TETRA TECH

TECHNICAL MEMORANDUM

To:	**Nevada Environmental Response Trust**
Cc:	Derek Amidon and Dan Pastor, Tetra Tech
From:	Eric Klink, Tetra Tech and Pat Convery, Cornerstone
Date:	August 4, 2016
Subject:	GWETS Effluent Pipeline Flow Evaluation

1.0 PURPOSE

At the direction of the Nevada Division of Environmental Protection (NDEP), the Nevada Environmental Response Trust (NERT or Trust) is currently considering several options to enhance and expand the treatment of perchlorate-impacted water at the NERT Site (Site) in Henderson, Nevada. The Infrastructure Audit and Data Accessibility Report (Tetra Tech, 2015) identified the capacity of the effluent pipeline as a potential key factor limiting NERT's ability to utilize the full capacity of the Groundwater Extraction and Treatment System (GWETS), and further identified that there may be a restriction in the effluent piping limiting maximum average flow to approximately 1,000 gallons per minute (gpm). The Infrastructure Audit and Data Accessibility Report recommended completion of a detailed evaluation of flow conditions in the GWETS effluent pipeline.

At the direction of the Trust, Tetra Tech, Inc. (Tetra Tech), supported by its subcontractor Cornerstone Energy Services (Cornerstone), has completed a hydraulic evaluation of the GWETS effluent pipeline. This Technical Memo summarizes the observed field testing conditions, the data collected, and the modeling results, and presents recommendations for potential system improvements and modifications that would achieve higher discharge rates.

2.0 BACKGROUND

The GWETS effluent line is approximately 3.8 miles long and is comprised of various diameter HDPE piping. The following table summarized the pipeline physical characteristics.

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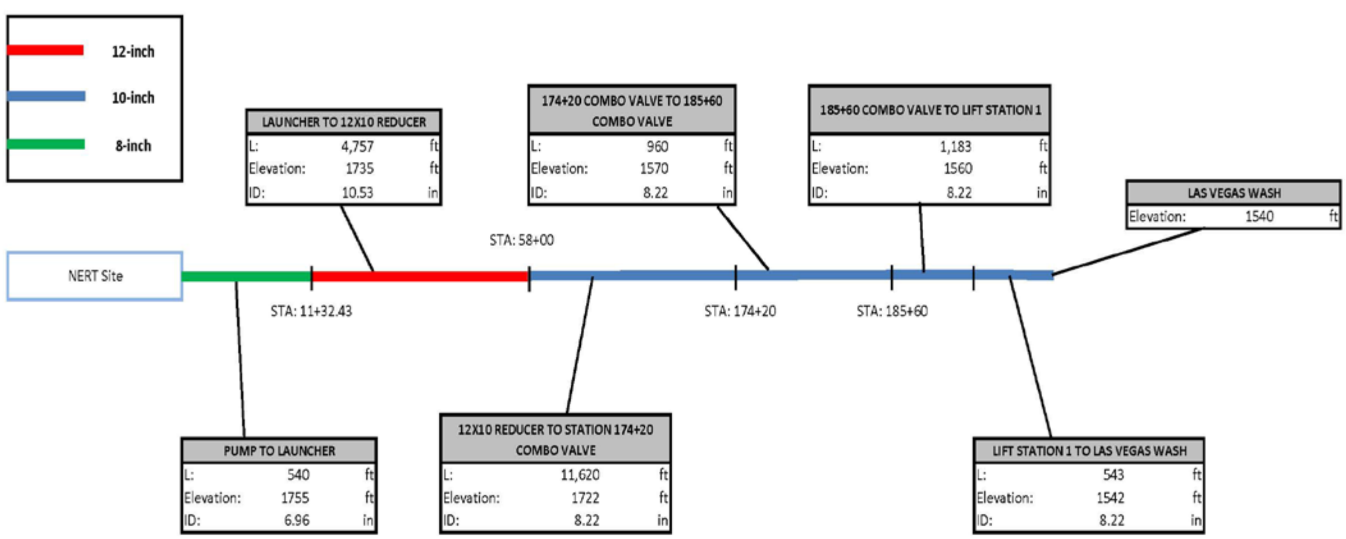
Table 1 Summary of GWETS Effluent Line

