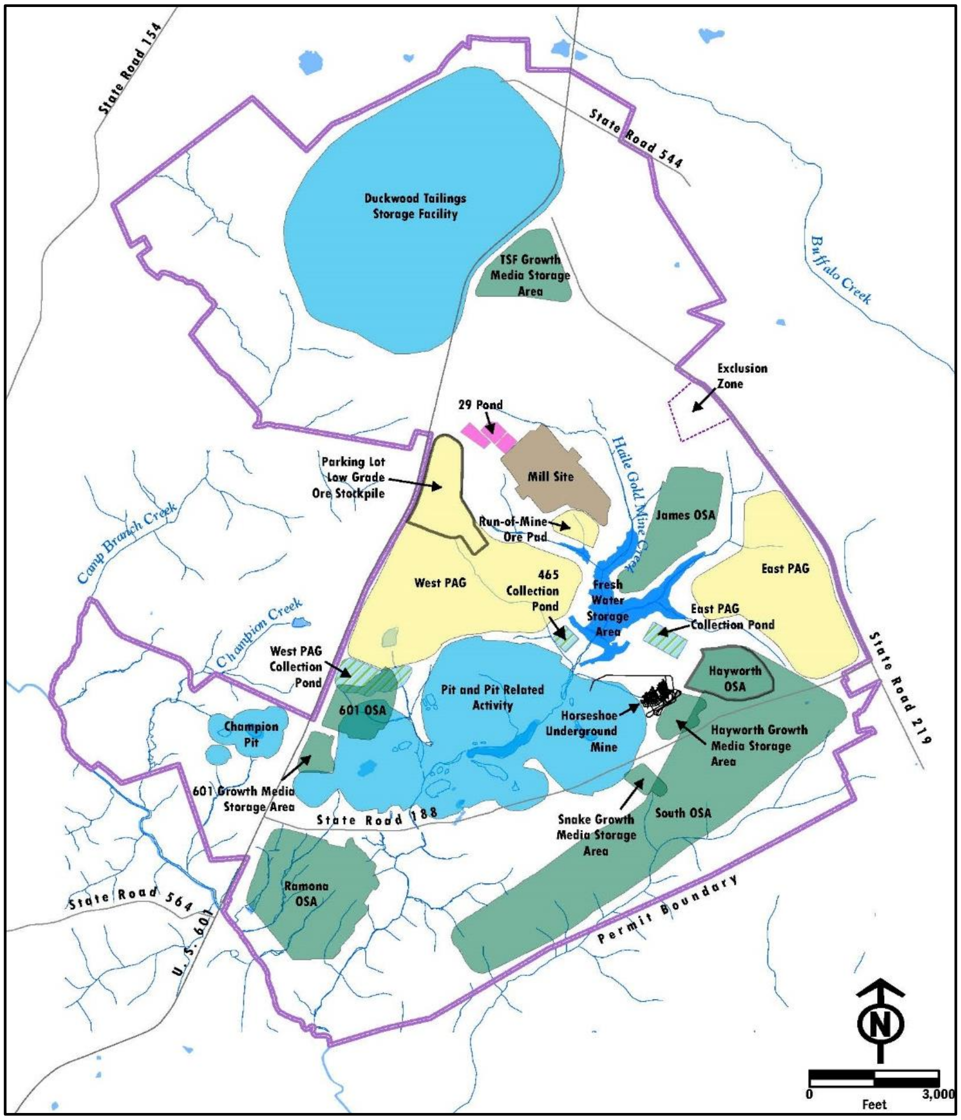
Haile Gold Mine
Site Wide Water Balance Report

Prepared for

Haile Gold Mine, Inc.



November 21, 2018
Revised January 29, 2019

Table of Contents

List of Tables

List of Figures

1.0 Introduction

Ecological Resource Consultants, Inc. (ERC) has been retained by Haile Gold Mine, Inc., a wholly-owned subsidiary of OceanaGold Corporation, (Haile) to conduct a site wide water balance analysis for mine operations corresponding to Haile's 2018 Revised Mine Plan at the Haile Gold Mine near Kershaw, South Carolina. The primary objectives of the site wide water balance are to estimate:

- Process water and precipitation storage at the Tailings Storage Facility (TSF)
- Available water supply versus demands for mine operations
- Amount of TSF reclaim water, contact water, and non-contact water used in Mill operations
- Amount of contact water requiring treatment
- Amount of treated contact water and non-contact water used for mine operations other than the Mill
- Rate at which treated contact water and pit depressurization water not used at the mine will be released

Assumptions used in the model, modeling techniques and results obtained are presented herein.

