control to limit motor speed and power draw under lower head conditions.
4 (36"θ @ 10m Burial)	565mm	470	180 to 500 L/s	760 L/s	Motor overloads at approximately 650 L/s, outside of pump and system curve operating range

Two options were able to meet the 2100 flow of 700 L/s, 3B and 4. Option 3B would require PLC control to prevent the motor overloading, where the motor draws more power than the motor rating. Should this occur, the motor would fault and shutdown. Option 4 provides both the necessary flow and is not subject to the overloading condition.

Pump curves, system curves and minimum turn down flow are provided in the following figures. The pumps are N-3312/865 3 – 670 models with either a 585 or 565 mm impellors. The vertical green lines are design flow, and the vertical red lines represent where a single pump motor overloads at full speed. All selected pumps operate at 600V.

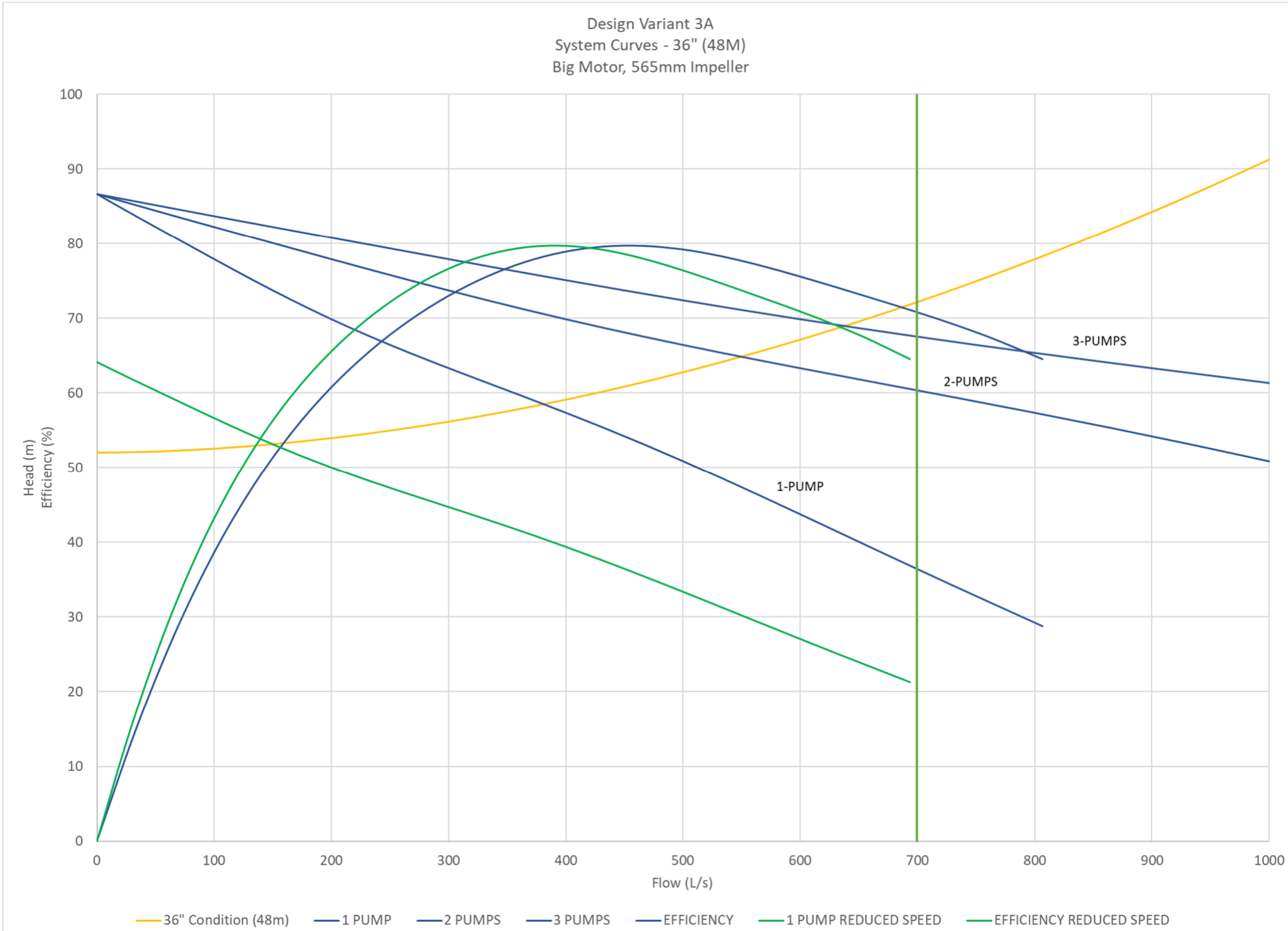


Figure 4. Design variant 3A Pump and System Curves

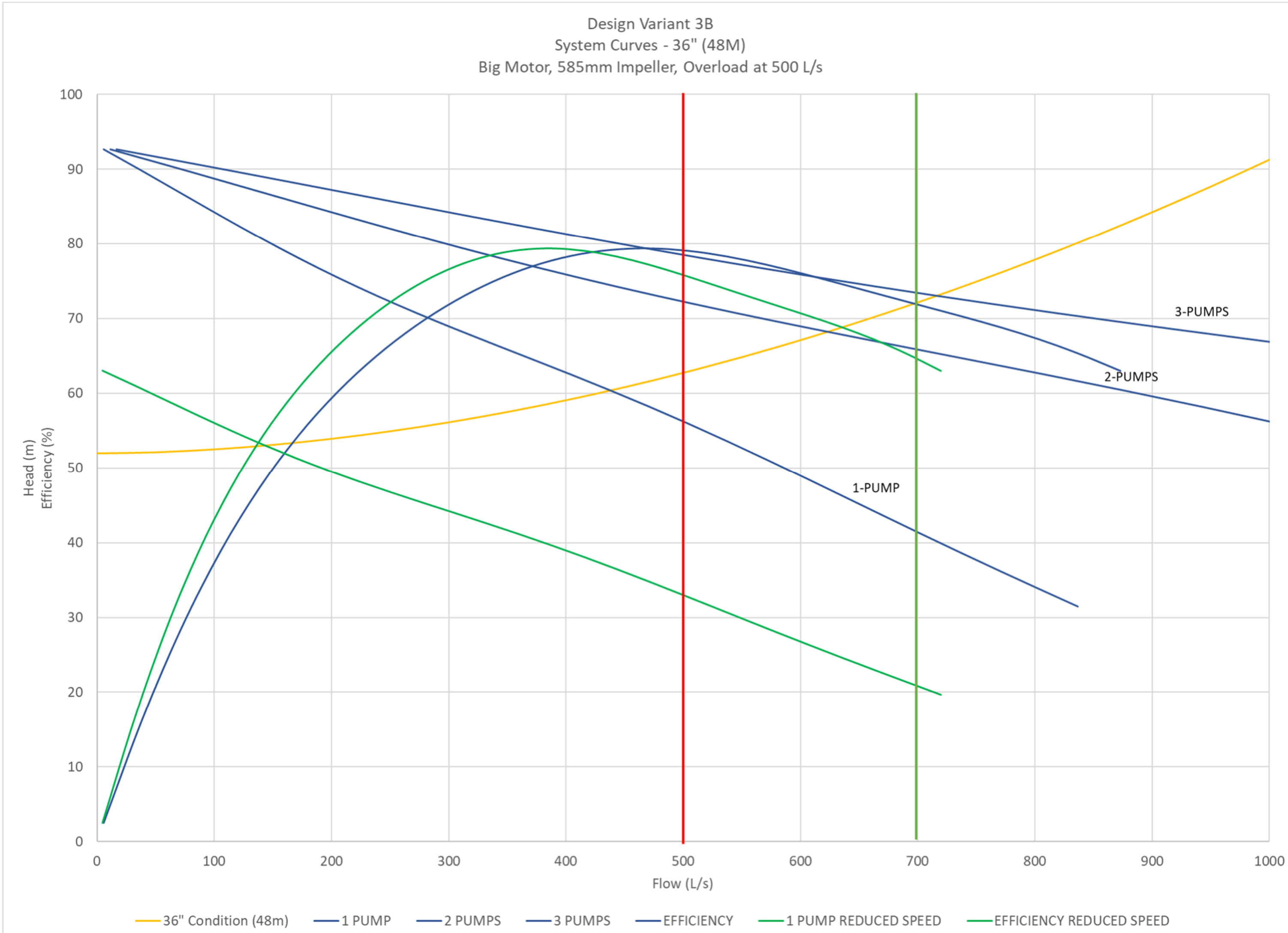


Figure 5. Design variant 3B Pump and System Curves

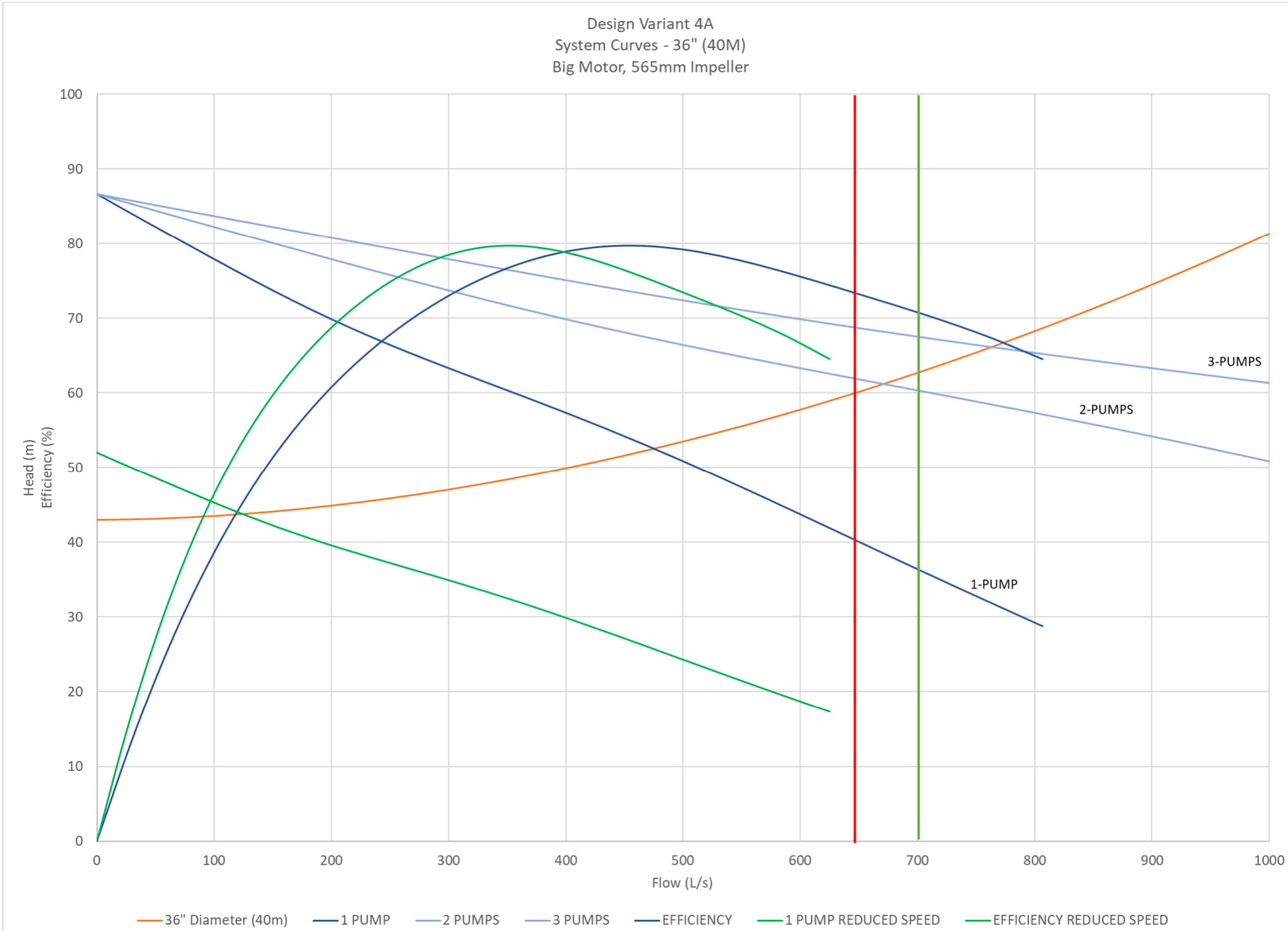


Figure 6. Design variant 4A Pump and System Curves