Pipe Segment	Pipe Length	External Diameter	Additional Information
Effluent Pumps (D-1 Building) to Equalization Area	540 feet	8 inch	Although the 8-inch line and a companion 10-inch line are indicated on the Fluidized Bed Reactor (FBR) piping and instrumentation diagrams (P&IDs), there are no design or as-built drawings available on this pipe segment. Length is based on a scaled Google Earth estimate of the distance from the D-1 Building to Equalization Area. This pipe segment cannot be pigged.
Equalization Area to Reducer (Station 58+00)	4,757 feet	12 inch	Information on this pipe segment is from the PBS&J/Kerr McGee effluent and influent line design drawings and has not been independently verified. This pipe segment can be pigged. The reducer is located at Station 58+00, on Pabco Road approximately 1,000 feet north of Warm Springs Road.
Reducer to LS 1	13,763 feet	10 inch	Information on this pipe segment is from the PBS&J/Kerr McGee effluent and influent line design drawings and has not been independently verified. This pipe segment can be pigged.
LS-1 to Outfall	543 feet	10 inch	There are no design or as-built drawings available on this pipe segment. Length is based on a scaled Google Earth estimate of the distance from LS-1 to the outfall. Diameter is based on observation in the field. This pipe segment cannot be pigged

The effluent pipeline system is graphically presented below, including the length of each segment, the estimated elevation of the beginning of each segment, and the internal pipe diameter.



The station 174+20 and 185+60 combo valves are called out as these locations were selected for installation of pressure gauges as part of the field testing activities, described in Section 4.

A pig is periodically used to clean the 12-inch and the 10-inch pipeline. The pig launcher is located at the Equalization Area adjacent to the east side of GW-11, and the pig exits near Lift Station 1. The material flushed from the pipe is captured in a sump at Lift Station 1 and pumped back to the on-site treatment system. A foam pig that is flexible enough to traverse both the 12-inch and 10-inch line is used. Based on information provided by Envirogen Technologies, Inc. (ETI), the pipeline is pigged sporadically, but generally one to two times a month.

3.0 PERMITTING

The current effluent discharge rate is limited by two permits. Clark County Department of Air Quality Minor Source Permit No. 17249 limits the maximium operating capacity of the FBR treatment plant to 1.44 million gallons per day (MGD), or 1,000 gpm. National Pollution Discharge Elimination System (NPDES) Permit No. NV0023060 limits the 30-day average effluent flow to 1.45 MGD (1,007 gpm), with a daily maximum limit of 1.75 MGD (1,215 gpm).

In order to test the upper capacity limits of the line, Tetra Tech planned to observe the system operating at flowrates higher than the permitted conditions of 1,000 gpm. According to discussion between a representative from Tetra Tech and Ted Lendis, Air Quality Supervisor, at the Clark County Department of Air Quality on January 22, 2016, submission of a request for a permit waiver is not required for facilities that meet the conditions of Clark County Air Quality Regulation 12.1.2(c)(7)(A) through (G), which the pipeline test met. Namely, the short-term flow rate test did not increase the facility's potential to emit or exceed 72 hours in duration. Written notice was provided, although not required, to the County via the 2015 Annual Report for Minor Source Permit 17249.

4.0 FIELD TESTING

Tetra Tech was assisted by Cornerstone staff during testing and data acquisition activities, and with performance of the pipeline hydraulic modeling. Tetra Tech and Cornerstone personnel mobilized to the Site on May 17, 2016. Following safety orientation, Tetra Tech worked with ETI to complete the following activities:

- Toured the effluent pump area, control room, and pig launch area with ETI to understand the system operations;
- Worked with ETI to have pressure gauges added to combination valves at stations 174+20 and 185+60 in order to have down-gradient pressure readings on the pipeline; and,
- Confirmed with ETI the plans for collecting key information under different operating conditions.

Pressure gauge at Station 174+20

Pressure gauge at Station 185+60

Pressure gauges were installed under the combination valves at stations 174+20 and 185+60 to get readings near the outlet of the effluent line. On the upstream part of the effluent line, existing pressure gauges on the 1302 pump skid and at the pig launcher were used. Pump frequency and instantaneous flow were taken from the SCADA screen in the control room; pump speed and voltage were recorded from the display on the VFD in the MCC room.

Operating data was collected at four operating points, summarized in Table 2.

Table 2 Summary of Operating Test Conditions

Run No.	Pipe Line Fouling Condition	Flow Rate
1 (Control)	Dirty (pre-pig)	1,000 gpm
2 (Clean, normal)	Clean (post-pig)	1,000 gpm
3 (Clean, high)	Clean (post-pig)	1,085 gpm
4 (Clean, low)	Clean (post-pig)	620 gpm

4.1 Field Observations

Observed data from the various operating conditions are presenting in Table 3.

Table 3 Observation Data from Test Runs

Run No.	Pump Speed (rpm)	Flow (gpm)	Frequency (Hz)	Pressure (psig)			
				Pump Discharge	Pig Launcher	174+20	185+60
1	1752	1,000	60	97	65	13	8.5
2	1574	1,000	53	71	44	12	9
3	1760	1,085	60	89	62	15	10
4	594	620	20	21	4	4	<4

4.1.1 Run 1 – Current Operating Conditions

Run 1 was completed on May 17 and consisted of collecting the baseline operating data for the current operating conditions. The system had reportedly been pigged 10 days prior. The field engineer noted that the pump speed and flow rate reported in Table 3 were relatively stable for the duration of the observations with no need for active operator intervention to manually set pump speeds.