This water balance is a revision to the water balance work that was done by ERC in support of the original project's Final Environmental Impact Statement (FEIS) issued in 2014. This revised water balance for the 2018 Revised Mine Plan incorporates greater total reserves to be mined, updated mine plan concepts and facilities (including underground mining), and an increased production rate.

Since the original EIS was completed, Haile also has continued to further refine its groundwater characterization based upon several years of depressurization (and monitoring) work done to support the mine construction and operations permitted in 2014. This additional hydrogeologic information has been incorporated into an updated site groundwater model (done by NewFields), the results of which are inputs to this ERC site wide water balance model and analysis.

2.0 Objectives

The mine water balance is an important tool for planning and operational considerations for Haile. At all times, adequate storage must be available in the TSF for both process water and precipitation. Additionally, facilities must be adequately sized to store the volume of contact water that will be generated. Also, treatment facilities must be adequately sized for contact water generated (and not otherwise sent directly to the Mill), and fresh water storage must be adequately sized for purposes of meeting makeup demands at the Mill or other operational demands (e.g., dust suppression) requiring fresh water.

This water balance model was developed as a tool to aid in the planning, design and operation of the TSF and water management facilities, to inform related impact analyses, and to assist with future water management planning.

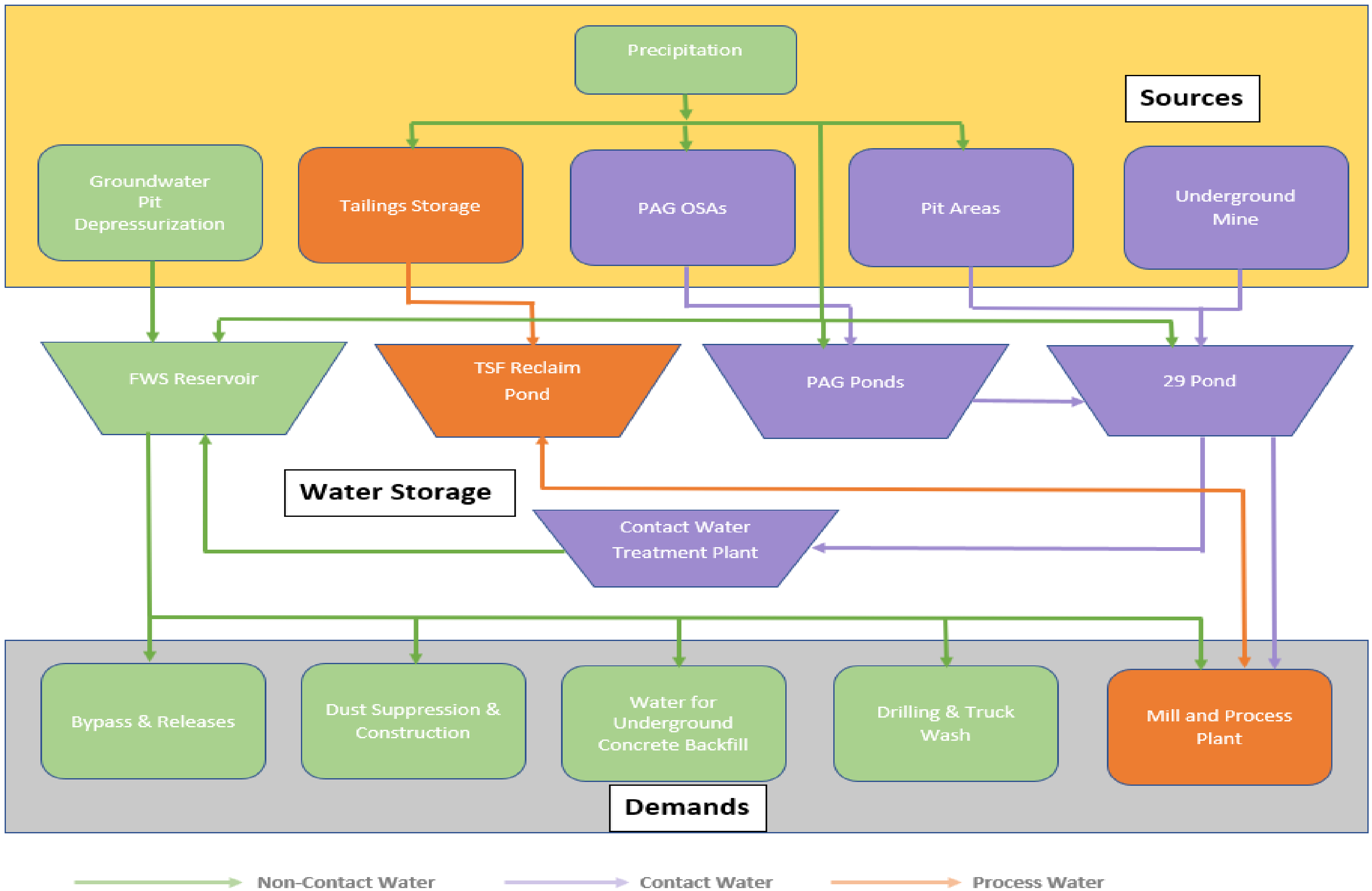
The water balance is heavily influenced by fluctuations in precipitation. Based on the site's climatic setting snowfall and freezing conditions are rate. They do not have a significant impact on the water balance. Given the uncertainty that variable precipitation adds to water management, the water balance was modeled in a probabilistic manner. Modeling included Monte Carlo simulations intended to understand the anticipated variability and required water management resulting from a range of potential precipitation conditions. Monte Carlo simulations include running the water balance multiple times, each time with differing, equally likely meteorological input. Results obtained from the different model runs are intended to provide insight into the probability of different outcomes, thus allowing for risk-based decision making. The computer software GoldSim, version 9.60, was used for these dynamic simulations. The updated model was run using a daily time step.