In all the above conditions there is a limit on the speed at which an individual pump can be turned down to meet low flow operations. This is approximately 80% of the maximum speed. This speed allows for pump operation at the bottom end of its AOR (allowable operating range), which is equal to 50% of BEP (best efficiency point) flowrate. As a result, the pump will need to cycle during low flow operation or accept the lower pump efficiency under these conditions. To accommodate pump cycling, a review of the wet well volume was completed to evaluate the minimum volume, during low flows, which would be required to limit pump cycling to less than 6 times per hour. This equated to 25m^3 when the four pumps are cycled (24 cycles per hour) and 50m^3 when only a single pump is cycled. This is equal to or less than the estimated operational wet well volume of 50 m^3 proposed in the conceptual wet well layouts required to meet the pump configurations, thus not a governing constraint.

Although the 36" pipe does result in a reduction in the cleaning velocity, limiting pump turn down results in a fluid velocity of around 0.8 m/s which is the minimum recommended velocity to lift sand (0.3 mm particles) up the inclining grade over Comox Hill. However, this will result in slug operation at the CVWPCC headworks which could negatively impact the grit removal through proposed vortex grit chambers; which will operate best with a continuous flow. At 80% speed the pump flow would be in the range of 120 to 150 L/s, which results in a fluid velocity of 0.3 m/s (1 fps) which would be expected to permit settlement within the forcemain. This flow is typical for the 2060 average day flow rate.

Operationally the challenge would be operating at a low, steady flow, with additional deposition in the forcemain, followed by seasonal flushing. Resulting in sediment slug loading at the treatment plant, or slug operation of the pumps and less grit accumulations in the forcemain.

Due to the increased static operating pressure in the system, there would no longer be a section of gravity flow on the eastern side of Comox Hill. This would reduce, but not eliminate, the need for odour and air management at the top of the hill. The reduction is the result of the elimination of turbulent flow and the associated release of volatile odours, however as this is a high point, air release is still required. Transient conditions would still persist, including vacuum pressures during the return transient wave, thus similar vacuum protection to the existing design would still be required.

Operationally, the new Courtenay pump station would be hydraulically linked to the operation of the Comox Pump station, similar to the current condition such that that the system hydraulics will vary as each pump station is cycled.

It is recommended to retain a 32" pipe on the eastern side of Lazo Hill where gravity flow conditions will prevail. As the flow transits from pressure to gravity along Morland Road, air and odour management will be required to manage odours. This would likely involve a mechanical odour treatment system such as a carbon scrubbing system.

Comox Pump Station Review

The Comox Pump station was also reviewed to evaluate the impact on the increase in discharge head. The evaluation was evaluated when the Courtenay Pump station was operating at the 2100 design flow of 700 L/s and the Comox Pump station operating at 303 L/s. The discharge head, to overcome the system pressure at the tie-in point, under both the 2m deep and 10m deep excavation options on Lazo Hill was considered. The hydraulic conditions are listed in Table 3 and the pump and system curves for these conditions are provided in Figure 7 below (separate page).