4.1.2 Pigging

Effluent during pigging operations. Immediately before (left) and after (right) pig discharge.

The pipeline was pigged by ETI on May 17 following completion of Run 1. The pig launcher is located near the Equalization Area to the east of GW-11. The pig is captured near Lift Station 1. The initial pipe segment between the effluent pumps and the pig launcher, and the final pipe segment between Lift Station 1 and the outfall cannot be pigged. ETI indicated that the effluent line is pigged one or two times per month to remove accumulated material. ETI further indicated that they believe the color of the pigging discharge may be indicative of ferric chloride and biofouling by iron bacteria, although testing has not been conducted. Ferric chloride is used in the treatment system for coagulation and clarity. Iron bacteria utilize dissolved ferrous iron and can create gelatinous biomass that can reduce pipe flow capacity. The photo on the left shows the effluent just before discharge of the pig. The photo on the right shows the effluent immediately following discharge of the pig. The effluent after pig discharge appeared to be more viscous and flowed at that consistency for approximately 30 seconds after discharge of the pig. These waters are all captured and returned to the treatment plant via Lift Station 1. No pigging related waters are allowed to discharge via the outfall.

4.1.3 Runs 2, 3, and 4 – Test Conditions

Runs 2, 3, and 4 were completed on May 18, the day after pigging was completed. For Run 2, the flow rate was held at the initial operating conditions of 1,000 gpm in order to evaluate the system changes resulting from the line pigging. For Run 3, the frequency has held at the initial operating conditions of 60 Hz in order to evaluate system changes at higher flow conditions. For Run 4, the pumps were set at 20 Hz, the lowest operating speed for the pump, in order to establish low operating conditions for model correlation.

During test Runs 2, 3, and 4, conducted the day after pigging, it was observed that the pump would cycle between 20 Hz and 60 Hz, allowing the pump feeder tank (T-621) to fill to high level set-point then emptying the tank to the low level set-point. In order to maintain steady flow rates to allow observations during the testing, the system operators had to manually set the pump speed due to cycling effects.

5.0 MODELING AND RESULTS

5.1 Modeling

A preliminary hydraulic model of the effluent line was developed by Cornerstone to establish initial hypotheses on how the line should perform. This hydraulic model calculates the dynamic pressure losses in the piping system due to friction based on the volumetric flow through the pipe, the pipe size, and the pipe length. The model also takes into account the elevation difference between two points as a drop in elevation yields a head gain in the system, and an increase in elevation from one point to another yields a head loss.

Dynamic losses in the piping system are calculated using the Darcy-Weisback Equation as the governing equation:

$$Hloss = f * \frac{L}{D} * \frac{V^2}{2g}$$

Where

$Hloss$ = Head loss (ft)

f = friction factor, calculated based on Reynold's Number for laminar or turbulent flow as applicable

L = Length of Pipe (ft)

D = Inside Diameter of Pipe (ft)

V = Fluid Velocity (ft/s)

g = gravitational constant (ft/s^2)

Using this equation, one can predict the head loss in the piping for a given length of pipe. Once head loss is determined, it is converted into pressure loss using the density of the fluid.

The model analyzes each section of the effluent line based on pipe size and calculates the theoretical pressure loss. There are four points throughout the system where pressure measurements were observed and recorded during field testing: the pumps, the pig launch, station 174+20, and station 185+60. Using the distance between these points and the line size and the flow rate, the model can determine what the pressure loss in the pipe should be, and the theoretical data generated can be directly compared to field measurements.

Upon completion of field activities, the data collected in the field was analyzed. Using field notes, photos, and videos taken of the pump station, the pig launcher, and the lift station, a more accurate count of the elbows and tees in the piping was obtained compared to original estimate done by analyzing the P&ID. These fittings add pressure loss due to friction and are modeled as "equivalent lengths of pipe" in the hydraulic analysis of the system so it was imperative that the model contained an accurate count of these fittings. With the accurate fitting count and pipe lengths, the hydraulic model was refined to more accurately reflect the effluent system.

5.2 Modeling Results

Attachment A includes two figures prepared by Cornerstone which graphically represent some of the modeling results. Figure 1, is a hydraulic diagram that summarizes the hydraulic analysis of the pipeline, taking into account all of the valves, fittings, and elevation differences in the pipeline. This diagram illustrates the theoretical performance of a clean plastic pipe operating at 1,000gpm. For this scenario, the pump pressure of 71 psi from Run 2, a post-pig run held at 1,000 gpm, was used as the starting pressure of the system. A comparison of the information presented in Figure 1 and the Run 2 pressures presented in Table 3 indicate significant differences in the theoretical and recorded pressures.