3.0 Water Balance System Components

3.1. Overall Water Balance

The site wide mine water balance was developed to include all major facilities that are expected to add water to the system, store water, require or consume water, or remove water from the system. A schematic of the overall system is provided as **Figure 3.1**.

Figure 3.1 Site Wide Water Balance Schematic



In simplified form, the water balance can be reduced to facilities that add water to the system, facilities that store water, facilities that use water, and facilities that treat water. Any water that enters the milling process stream and discharges to the TSF has the potential to contact cyanide and is considered process water (illustrated in **orange** on **Figure 3.1**). All process water will be stored in a fully closed-loop system (including only the Mill, the TSF, and pipelines connecting them) that prevents the release of any process water. A majority of process water will be reused in the mining process by reclaiming this water from the TSF Reclaim Pond. Other water that is added to the system is grouped into two categories, contact water (illustrated in **purple** on **Figure 3.1**) and non-contact water (illustrated in **green** on **Figure 3.1**). Contact water is water that may be contaminated as a result of contact with potentially acid generating (PAG) material. Non-contact water is water in the Project area (e.g., direct precipitation and runoff or groundwater from depressurization) that does not come into contact with PAG material and is collected and stored in the Fresh Water Storage Area (FWSA) behind the Fresh Water Storage Dam (FWSD). Both contact and non-contact water will be used at the mine. Any contact water not used in the milling process will require treatment at the Contact Water Treatment Plant (CWTP) before it can be released. Anticipated sources of process, contact, and non-contact water are summarized below.

