Technical and Engineering Considerations Summary
Treatment Options for Mining-Influenced Water
Upper Cement Creek, Bonita Peak Area

Executive Summary

This Technical and Engineering Considerations Summary evaluates and compares the potential applicability of proven active and emerging passive water treatment methods to address the mining-influenced water (MIW) sources in the Upper Cement Creek portion of the Bonita Peak area near Silverton, Colorado. This evaluation considers the technical and engineering issues associated with the MIW from the Gold King, Mogul, Grand Mogul, Red and Bonita, and American Tunnel, referred to collectively as the "Upper Cement Creek MIW sources" in this evaluation. This summary focuses specifically on the potential suitability of passive technologies as compared to the known effectiveness of active water treatment systems for these sources.

Passive treatment systems implemented for primary treatment of MIW have been successful at some sites and have failed at others. The technologies and construction methods are still under development and many of the systems currently in use are considered experimental or pilot projects and the long-term success remains unproven. In contrast to some of the successful sites, many passive systems have failed to achieve a significant reduction in metal concentrations and meet the final effluent quality requirements. All passive MIW treatment systems require significant monitoring and maintenance efforts and are generally considered to be "semi-passive" at best. In this evaluation no distinction is made between "passive" and "semi-passive" systems and both are referred to only as passive systems.

Primary factors when considering passive MIW treatment include: the amount of available land and its topography; flow rates, water chemistry, system longevity and maintenance requirements; accessibility and remoteness; and climate (EPA, 2014a). The likelihood of successful application of passive MIW treatment technologies is considerably more dependent upon site-specific conditions and constraints than when active treatment systems are utilized. Given these critical factors, the evaluation considered applicability of the various water treatment technologies in three potential scenarios:

1. Installing small passive systems at each individual MIW source.
2. Collecting and routing the MIW from each source to a theoretical centralized passive water treatment facility.
3. Collecting and routing each MIW source to the existing Gladstone Interim Water Treatment Plant (IWTP).

Based on this evaluation, collecting and routing of the Upper Cement Creek MIW sources to the current Gladstone IWTP provides the greatest certainty of beneficial results combined with the ability to implement new or improved technologies as they are developed and proven in the future. This recommendation is based on the considerations described below.

Concerns associated with small individual passive systems:

- Unavailability of suitable land, inadequate access, and the harsh environment would make construction, operations, monitoring, maintenance, and reporting more difficult if small individual source treatment systems were employed.
- Lack of similar projects using "off-the-shelf" directly applicable technology with proven success. Use of passive systems at each source would likely require extended study, design, operational adjustment, and modification over many years to decades to achieve the desired results.
- It is likely that small individual passive systems would never perform as intended and may ultimately need to be replaced by an active system to meet applicable discharge requirements.
- The differing flowrates and water chemistries for each source would make each design unique and challenging. Design costs would increase considerably, and system initiation and optimization would be more difficult.
- The unique design required for each source may require different monitoring and maintenance methods and schedules, further complicating overall site management, monitoring, and maintenance.
- Seasonal conditions, including a short (approximately 4 month) growing season, limited access, deep snow, and cold temperatures - all significant issues at the Upper Cement Creek MIW sources - are known to adversely affect passive treatment systems.

Concerns associated with a theoretical centralized passive treatment system:

- If a suitable location with enough area could be found, it may be theoretically possible to build a large-scale centralized passive system well downstream from the existing Gladstone IWTP. Such a system would require portal improvements, a collection network, and equalization systems nearly identical to an active system, but overall it may be simpler to implement and maintain than smaller individual source passive systems.
- It does not make practical sense to route the MIW past an existing water treatment plant with enough capacity to treat all the sources. Routing MIW in pipes is consistently problematic as the pipes are prone to plugging from chemical and biological sludge production (EPA, 2014b). To maintain sufficient velocities and keep sediment entrained in the MIW throughout transmission, pipes must be constructed with an uninterrupted negative slope with no sags. In most cases each individual MIW source would need to be routed in its own pipe to prevent the chemical reactions and sludge precipitation that occurs when mixing different MIW chemistries in a single pipe. It may not be feasible to meet all these requirements and the issues with installation and maintenance increase as the transmission distance increases.
- Because there are no currently operating centralized passive systems with a sufficient length of operations to gather long-term data for comparison, the long-term effectiveness and operating costs for these systems are difficult to quantify. It is unclear at this time if these systems will be cost-effective in the long term.