Figure 2 presents the theoretical hydraulic gradient of the pipeline compared to actual performance. Note that because of a lack of details regarding the initial 8-inch diameter pipe segment slopes and grading, information presented in Figure 2 starts at the pig launcher.

As can be seen by comparing the slopes of the hydraulic gradients presented in Figure 2, the effluent pipeline from the pig launcher to the Wash exhibits a pressure drop due to friction that is almost three times the theoretically predicted value, on a per foot basis. Although it is not certain based on the limited test data, many of the models produced indicate the 12-inch section of the pipeline exhibits worse performance compared to optimal than the 10-inch section. While the exact cause of this behavior is unknown without further investigation, some possible causes are listed below:

- Pipe diameter installed is smaller than that shown on the PBS&J/Kerr-McGee design drawings;
- Pipe is severely fouled with material that is not readily removed with a foam pig;
- A large number of elbows and other restrictive fittings were installed but not documented;

Of the causes listed above, the fouling of the pipe is most feasible. Although the pipe is regularly pigged, the foam pig is flexible enough to travel through both the 10-inch and 12-inch sections of the line unimpeded. It is possible that the pig is also flexible enough to travel past significant accumulation of buildup on the inside pipe walls.

The undocumented use of smaller diameter pipe is possible, but is not very practical on a modern construction project such as this pipeline. Typically all the line pipe is delivered at the beginning of a project and wholesale changes to the diameter are not easily accomplished. So, even if no as-built inspection or survey was accomplished, it is unlikely the diameter of the pipeline would significantly deviate from the design.

Suggestions have been made about air pockets in the line affecting the hydraulic performance. The presence of large air pockets at local high points in the pipeline can increase head loss. These high points can be relative to the grade level, or relative to the hydraulic gradient, which is not as easily observed.

The designers of the pipeline appear to have anticipated the separation of entrained air from the effluent based upon the number of air release / vacuum release valves (combination valves) along the length of the effluent pipeline. The specified placement of these air release valves complies with good engineering practice[1]. While not every air release valve was installed at the point the design drawings specified, most were. Upon inspection, each valve that could be located and accessed appeared to be undamaged and serviceable. Note that two combination valves indicated in the PBS&J/Kerr McGee design drawings for the upper segments of the effluent line (stations 24+59 and 41+54) were not located and do not appear to be present. In addition to the presence of air release valves, considering the documented and observed profile of the pipeline, the velocity in the pipeline is generally capable of flushing out air pockets.[2] Finally, regular pigging of the pipeline would temporarily remove all air pockets. The poor performance of the line relative to the theoretical performance is not likely caused by air pockets.

6.0 EVALUATION OF POTENTIAL TO INCREASE CAPACITY

Typical flow through the effluent line is 1,000 gpm at normal operating conditions. Immediately after cleaning via the foam pig, unstable operation occurs wherein the pump cycles between minimum and maximum speed. At maximum speed, unstable flow of approximately 1,100 to 1,200 gpm were observed. The instability is suspected to be caused by the oversensitive level control system; however, the unstable operation reveals information regarding the capacity of the effluent line system.

The capacity of the pipeline system is best observed by the pump discharge pressure required to move 1,000 gpm of effluent down the pipeline. In the pre-pigged condition (Run 1) the system requires 97 psig to move 1,000 gpm. During Run 1 the pump was operating at full, stable speed, indicating that this is the practical maximum flow of the pump/pipeline system in these conditions. Although the specific operating curves for the pumps were not available, a generic curve family (Corcoran Model 8000D) from the manufacturer's website was reviewed. The rated pump curve indicates that the operation may be pump limited at these conditions. In addition, the rated pressure of the CPVC and HDPE piping, valves and components was not determined, but 100 psig is a common pressure rating for these materials. If the system is rated at 100 psig, it may also be nearing the pressure limitation at the pump discharge. If pressures greater than 100 psig are safely sustainable, then system capacity increases may be possible by pump modification alone. Additional research could be conducted to attempt to determine if the effluent piping system was designed to support a higher pressure; however, because readily available design and as-built information is incomplete, it would be difficult to confirm that every component of the system can support pressures greater than 100 psig. It would not be prudent to base modifications to the system on the potential to manage higher pressures when a single weak point in the system could result in failure.

Cleaning the section of line between the pig launcher and Lift Station 1 results in a reduction in the required pump pressure to move 1,000 gpm from 97 psig to 71 psig. This effectively increases the pump/pipeline system capacity to approximately 1,085 gpm at a pump discharge pressure of 89 gpm, as observed (Run 2). Referencing the rate pump curve shows that a steady state flow of 1,085 gpm at 89 psig is likely pump limited. A pump with greater capacity for discharge pressure could be reasonable expected to move 1,150 gpm at approximately 97 psig if the line were kept in a clean condition.