Process Water

- Free water in the TSF
- Any water in the Mill process stream
- Natural moisture in the processed ore

Contact Water

- Runoff and seepage from PAG storage areas
- Water pumped from the underground mine workings
- Direct precipitation and runoff accumulated in and pumped from the open pits

Non-Contact Water

- Groundwater from pit depressurization
- Runoff that does not come in contact with PAG

Some non-contact storm run-off within the Project area from green overburden storage areas (OSAs), growth media stockpiles, and undisturbed ground is not collected in FWSA but rather flows directly (or sometimes via storm pond) into Haile Gold Mine Creek and its tributaries, other adjacent streams and their tributaries, and/or the Little Lynches River. As a result, this non-contact run-off is not addressed in the site wide water balance. This non-contact storm run-off is addressed in a separate detailed assessment of surface water flows in Haile Gold Mine Creek and its tributaries, other adjacent streams and their tributaries, and the Little Lynches River, which was completed as part of the Haile Surface Water Direct and Indirect Flow Impact Assessment Report (ERC 2018).

There are several water storage facilities included in the water balance model:

- The TSF Reclaim Pond is effectively a water storage pond within the footprint of the TSF where process water is stored.
- Contact water is stored in several PAG ponds (including the 465, 469, West PAG, and East PAG Ponds) and 29 Pond (which serves the Mill and CWTP). PAG ponds are intended to temporarily store runoff and seepage from the PAG facilities. Contact water also is temporarily stored in pit sumps after rainfall events until this water is evacuated shortly after storms. Contact water from the PAG ponds and pit sumps will be sent to the 29 Pond, and from there it will be used in the Mill or treated at the CWTP.
- Non-contact water is stored in the FWSA. Inputs to the FWSA include direct rainfall and non-contact runoff, groundwater depressurization water, a portion of flow retained from Haile Gold Mine Creek, and effluent from the CWTP.

3.2. Major System Components

Each of the major elements of the water balance is described below.

3.2.1 Mill

The supply of operational water to the Mill is generally the largest water demand at the mine. The Mill uses water to process ore to remove the gold from it. The remaining waste from the milling process (i.e., tailings) is then sent to the TSF in the form of tailings slurry.

The model was run for the period of January 1, 2020 through December 31, 2032 for an overall period of 13 years. Planned production is assumed to be a constant of 12,080 tons per day over this period. It is assumed that approximately 12,555,000 tons will have been processed prior to January of 2020, so the total processed volume at the end of 2032 is expected to be approximately 65,465,000 tons.

Tailings produced at the Mill and sent to the TSF were modeled as having a solids content of 51.4% by weight. The tailings production rate and slurry content result in a total estimated 1,900 gpm of water sent to the TSF as part of the slurry based on the 12,080 tons/day production rate at the Mill[1].

3.2.1.1 Mill Non-Contact Water Requirements

Non-contact (fresh) water is required for parts of the Mill process. Mill requires a total of 245 gpm of fresh water that must come from non-contact sources for gland seals (177 gpm) and water for reagents (68 gpm).

3.2.1.2 Natural Ore Moisture

Ore processed at the Mill also contributes moisture to the system. An average natural ore moisture content of 4% was used in the water balance model. At a production rate of 12,080 tons of ore per day, natural ore moisture accounts for a constant input of 80 gpm to the system.

3.2.1.3 Consumed Water

Approximately 20 gpm of water is consumed at the Mill via evaporation. This water input was included in the model, as well.