- Seasonal conditions, including a short (approximately 4 month) growing season, limited access, deep snow, and cold temperatures - all significant issues in the area - are known to adversely affect passive treatment systems.

Preference for using the existing Gladstone IWTP:

- Given the setting and complexities in Upper Cement Creek and considering the uncertainties with passive treatment, a centralized active treatment system provides the only certain way to meet applicable discharge requirements.
- The costs and benefits can be accurately projected.
- Use of the existing Gladstone IWTP would capitalize on an already-constructed facility and should require only minor upgrades.
- Use of the Gladstone IWTP will take less time to implement and will provide immediate benefits.
- Use of the Gladstone IWTP would minimize transmission distances and decrease the complexity of the collection network.
- The long-term maintenance costs and facility replacement schedules for an active system are well known. If at some point in the future new technologies become cost-effective, proven and workable within the various constraints, they could be used to upgrade or replace all or part of the Gladstone IWTP in the normal maintenance and repair schedule.

Introduction and Background

In the United States, numerous abandoned or legacy hardrock and coal mine sites produce mining-influenced water (MIW) that can cause negative impacts to the surrounding environment. In many cases, the MIW exceeds established federal or state water quality requirements for metals (typically human health standards and aquatic life criteria) and would require some form of treatment prior to discharge to meet applicable water quality requirements in receiving waters. Active water treatment through pH adjustment, settling, filtration, and other methods is often the standard and proven treatment for MIW. Because of the costs, complexities, and secondary waste stream (sludge) associated with active water treatment technologies, there is growing interest in the use of "passive" and "semi-passive" treatment technologies or systems to potentially reduce long-term operating and maintenance requirements and costs of MIW treatment.

All passive MIW treatment systems require significant monitoring and maintenance efforts and are generally considered to be "semi-passive" at best. In this evaluation no distinction is made between "passive" and "semi-passive" systems and both are referred to only as passive systems.

This Technical and Engineering Considerations Summary evaluates and compares the potential applicability of proven active and emerging passive water treatment methods to address the mining-influenced water (MIW) sources in the Upper Cement Creek portion of the Bonita Peak area near Silverton, Colorado. This evaluation considers the technical and engineering issues associated with the MIW from the Gold King, Mogul, Grand Mogul, Red and Bonita, and American Tunnel, referred to collectively as the "Upper Cement Creek MIW sources" in this evaluation. This summary focuses specifically on the potential suitability of passive technologies as compared to the known effectiveness of active water treatment systems for these sources.

The goal of passive treatment systems is to use naturally-occurring physical, biological, and chemical processes in a confined system to treat MIW. The primary or more common configurations of passive MIW treatment systems include: aerobic wetlands (AeW), anaerobic wetlands (AnW), successive alkalinity producing systems (SAPS), anoxic limestone drains (ALD), limestone ponds, and open limestone channels (OLC). In many cases, several of these methods are combined to create a passive treatment system. These passive MIW treatment systems have been constructed as stand-alone or combination systems and have also been used as a polishing step for active water treatment systems.

Passive treatment systems implemented for primary treatment of MIW have been successful at some sites and have failed at others. The technologies and construction methods are still under development and many of the systems currently in use are considered experimental or pilot projects and the long-term success remains unproven. In contrast to some of the successful sites, many passive systems have failed to achieve a significant reduction in metal concentrations and meet the final effluent quality requirements. Most of the completed case studies are for sites in the eastern U.S. that were completed to address the MIW from legacy coal mines and are in very different environments than the Upper Cement Creek MIW sources.

Screening Considerations

Primary factors when considering passive MIW treatment include the amount of available land and its topography; flow rates, water chemistry, system longevity, and maintenance requirements; accessibility and remoteness; and climate (EPA, 2014a). This screening approach integrates relevant components or criteria developed by the U.S. Environmental Protection Agency (EPA), Office of Surface Mining Reclamation and Enforcement (OSMRE) and others in recent decades to assess the feasibility and applicability of a passive MIW treatment process for the sources in Upper Cement Creek. The screening included the following:

1. MIW Considerations
    - Is the variability of MIW flows and/or water chemistries suitable for passive MIW treatment rather than active MIW treatment?
    - What is the likelihood and long-term reliability of compliance with effluent quality discharge requirements over the design life of the passive MIW treatment system?
2. Environmental/Site-Specific Considerations
    - Is the climate (e.g., precipitation, number of days at or below freezing, growing days, etc.) conducive to the performance of the system?
    - In an alpine area with little native vegetation, what plant species will be suitable to the high altitudes and short growing season?
    - Are there limiting topographic conditions, such as slope, available land area, and excavation constraints such as near surface bedrock or mineralized materials?