As indicated in Table 3, a significant pressure drop is measured in the 8-inch diameter piping section upstream of the pig launcher. Based on the short pipe segment and 20 foot change in elevation, the model predicts that a slight pressure increase should be observed at the pig launcher because the system gains more pressure from the elevation change than should be lost due to friction. The likely cause of this poor performance is the unmitigated buildup of fouling on the pipe walls and valves. This section of pipe is not set up for pigging, so

[1] Stephenson, David. Pipeline Design for Water Engineers, Elsevier Scientific Publishing Company, Amsterdam: 1981

[2] P. Wisner, FM Mohsen and N. Kouwen, *Removal of Air from Water Lines by Hydraulic Means*. Proc., ASCE. 101, HY2, 11142, p.243-257 Feb. 1975

fouling has likely been building up since the system was constructed. If this section of piping, which is 8-inch diameter and approximately 540 feet long, was rebuilt using a pigable design, and optimized to reduce pressure drop with a 12-inch diameter pipe, the pump discharge pressure required would decrease and the overall system capacity would increase. It is estimated that these modifications would result in an increase of approximately 150 gpm, similar to that observed by pigging the line.

As a potential option to replacing the 8-inch line, it is noted that a parallel 10-inch line is present but currently unused. The conditions of this line are unknown. Use of the 10-inch line could reduce pressure loss currently observed in the initial line segment. Further, the cross-sectional area of a new clean 8-inch line and a 10-inch line is approximately equivalent to a 12-inch line, thus running both the existing lines could significantly reduce pressure loss in this segment of the effluent line. Note that the gains would be temporary as these lines are not set up for pigging and cannot be maintained.

Increased pigging of the long section of pipe from the pig launcher to Lift Station 1 and replacing the 8-inch section of piping have an independent and additive effect of the pipeline capacity. By implementing both, the resultant required pump discharge pressure to achieve approximately 1,300 gpm is estimated to be less than or equal to the 97 psig now observed to achieve 1,000 gpm operations.

Although field observations indicate the pumps can reach 1,300 gpm for short periods of time, the existing pump body does not have the volumetric capacity to sustain 1,300 gpm for standard effluent line operations and a larger pump with 6-inch outlet connection would be required.

7.0 ADDITIONAL CONSIDERATIONS

7.1 Pumps

The pumps used to inject effluent into the pipeline system were examined for suitable design and proper operation. The pumps are centrifugal, electric motor driven with a Variable Frequency Drive (VFD) to control the pump speed. They are arranged in a 2 x 100% configuration, where one pump can carry the load, and the other is a spare. While the specific operating curves were not available, a generic curve family from the manufacturer’s website (Corcoran Model 8000D) was used to assess the suitability.

Based on typical curves, at 1,000 gpm and a discharge pressure of approximately 97 psig, the pump runs at near peak efficiency. If piping or operations modifications were implemented, the pump could produce up to approximately 1,200 gpm with a discharge pressure of about 75 psig, with a loss of 5 percentage points of efficiency (i.e. additional electrical usage). Sustainable flows above 1,200 gpm are not feasible with the pump/motor selection.

As a basis for comparison, the next larger pump available from the same manufacturer with a six-inch discharge nozzle and 150 horsepower motor would accommodate higher pipeline flows, up to approximately 1,550 gpm, which is approaching the limit of reasonable theoretical design of the downstream 10-inch diameter pipeline segments. As noted in Section 6, replacing the 8-inch pipe segment with an appropriate sized and pigable pipe, and clean operation of the effluent line (i.e. frequent pigging) are predicted to support 1,300 gpm operation, thus the 1,550 gpm model may be oversized and other pump models should be considered.

7.2 Fouling of the Pipeline in Normal Service

The pipeline system is subject to regular fouling, possibly associated with use of ferric chloride in the treatment system. Based on field measurements, precipitants are producing a measureable degradation of pipeline system performance in less than 10 days of normal operation.

If the precipitant is in particulate form upstream of the pumps, installation of a particulate filter should be evaluated, although filtering systems can be difficult to manage and may involve significant maintenance. If the precipitant is in solution and precipitates out downstream of the pumps, other methods could be explored to prevent the repeated deposition of fouling agent into the pipeline system. If ferric chloride is proven to be the primary contributor to fouling, alternative chemical additives to achieve coagulation and clarity in the treatment system could be evaluated. Alternatively, if the fouling cannot be avoided, automated and more effective pigging processes should be installed to allow frequent pigging to maintain higher performance. If biofouling is the primary issue, addition of a chlorination system may be more efficient and eliminate the problem in lieu of increased pigging. If properly chlorinated to mitigate the iron bacteria and biomass, the required frequency of pigging could possibly be reduced.