3.2.2 Tailing Storage Facility

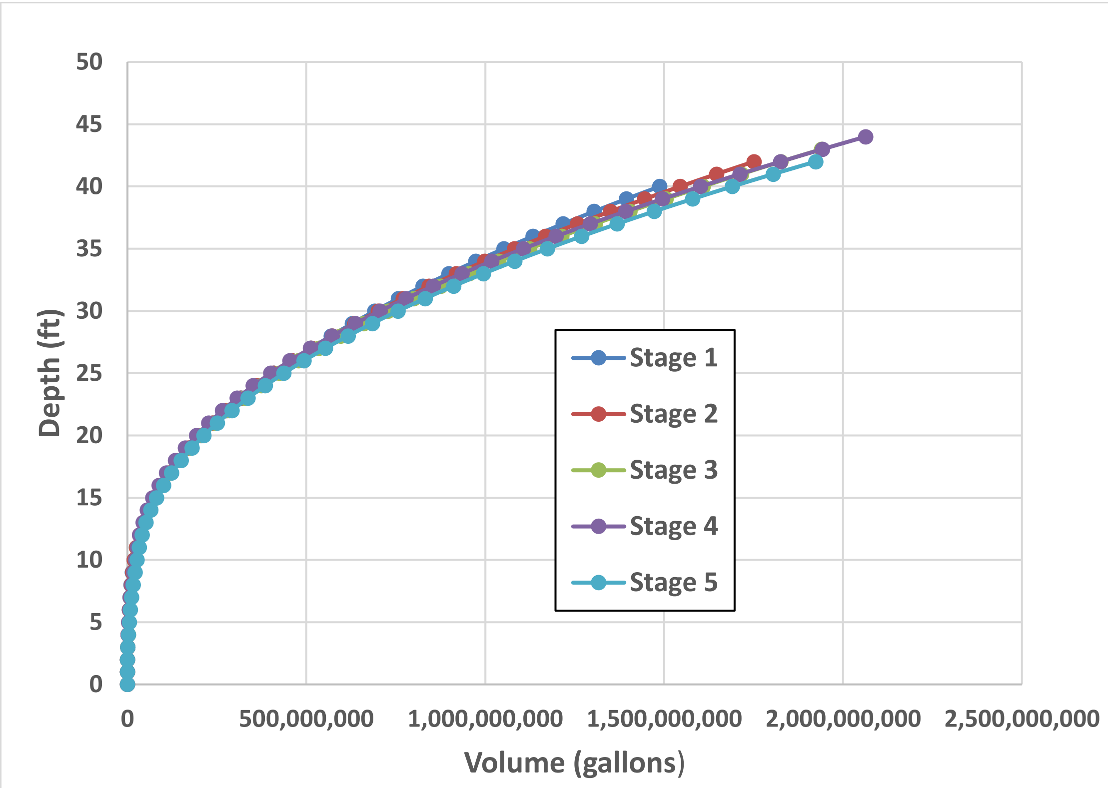
Process water is stored in the Reclaim Pond within the TSF. Reclaimed process water is the primary water source used to meet Mill water demands. Free water in the TSF Reclaim Pond is comprised of process water that drains from the tailings slurry and from direct precipitation. Water from the TSF Reclaim Pond can be used to meet much of the 1,900 gpm that the Mill sends to the TSF in the tailings slurry while operating at 12,080 tons/day. Because the Mill requires 245 gpm of non-contact water and receives 80 gpm from ore moisture, a maximum of 1,575 gpm of water can be reused from the TSF Reclaim Pond. Actual reclaim rates are calculated by the model based on water available in the TSF Reclaim Pond and are discussed in **Section 6.5.**

Because the TSF will be built in five different stages (with an ultimate crest elevation of 670 feet), ERC needed to evaluate the relationship between stored volume and water depth at each stage to accurately model this relationship. NewFields provided filling

[1] The Haile Project Description (Revision 1) states that the maximum operational rate for the Mill under the Haile 2018 Mine Expansion Plan is 14,400 tons/day. However, based on the assumption that the Mill would operate at an annual average rate that is approximately 85% of the maximum capacity of the Mill, ERC is using 12,080 tons/day.

curves for the TSF Reclaim Pond at each of the five embankment stages, and ERC plotted depth versus capacity for each stage. The results are presented in **Figure 3.2**.

Figure 3.2 TSF Reclaim Pond Filling Curves



Given the similarities of the curves for the various embankment stages, a single depth-area-volume relationship was used for all stages. **Table 3.1** includes the modeled Reclaim Pond geometry.

Table 3.1 Reclaim Pond Geometry

DEPTH (ft)	AREA (ft^2)	CUMULATIVE VOLUME (ft^3)	CUMULATIVE VOLUME (gal)
0	0	0	0
1	419	140	1,045
2	31,545	12,007	89,816
3	95,892	72,819	544,722
4	192,974	214,451	1,604,207
5	322,609	469,482	3,511,970
6	385,146	822,898	6,155,706
7	452,983	1,241,504	9,287,098