- Are there stream or other space constraints that would impact the layout or effectiveness of the treatment system?
- Is the source accessible for the long-term maintenance necessary to sustain the treatment operations?
- Will the system be subjected to and/or protected from rock slides, avalanches or seasonal flooding?
- Are there regulatory issues (e.g., threatened and endangered habitat, sensitive areas, floodplains, existing wetlands, etc.) that add constraints to the layout of the treatment system?
- Is the source accessible for removal and replacement of organic substrate and sludges? Can these waste materials be handled and easily disposed of in an environmentally sound manner?

3. Engineering Considerations

- Given the short construction season, could the system(s) be constructed in the available construction window?
- Does the source have suitable access for construction and long-term maintenance and monitoring?
- Would access and site improvements (e.g., road cuts, foundation, leveling, and underground treatment cell excavations) cause disturbance of additional mineralized materials or cause instability?
- Are there underground workings in the area that further constrain space and make surface improvements and construction unsafe?
- Is the potential passive treatment system capable of handling the 90^{th} percentile flow and variable contaminant loads?
- Can the proposed design respond to severe seasonal changes in surface and/or groundwater flows and/or load conditions exceeding the 90^{th} percentile?
- Are total passive treatment system project costs, including operations and maintenance (O&M), provably lower than an active treatment system?

4. Other Considerations

- Are the logistical and time considerations to access, monitor, and maintain several small individual systems worth the effort when compared to the ability to install fully-appointed facilities at a larger centralized system?
- If there is a large enough area available to construct a regional centralized passive system (assuming substantially identical collection networks), would a centralized passive system be more cost-effective than a using the existing Gladstone Interim Water Treatment Plant (IWTP)?

Feasibility Assessment

Management of MIW using passive treatment technology is most successful when the water chemistry meets the criteria listed in Table 1 (Skousen, 2017, Table 1). If the criteria in Table 1 can be met, selection of the most promising treatment can be made through bench and pilot scale testing.

Table 1 - Influent and MIW Characteristics Required for Successful Use of Passive Treatment Technologies

Technology	Ave. Acidity (mg/ $CaCO_3$)	Ave. Acidity Load (Kg/ $CaCO_3$/day)	Ave. Flow Rate (L/sec)	Dissolved Oxygen (mg/L)	Max. pH Attainable (std. units)	Typical Influent pH (std. units)
Anoxic Limestone Drain (ALD)	<500	<150	<20	<1	6-8	>2
Limestone Diversion Well (LDW)	<500	1-1,000	<1,000	Ambient	6-8	>2
Aerobic Wetland (AeW)	<500	≤1	HRT 1-5 days[1]	Ambient	N/A	>6
Anaerobic Wetlands (AnW)	<500	1	HRT 1-5 days[1]	Ambient near surface and <1 subsurface	N/A	>2.5
Successive Alkalinity Producing System (SAPS)	<300	<100	<15	<1-3	6-8	>2.5
Organic Rich Permeable Reactive Barriers (PRB)	<500	≤14	<1	Relatively reducing environment	>6.5	>3

Notes: 1) HRT = Hydrologic Residence Time

Evaluation

The evaluation considered applicability of the various water treatment technologies in three potential scenarios:

1. Installing small passive systems at each individual MIW source.
2. Collecting and routing the MIW from each source to a theoretical centralized passive water treatment facility.
3. Collecting and routing each MIW source to the existing Gladstone IWTP.