Table 3. Comox Pump Station Hydraulic Parameters

Design Number	Design Configuration	2060 Comox Discharge TDH	2100 Comox Discharge TDH	Static Head
1	36" HDPE Forcemain 2 m burial depth at Lazo Height of Land 2100 PWWF Design	58m	61m	48m
2	36" HDPE Forcemain 10 m burial depth at Lazo Height of Land 2100 PWWF Design	50m	53m	40m
Notes: 1. System Modelled at C=130; total length 8.5km; 32" pipe diameter from top of Lazo hill to CVWPCC; Comox Connection modelled at C=130; length of 100m; 18" DR17 HDPE 2. Assumed low wet well levels at CPS of -4.0m and CXPS of -5.2m 3. An additional static head of 3m (2060) and 5m (2100) is included when the Courtenay Pump station is operating at PWWF.				

The resulting pump selections are 160 hp and similar in physical size to the pumps noted on the as-built drawings for the Comox Pump station, based on four pumps in a 3+1 operation. Challenges within the existing pump station, such as spatial constraints would still exist. The generator would be approximately 800 kW and the MCC line-up would be around 9m long. Several configurations for the pump station have been reviewed and generally include an interior generator with exterior exhaust plenum and MCC within the building. An exterior fuel system and washroom facility would likely be required.

The proposed pumps were reviewed to confirm they would fit in the existing wet well. The existing hatches are 1500 x 2400mm, sub-divided with a removable channel. The proposed N-3315 HT 3 – 458 (160 hp) pump has a physical footprint of 1050 x 620mm which is significantly less than the existing hatches. The Comox Pump Station electrical single line drawing notes that the original design considered an ultimate pump size of 4 pumps at 180 hp each. As such, the existing wet well appears to have been designed with consideration for pumps up to 180 hp.

Comparison to Short List Review

The proposed overland option presented in the WSP September 2020 Memo, CVRD LWMP Stage 2 – Conveyance Options Assessment – Final is discussed below and compared to the above evaluation. Hydraulically the system proposed in the above memo was based on a 42" diameter forcemain from the Courtenay Pump Station to the Comox Pump Station, and a 48" diameter forcemain to the CVWPCC. This configuration resulted in Courtenay Pump Station discharge head of approximately 63m. The WSP analysis used a 52m height of land and top of pipe at 50m, which was based the available LiDAR data. With a 2m burial depth the pipe invert can be reduced to 48m. This compares to Option 3, which has a maximum Courtenay pump station head of 70m. The deeper trench installation depth, Option 4, would permit a decrease in the Courtenay pump station head to around 62m.

A considerable risk with the proposed 42” and 48” pipes used in the WSP assessment is the low operational velocity in the forcemain. At average 2060 flows, the velocity is 0.2 m/s and at 2060 PWWFs the velocity is 0.9 m/s. Only during PWWF would the minimum flushing velocity of 0.8 m/s be exceeded, increasing the risk of solids deposition, and exacerbating the risks of large seasonal solids loading at the CVWPCC.

WSP noted that there is a higher complexity when operating at high discharge heads. We would agree that this would be the case should existing pumps not be available and pumps in series, or non-standard pumps be required to meet this head. This is, however, not the case with a 36” diameter forcemain. WSP also noted that at this pumping head a new Courtenay pump station would be required and a new Comox pump station would be required. The overall project assumes a new Courtenay pump station is required, and based on the reviewed pumps for Comox pump station, and some compromises on the installation configuration at the Comox station – such as placing the fuel tank outside, internal generator, exterior sound pods and stand-alone washroom, there appears to be an option to modify the existing Comox Pump Station for the interim 20-40 year period.

To assess the use of high head pumps, we discussed the proposed 36” diameter forcemain with Xylem and confirmed that the proposed pump (N-3312) is suitable for the high head application and flow. Flygt noted that there will be a turn-down limit on the pump which, as discussed above, requires consideration in the pump operation to maintain flushing velocities in the forcemain.

We trust the above options evaluation provides the immediate guidance necessary to review the technical feasibility of the overland option.