8	526,029	1,730,555	12,945,453
9	604,194	2,295,216	17,169,405
10	687,390	2,940,561	21,996,921
11	775,531	3,671,579	27,465,315
12	1,072,559	4,591,619	34,347,698
13	1,410,752	5,829,419	43,607,081
14	1,784,110	7,423,202	55,529,404
15	2,184,680	9,404,219	70,348,441
16	2,606,811	11,796,859	88,246,632
17	3,047,015	14,620,911	109,372,012
18	3,494,085	17,888,912	133,818,354
19	3,941,080	21,604,253	161,611,035
20	4,391,568	25,768,546	192,762,108
21	4,847,932	30,386,416	227,306,174
22	5,310,906	35,464,075	265,289,705
23	5,781,617	41,008,671	306,766,165
24	6,260,499	47,028,142	351,794,933
25	6,893,903	53,602,800	400,976,791
26	7,394,177	60,745,380	454,406,997
27	7,899,310	68,390,733	511,598,207
28	8,407,337	76,542,737	572,579,433
29	8,915,919	85,203,120	637,363,598
30	9,425,128	94,372,465	705,955,061
31	9,937,136	104,052,468	778,366,517
32	10,451,296	114,245,604	854,616,468
33	10,966,597	124,953,518	934,717,222
34	11,481,692	136,176,677	1,018,672,283
35	11,995,149	147,914,161	1,106,474,763
36	12,506,424	160,164,058	1,198,110,359
37	13,012,761	172,922,814	1,293,552,478
38	13,512,334	186,184,577	1,392,757,358
39	14,003,141	199,941,586	1,495,666,926
40	14,483,312	214,184,137	1,602,208,613
41	14,954,205	228,902,268	1,712,307,873
42	15,415,962	244,086,766	1,825,895,807
43	15,868,203	259,728,303	1,942,902,633
44	16,309,455	275,816,628	2,063,251,660

Geometric data for the different stages of the TSF that impact direct runoff into the TSF and therefore the water balance were provided by NewFields. Pertinent information is summarized in **Table 3.2**. Areas and elevations in the table below represent properties at the beginning end of each corresponding phase. The beginning of Stage 1 listed below is January 2020, which is the start of the water balance model.

Table 3.2 TSF Geometry

Stage	Time	Geomembrane Area (ft2)	Exposed Liner Area (ft2)	Tailings Area (ft2)
1 - Beginning	January 2020	14,034,182	1,454,132	12,580,050
1 – End	October 2020	14,034,182	550,228	13,483,954
2 – Beginning	November 2020	15,497,832	1,856,151	13,641,680
2 – End	October 2023	15,497,832	410,801	15,087,031
3 – Beginning	November 2023	17,081,560	1,867,244	15,214,316
3 – End	May 2028	17,081,560	203,617	16,877,943
4 – Beginning	June 2028	18,311,495	1,326,591	16,984,903
4 – End	June 2031	18,311,495	401,552	17,909,943
5 – Beginning	July 2031	19,573,155	1,563,386	18,009,769
5 - End	June 2035	19,573,155	679,053	18,894,102

Tailings are assumed to have a specific gravity of 2.85 and to be deposited in the TSF at a dry density of 80 pounds per cubic foot (pcf). Deposited tailings were assumed to be 100% saturated.

3.2.3 PAG Overburden Storage Areas

There will be two PAG Overburden Storage Areas (OSAs) on the mine site, West PAG (which incorporates the original Johnny's PAG) and East PAG. The facilities will contain potentially acid generating (PAG) material, will be lined with an 80-mil, high-density polyethylene (HDPE), and will be equipped with an underdrain to collect any water that infiltrates through the PAG material. Runoff and seepage flow from the PAG facilities is considered contact water and will either be used at the Mill or be treated at the CWTP before storage in the FWSA. Runoff and seepage from the West PAG gravity will drain to the 465 and 469 collection ponds. Runoff and seepage from the East PAG will drain to the East PAG collection pond. Contact water in these collection ponds will be pumped to the 29 Pond from where it can be used at the Mill.

A curve number (CN) of 75 was used to calculate direct PAG runoff. Water that does not directly run off the PAG facilities will either be lost to the system through evaporation or infiltrate through the PAG. The top surface of the PAG facilities was assumed to retain up to two inches of moisture that was available for evaporation. Any water in excess of two inches was assumed to infiltrate.