A comparison of the available MIW characteristics, environmental, and engineering considerations for the Upper Cement Creek MIW sources resulted in the following findings:

1. MIW Considerations

   - A review of historical water quality data (ARSG, 2018) indicates that Upper Cement Creek MIW sources may be responsive to passive MIW treatment. Results for acidity and iron speciation were not available and additional sampling and analysis would be needed to determine if the water chemistry is potentially suitable for a passive system.
   - Flows from the Mogul have been relatively stable since 2015, ranging from 50 to 60 gallons per minute (gpm) and are primarily influenced by precipitation (Deere & Ault, 2017).
   - The combined average flows from the Red and Bonita and the Gold King vary from 563 gpm to 916 gpm (Deere & Ault, 2017). The cause of the variation of the flows is not fully understood and may be related to changes in precipitation/infiltration, hydraulic changes in the underground mine works, or a combination of both. Any treatment system design needs to accommodate the full range of flows that may be encountered.
   - It is unknown at this time how the flows may be affected by changes to the existing bulkheads. Some consideration of these potential changes would need to be considered in the design of a passive treatment system.
   - Passive treatment systems require some type of equalization/surge feature to maintain a relatively steady-state flow rate. Large flows can overwhelm biological populations and seriously compromise the effectiveness of the system (Gusek, 2002). This is a significant issue given the space constraints throughout the area.

2. Environmental/Site-Specific Considerations

   - The dominant concerns in Upper Cement Creek are the limited area and harsh winters as they relate to the installation, operation, and maintenance of a passive MIW treatment system. These factors will severely limit applicability and potential for success of small systems at each MIW source.
   - The valleys at the site are generally narrow and lack sufficient area for a central passive MIW treatment plant until well downgradient from the existing Gladstone IWTP.
   - The Upper Cement Creek MIW sources are at very high elevations, ranging from 10,525 feet above mean sea level (amsl) at the Gladstone IWTP to 11,830 feet amsl at the Grand Mogul.
   - The topography of the area is rugged, mountainous terrain dominated by steep slopes with narrow, hanging valley bottoms that are subject to high spring runoff flows. The slopes are mostly talus covered with tundra type vegetation and range in steepness from 45% to 75% (USGS NED, 2018).
   - The area is prone to periodic rock slides and avalanches. Any above ground structures or facilities would be at risk of damage from these types of events.
   - The climate at the Upper Cement Creek MIW sources is classified as alpine zone, with snow cover typically from September to June. The total average annual precipitation is approximately 40 inches (Deere & Ault, 2017), primarily in the form of snow at approximately 172 inches per year.

3. Engineering Considerations

- For passive MIW treatment systems to be successful, the system is designed to provide excess alkalinity (i.e., raise pH) to precipitate and sequester the metals. Most system failures can be attributed to undersized systems that do not provide enough alkalinity or residence times that are too short to increase the pH and precipitate the metals.
- During cold weather, when organic decomposition is low or non-existent, anaerobic treatment systems require addition of a liquid carbon source to maintain removal efficiencies (Ness and Strewart, 2014).
- Due to the steep topography, limited available area and high flow rates at these sources, and the likely high hydraulic gradients of a constructed system, obtaining sufficient residence time would be problematic.
- Each individual passive MIW treatment source would require a unique and highly customized design, with potentially different maintenance methods, routines, and schedules.

4. Other Considerations

- The Rico Argentine Mine, a closed hardrock mine located near Rico, Colorado at an elevation of 8,825 feet amsl and adjacent to the Dolores River, is one of the highest elevation sites in the United States using passive bio-chemical MIW treatment. The Rico Argentine Mine uses settling basins, bioreactors, aeration channels, and manganese removal cells to treat the MIW prior to discharge to the Dolores River (EPA, 2016). The base flow from seven adits/seeps is approximately 600 gpm with a seasonal high of approximately 1,000 gpm in the spring. The Rico site has relatively consistent and singular water chemistry; MIW is near neutral to slightly acidic (ranging from 6.3 to 7.4), with elevated metals of concern primarily zinc (Zn) and cadmium (Cd) (Stilwell, et al., 2004). The MIW flows through a series of treatment cells comprised of sawdust and other organic material, and then flows through 11 settling ponds prior to discharge to the Dolores River. The enhanced wetland and settling ponds encompasses approximately 80 acres of relatively flat land directly downgradient of the mine. The valley configuration allows year around access to the ponds, while still allowing for development of portions of the mine site by the town of Rico. The Rico site has a repository on-site for disposal of waste materials from the treatment system. Compared to the Upper Cement Creek sources, the Rico site is significantly lower, with relatively steady flow and MIW chemistry, less acidic MIW, and has significantly more available area.
- The Gladstone IWTP sits at an elevation of approximately 10,525 feet (1,700 feet higher than the Rico site) and has very limited additional area near the existing water treatment plant footprint. A suitable location for a passive system would need to be located well downstream from the current Gladstone IWTP to be in an environment similar to the Rico site.
- The Gladstone IWTP is currently treating MIW from the Gold King and has a designed capacity of 200 to 900 gpm, with a spike of 1200 gpm. However, the Technical Memorandum in Appendix A of the 2016 EE/CA (CDM, 2016) concludes that "...the plant as currently designed and operated can reliably remove 95% (or better) of the daily

average loading of Cd, Cu [copper], and Zn in the influent at flows up to 1,800 gpm, with the incoming composition similar to the average mine drainage composition observed since August 2015."