Sincerely,
HDR Corporation

Walt Bayless, P.Eng.
Project Manager

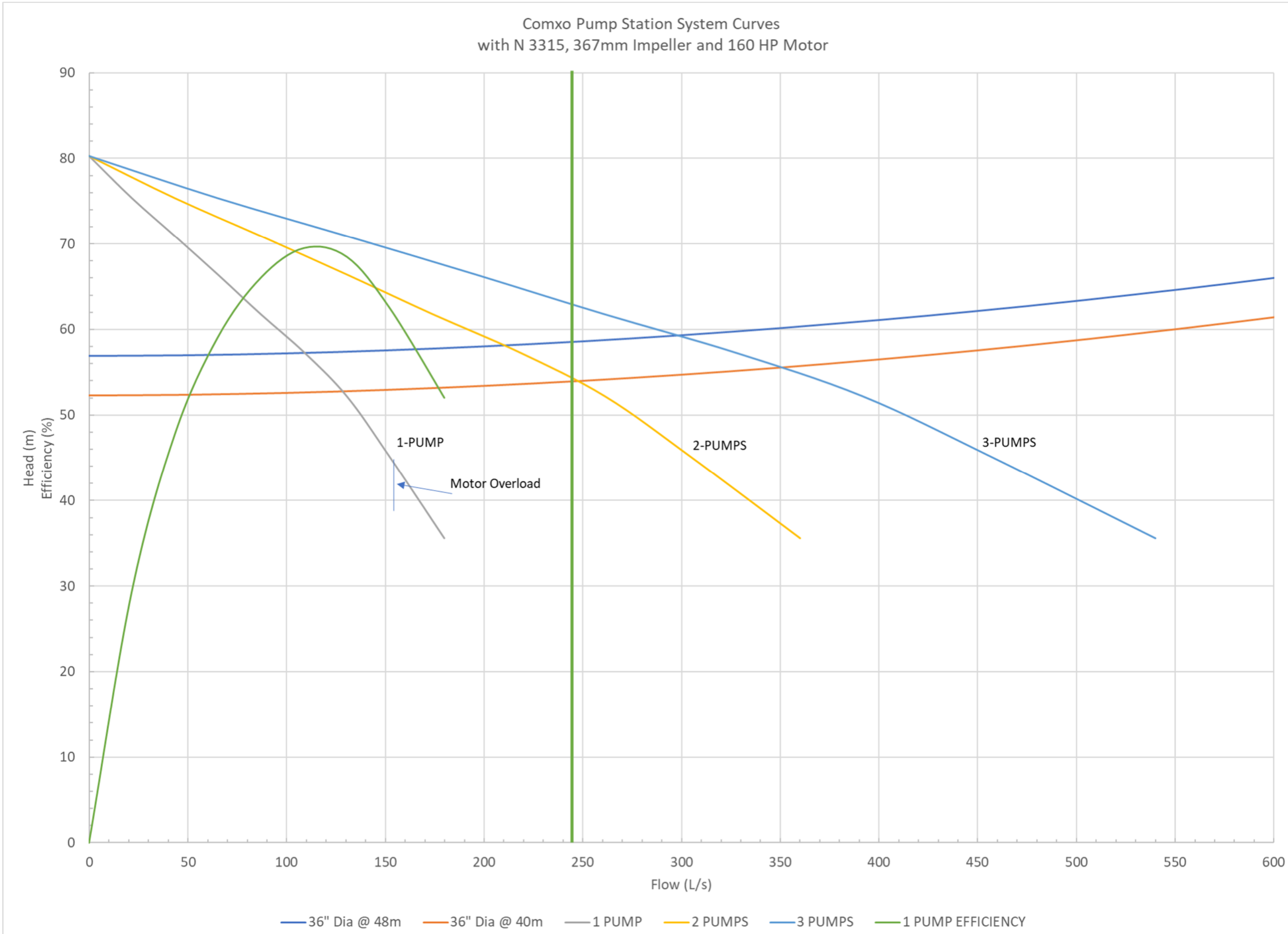


Figure 7. Comox Pump Station System Curve