7.3 Pipeline System Stabilization

After pigging the pipeline, the system effluent pumps frequently cycle between low flow and high flow for a period longer than a day. The exact time to reach stabilization was not observed during the field activities. The engineers performing the testing observed the cause of this instability being a mismatch between the flow through the pipeline pumps (approx. 1,100 to 1,200 gpm) and the supply of effluent to the pumps (approx. 1,000 gpm). The pipeline pumps are controlled by the level of water in tank T-621 (capacity 9,200 gallons) on the pump suction. As the flow into the pipeline reaches its “clean” rate of approximately 1,100 to 1,200 gpm, the level drops quickly causing the pumps to slow to a minimum speed. As the level rises the pumps then return to full speed operation and cycling occurs for some period. The system relationship between the effluent pump speed and the water level present in feed tank T-621 is referred to herein as the level control loop.

Tuning the level control loop could reduce the severity of the cycling when the pipeline/pump capacity exceeds the inflow rate from the treatment plant. Because the pump normally operates at full speed (60 Hz on the VFD) at 1,000 gpm in a “dirty” condition, it is inferred that 1,000 gpm is the maximum available “takeaway” volume of the system. When the effluent line is pigged, additional available takeaway volume is created. It is expected that the pump would be balanced with tank T-621 and run at a lower speed to create the discharge pressure necessary to pump the volume being delivered to T-621. Instead oversensitivity of the level control loop creates full scale swings in pump speed.

If modifications are made to operations or piping that reduce the head needed to flow 1,000 gpm, it will be important to address the tuning of the level control loop as the pump will not need to operate at maximum capacity. Ideally, modifications would be made to the system that result in normal, stable operations at a speed other than 60 Hz, indicating that the system has some reserve capacity beyond the normal operating point.

7.4 Increase Effluent Flow Downstream of Lift Station 1

The Trust is considering adding treatment capacity in the vicinity in the Seep Well Field. Tetra Tech was requested to evaluate if the 10-inch diameter pipe section between Lift Station 1 and the outfall could accommodate additional volume if additional effluent were directed into the system. The 10-inch diameter section downstream of Lift Station 1 is not easily pigged, but is quite short (approx. 700 feet). If additional volume was added in the vicinity of Lift Station 1, this short section would likely handle 1,300 gpm without adverse impact on the rest of the system. If this section were to be modified to be pigable, higher volumes could be accommodated. The theoretical capacity of this section of 10-inch pipe, using velocity as a limiting parameter is about 1,650 gpm.

8.0 SUMMARY AND RECOMMENDATIONS

The pipeline system adequately serves the current requirements of 1,000 gpm of effluent. An increase in operating capacity up to approximately 1,150 gpm could be accomplished by maintaining the pipe in a clean condition with increased foam pigging frequency to approximately every three days or implementation of a chlorination system if biofouling is determined to be the primary problem.

In addition to maintaining the pipe in a clean condition, capacity could be increased to 1,300 gpm by replacement of the 8-inch piping section between the pump and the pig launcher with a pigable 12-inch diameter section coupled with replacement of the pumps to a higher power model with a six-inch discharge.

As noted in Section 7.3, tuning the level control loop to support the increased flow is an integral part of any plan to increase effluent flow. Additional modifications of the treatment plant upstream of the effluent pumps may be required to provide an adequate supply of water to be discharged at the higher rates.

As part of any redesign and enhancement project additional research should be conducted to determine, if possible, the existing effluent pipe pressure ratings and safe design pressures for the entire piping path. In addition, options to mitigate deposition of precipitates in the effluent line should be considered.

8.1 Recommendations

8.1.1 Support Increased Flow Up to 1,300 gpm

As outlined above, modeling predicts flows of up to 1,300 gpm can be reached by maintaining a clean line, replacing the 8-inch pipe segment, and replacing the effluent pumps. To support increased flow of up to 1,300 gpm in the effluent pipeline, Tetra Tech recommends the following:

1. <u>Complete sampling and analysis of the pipeline effluent following a pigging event to characterize the materials removed during pigging</u>. This work would attempt to confirm if iron fouling bacteria and/or ferric chloride is the primary fouling agent and identify other compounds that are precipitating in the line. Sampling would consist of collection of samples at the pig exit area following a pigging event and from the outfall during normal operations for comparative purposes. Analysis would likely include pH, cations, anions, and metals, as well as biological testing. The testing results and recommendations to mitigate the problem will be documented in a technical memo. Depending on the analytical results, potential solutions considered could include increased frequency of pigging, addition of a chlorination system, or a change in the chemical additives in the FBRs to eliminate ferric chloride in the system.