- The average influent flow from the Gold King is 600 gpm (Deere & Ault, 2017). Adding average flows of 29 gpm for the Grand Mogul, 60 gpm for the Mogul, 311 gpm for the Red and Bonita, and 109 gpm for the American Tunnel (Weston, 2016) results in a total combined average influent flow of 1,109 gpm, which is slightly above the Gladstone IWTP designed capacity of 900 gpm and well below the 1,800 gpm maximum capacity suggested in the EE/CA for the Gladstone IWTP.
- The maximum influent flows from 2009 through 2017 of 97 gpm for the Grand Mogul, 143 gpm for the Mogul, 516 gpm for the Red and Bonita, and 149 gpm for the American Tunnel (Deere and Ault, 2017) and 900 gpm Gladstone IWTP maximum design flow for the Gold King provides a total combined maximum influent flow of 1,805 gpm, well above the designed capacity of 900 gpm, but close to the 1,800 gpm maximum discussed in the EE/CA for the Gladstone IWTP.
- Although the 900 gpm design flow and 1,800 gpm maximum flow listed in the EE/CA suggests the Gladstone IWTP could likely treat the combined flows from the Upper Cement Creek MIW sources, minor upgrades and/or improvements to the Gladstone IWTP may be necessary to ensure potentially higher flows could be accommodated and still meet the desired 95% load reduction. Spike flows could be controlled through adit flow management, and through expansion of the existing ponds or construction of additional ponds for enhanced flow and chemistry equalization. Additional investigation and analysis are needed to fully develop any potentially necessary design or operational changes to the Gladstone IWTP.
- As a recent example from a large mining site, the Silver Valley Central Water Treatment Plant in Kellogg, Idaho has been in operation for over 40 years. This active treatment plant is currently being expanded and upgraded to collect additional sources from the surrounding areas and enhance metal removal. The EPA and other agencies completed a detailed analysis of the MIW sources in the Silver Valley, evaluated passive and other treatment alternatives, and then elected to upgrade and continue to operate the active system rather than replace it with a passive system or install passive systems at each MIW source.

Conclusions

A review of the available literature suggests that passive treatment systems implemented for primary treatment of MIW have been successful at some sites and have failed at others. The technologies and construction methods are still under development and many of the systems currently in use are considered experimental or pilot projects and the long-term success remains unproven. In contrast to some of the successful sites, many passive systems have failed to achieve a significant reduction in metal concentrations and failed to meet the final effluent quality requirements. Most of the completed case studies are for sites in the eastern U.S. that were completed to address the MIW from legacy coal mines and are in very different environments than the Upper Cement Creek MIW sources.

There is no “cookie cutter” or “one size fits all” approach to predict the success of a passive MIW treatment system to meet water quality requirements. The effects of the source-specific water chemistries and seasonal flows from each source will influence the system and must be given careful consideration. Large seasonal fluctuations in water chemistry and flows often negatively impact the efficiency of the systems and greatly add to project costs and maintenance requirements. Passive systems may or may not be adaptable enough or be able to self-adjust to these changing conditions, which may result in periods where the treatment system is not meeting the desired removal efficiencies.

Passive treatment systems typically require large areas with a level surface to provide adequate residence time which is not available in Upper Cement Creek. Excavation depths greater than 6 feet below ground surface for the subsurface components (e.g., AnW ponds, drain lines, valves, etc.) are typically needed, and may not be feasible in steep areas close to bedrock, mineralized layers, or underground workings. Space for construction and operations will be problematic in the Upper Cement Creek area with its narrow valley bottoms, shallow soils, and limited seasonal accessibility. Treatment systems that include a biological component (e.g., microbes, vegetation) can be adversely affected by the highly seasonal variations in air and water temperatures, and may require that the treatment cells be buried, which may not be feasible at some or all the sources.