2. <u>Evaluate hydraulic capacity limitations upstream of the effluent pumps</u>. The evaluation of upstream capacity limitations would start with the effluent pump feeder tank T-621 and associated pumps to determine if they are adequately sized to provide increased flow to the effluent pumps. Section 3.6.2 of the Infrastructure Audit and Data Accessibility Report indicates that according to ETI the major subsystems of the FBR treatment plant are designed for flow rates well in excess of 1,000 gpm, but further notes that the internal piping systems may limit hydraulic capacity. As steps are taken to increase the discharge capacity of the effluent line, the FBR plant must be capable of supplying an adequate flow of treated water.

3. <u>Develop a work plan and budget to replace the existing 8-inch pipe segment and implement the recommendations from the Technical Memo developed for item 1.</u> Tetra Tech would develop a plan with input from ETI to replace the 8-inch pipe segment between the effluent pumps and the equalization area with an appropriately sized pipe. As noted earlier, a pigable 12-inch diameter pipe would be capable of handling the modeled 1,300 gpm flow. The work plan would also address other changes necessary to meet the target flow rate including implementation of recommendations to maintain a clean pipe based on the results of the effluent analytical testing (item 1 above), effluent pump upgrades, and understanding and optimization of the level control loop.

Following Trust approval of this Technical Memo, Tetra Tech will prepare a budget and schedule to complete recommendations outlined above.

8.1.2 Evaluate Flow Greater than 1,300 gpm

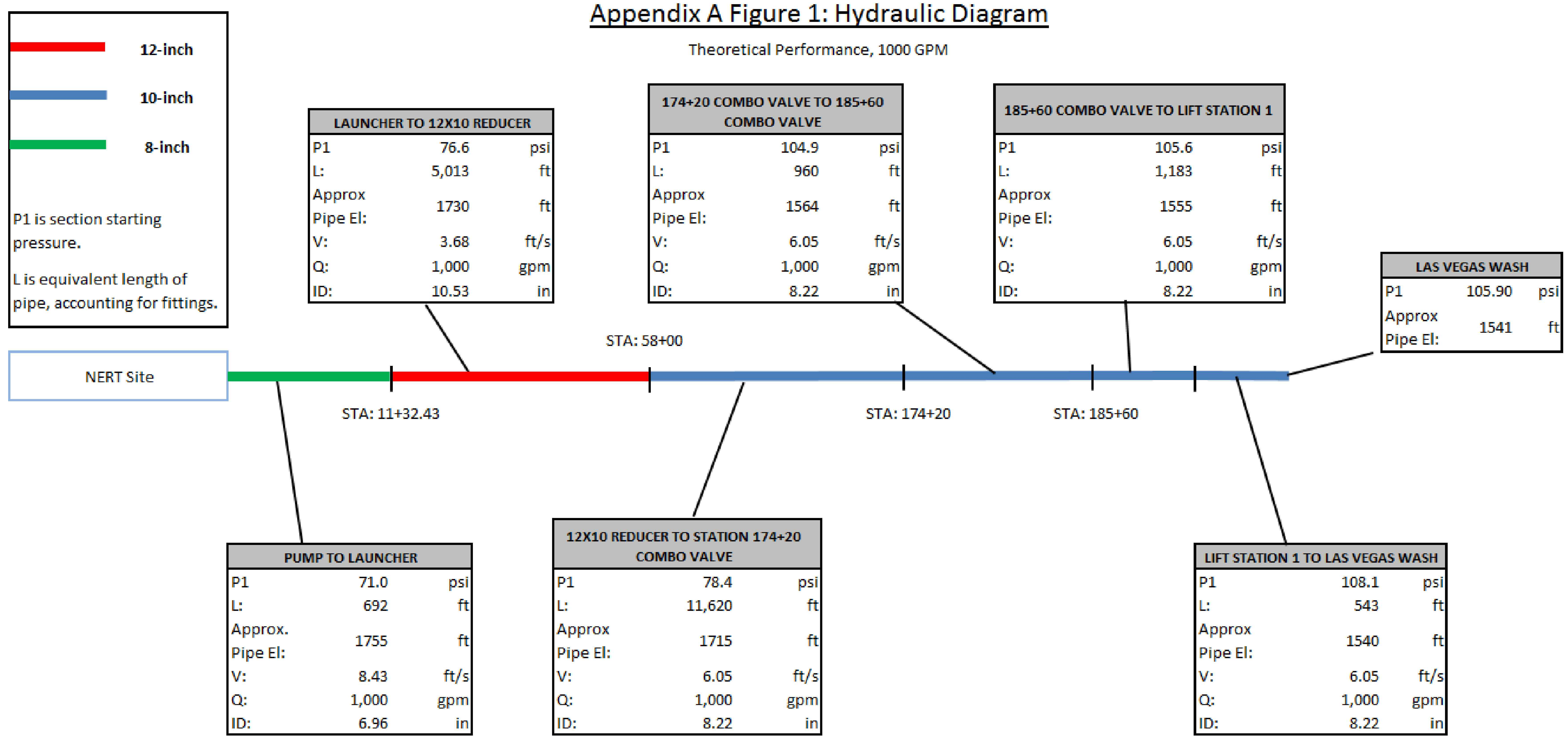
The current work as summarized in this Technical Memo focused on modeling the existing effluent line conditions. Limited operational changes and equipment modifications were evaluated and subsequent flow increases modeled. The current NPDES permit application proposes a 30-day average effluent discharge limit of 1,750 gpm and a daily maximum discharge limit of 2,000 gpm. Assuming the IX System to be implemented at Lift Station #1 is designed to manage the water produced at the Seep Well Field, the combined flows of 1,300 gpm from the FBRs with approximately 500 to 600 gpm from the IX system would result in flows of 1,800 to 1,900 gpm in the final pipe segment from the juncture located in the vicinity of Lift Station 1 to the outfall. As discussed in Section 7.4, the theoretical capacity of this section of 10-inch pipe using velocity as a limiting parameter is about 1,650 gpm. Enhancements to the system should be designed to meet the daily maximum, and the system then managed to ensure that the 30-day average is not exceeded, thus the final pipe segment that would carry the combined flow from the FBRs and the IX system should be designed to handle 2,000 gpm.