Passive MIW treatment systems, while not requiring daily maintenance, do need intensive routine maintenance. Passive systems require regular replacement of the treatment media due to the accumulation of metal precipitates, plugging of the substrate, or armoring of the alkaline materials (Ford, 2003; Gusek, 2002). The physical components of passive systems (e.g., buildings, pipes, cells, etc.) are subject to the same deterioration over time as active systems and would need to be repaired and replaced on a similar time scale. Access to the system for repair and replacement will be limited to summer and early fall because of snow and other access restrictions. These passive systems could fail during a period when the site is inaccessible, which would allow discharge of partially treated or untreated water until the site can be accessed and repairs implemented.

Given the considerations above, this evaluation considered the applicability of the various water treatment technologies in three potential scenarios:

1. Installing small passive systems at each individual MIW source.
2. Collecting and routing the MIW from each source to a theoretical centralized passive water treatment facility.
3. Collecting and routing each MIW source to the existing Gladstone IWTP.

Based on this evaluation, collecting and routing of the Upper Cement Creek MIW sources to the current Gladstone IWTP provides the greatest certainty of beneficial results combined with the ability to implement new or improved technologies as they are developed and proven in the future. This recommendation is based on the considerations described below.

Concerns associated with small individual passive systems:

- The unavailability of suitable land, inadequate access, and the harsh environment would make construction, operations, monitoring, maintenance, and reporting more difficult if small individual source treatment systems were employed.
- Lack of similar projects using “off-the-shelf” directly applicable technology with proven success. Use of passive systems would likely require extended study, design, operational adjustment, and modification over many years to decades to achieve the desired results.
- It is likely that small individual passive systems would never perform as intended and may ultimately need to be replaced by an active system to meet applicable discharge requirements.
- The differing flowrates and water chemistries for each source would make each design unique and challenging. Design costs would increase considerably, and system initiation and optimization would be more difficult.
- The unique design required for each source may require different monitoring and maintenance methods and schedules, further complicating overall site management, monitoring, and maintenance.
- Seasonal conditions, including a short (approximately 4 month) growing season, limited access, deep snow, and cold temperatures - all significant issues at the Upper Cement Creek MIW sources - are known to adversely affect passive treatment systems.

Concerns associated with a theoretical centralized passive treatment system:

- If a suitable location with enough area could be found, it may be theoretically possible to build a large-scale centralized passive system well downstream from the existing Gladstone IWTP. Such a system would require portal improvements, a collection network, and equalization systems nearly identical to an active system, but overall may be simpler to implement and maintain than smaller individual source systems.
- It does not make practical sense to route the MIW past an existing water treatment plant with enough capacity to treat all the sources. Routing MIW in pipes is consistently problematic as the pipes are prone to plugging from chemical and biological sludge production (EPA, 2014b). To maintain sufficient velocities and keep sediment entrained in the MIW throughout transmission, pipes need to be constructed with an uninterrupted negative slope with no sags. In most cases each individual MIW source would need to be routed in its own pipe to prevent the chemical reactions and sludge precipitation that

occurs when mixing different MIW chemistries in a single pipe. It may not be feasible to meet all these requirements and the issues with installation and maintenance increase as the transmission distance increases.

- Because there are no currently operating centralized passive systems with a sufficient length of operations to gather long-term data for comparison, the long-term effectiveness and operating costs for these systems are difficult to quantify. It is unclear at this time if these systems will be cost-effective in the long term.
- Seasonal conditions, including a short (approximately 4 month) growing season, limited access, deep snow, and cold temperatures - all significant issues in the area - are known to adversely affect passive treatment systems.

Preference for using the existing Gladstone IWTP:

- Given the setting and complexities in Upper Cement Creek and considering the uncertainties with passive treatment, a centralized active treatment system provides the only certain way to meet applicable discharge requirements.
- The costs and benefits can be accurately projected.
- Use of the existing Gladstone IWTP would capitalize on an already-constructed facility and should require only minor upgrades.
- Use of the Gladstone IWTP will take less time to implement and will provide immediate benefits.
- Use of the Gladstone IWTP would minimize the complexity of the collection network and minimize transmission distances.
- The long-term maintenance costs and facility replacement schedules for an active system are well known. If at some point in the future new technologies become cost-effective, proven and workable within the various constraints, they could be used to upgrade or replace all or part of the Gladstone IWTP in the normal maintenance and repair schedule.

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