Tetra Tech recommends that options to increase the capacity for the final combined flow segment are evaluated. Following Trust approval of this Technical Memo, Tetra Tech will prepare a budget and schedule to evaluate options to achieve design flows in the final piping segment.

Attachment A
Modeling Summary Figures, Cornerstone

Appendix A Figure 1: Hydraulic Diagram

Theoretical Performance, 1000 GPM



FOR INFORMATION ONLY

REV. NO.	DATE	DESCRIPTION	DRWN BY	CHK'D BY	APP'D BY
C	6/16/2016	REVISED PIPE ELEVATION LABELS	TRB	PMC	
B	6/10/2016	REVISED REDUCER LOCATION	TRB	TBC	
A	6/2/2016	ISSUED FOR REVIEW	NPA	TRB	

REVISIONS

DRAWING NUMBER	DRAWING TITLE	COMPANY

DRAWING REFERENCES

Cornerstone Energy Services

DRAWN BY: NPA DATE: 6/2/2016
CHECKED BY: TRB DATE: 6/2/2016
APPROVED BY: DATE:
FILE NAME: NERT HYDRAULIC ANALYSIS_061616.DWG

DRAWING SCALE: NONE

NEVADA ENVIRONMENTAL RESPONSE TRUST
GROUND WATER EXTRACTION & TREATMENT SYSTEM
HENDERSON, NEVADA

GWETS EVALUATION
HYDRAULIC DIAGRAM

HYDRAULIC DIAGRAM

SET REV. C

APPENDIX A FIGURE 2: HYDRAULIC GRADIENT DIAGRAM

*GRADE IS REPRESENTATIVE AND COMPILED FROM MULTIPLE SOURCES

**EFFLUENT LINE STATIONING IS APPROXIMATE AND COMPILED FROM MULTIPLE SOURCES. PIPELINE SURVEY WAS NOT PERFORMED AS PART OF THIS ANALYSIS

NATURAL GROUND
HDPE PIPE
CALCULATED GRADIENT
DIRTY
CLEAN
(V) COMBINATION VALVES

FOR INFORMATION ONLY

DRAWING NUMBER	DRAWING TITLE	COMPANY

DRAWING REFERENCES

REV. NO.	DATE	DESCRIPTION	DRWN BY	CHK'D BY	APP'D BY
C	6/16/2016	REVISED GRADIENTS	TRB	PMC	
B	6/10/2016	REVISED REDUCER LOCATION	TRB	TBC	
A	6/2/2016	ISSUED FOR REVIEW	NPA	TRB	

REVISIONS

Cornerstone Energy Services

NEVADA ENVIRONMENTAL RESPONSE TRUST
GROUND WATER EXTRACTION & TREATMENT SYSTEM
HENDERSON, NEVADA

GWETS EVALUATION
HYDRAULIC GRADIENT DIAGRAM

DRAWN BY: NPA	DATE: 6/2/2016	DRAWING SCALE: NONE	HYDRAULIC GRADIENT DIAGRAM
CHECKED BY: TRB	DATE: 6/2/2016		SET REV. C
APPROVED BY:	DATE:		

FILE NAME: NERT HYDRAULIC ANALYSIS_061616.DWG