Infiltration rates through the pile were calculated based on unsaturated flow regimes using the Van Genuchten equation, presented below.

$$\theta(\psi) = \theta_r + \frac{\theta_s - \theta_r}{[1 + (\alpha|\psi|)^n]^{1-1/n}}$$

where

$\theta(\phi)$ is the water retention curve $[L^3L^{-3}]$;
$|\psi|$ is suction pressure ($[L^{-1}]$ or cm of water);
θ_s saturated water content $[L^3L^{-3}]$;
θ_r residual water content $[L^3L^{-3}]$;
α is related to the inverse of the air entry suction, $\alpha > 0$ ($[L^{-1}]$, or cm^{-1}); and,
n is a measure of the pore-size distribution, $n > 1$ (dimensionless).

Modeled parameters for flow through the PAG are given on **Table 3.3**.

Table 3.3 Material Properties

Parameter	Modeled Value
Alpha (cm-^{1})	0.1
N	1.35
M	0.23
theta r	0.03
theta s	0.35
Ko (cm/sec)	10

All PAG facilities will be operational throughout the duration of the model. Areas of the PAG facilities are summarized on **Table 3.4**.

Table 3.4 PAG Geometry

PAG Facility	PAG Area (ft^2)	Pond Area (ft^2)
JPAG[2]	3,886,700	189,200
West	9,809,000	437,000
East	9,050,000	290,000

3.2.4 Pits

Six open pits (Mill Zone, Red Hill, Snake, Haile, Ledbetter and Champion) will be in operation at various times. Precipitation in the pits will be considered contact water and therefore will be pumped to the 29 Pond from where it will be either used at the Mill or sent to the CWTP. Pit areas were split into pit highwall/floor area or backfill for calculations with the two area types having different runoff characteristics. Areas used in the model are presented in **Table 3.5**. Since Champion Pit is a stand-alone pit and the other five pits are generally connected, the table lists values for the "Main" Pit and Champion Pit only. Areas at intermediate times from those presented in the table are interpolated by the model. Total areas of each system are equal to the sum of the highwall/floor area and the backfill area.

Table 3.5 Modeled Pit Areas

PAG Facility	Main Pit Highwall/Floor (ft^2)	Main Pit Backfill (ft^2)	Champion Pit Highwall/Floor (ft^2)	Champion Pit Backfill (ft^2)
Jan 2020	7,610,000	0	0	0
Jan 2021	9,720,000	0	0	0
Jan 2024	12,800,000	0	0	0
Jan 2029	14,599,675	3,511,325	0	0
Dec 2032	11,101,542	7,900,483	320,975	0

Pumping from the pits is limited to pump capacities within each pit, and at times excess storm water will be temporarily stored in the pits. Predicted daily pumping from each pit and accumulated volumes of stored water are calculated by the model.

[2] The current JPAG will get integrated into the ultimate West PAG.

3.2.5 Contact Water Pumping for Underground Mine Operations

The mine will be pumping to dewater the underground mine and dewater areas near pit sumps. NewFields calculated the amount and timing of this pumping as part of their groundwater modeling (NewFields 2018). Water pumped as part of this process has the potential to come into contact with mine workings and is therefore considered contact water. This water will be sent to the 29 Pond where it will comingle with other contact water. Some amount of contact water may be used as makeup at the Mill when reclaim from the TSF isn't fully available. At all other times, this water will be sent to the CWTP, where it will be treated and released to the FWSA. The timing and amount of water predicted by NewFields to be generated from dewatering of the underground mine and used in the water balance model is given in **Table 3.6**.

Table 3.6 Contact Water Pumping for Underground Mining

Time	Contact Water Pumping for Underground Mining (gpm)
2020	617
2021	628
2022	707
2023	749
2024	746
2025	739
2026	759
2027	520
2028	547
2029	543
2030	738
2031	693

3.2.6 Contact Water Treatment and Pretreatment Storage

All contact water not used in the Mill process will require treatment before it can be released from the system. The model assumes that the CWTP will be expanded from its current 1,200 gpm capacity to 2,000 gpm.

Monthly contact water runoff rates may peak at rates higher than 2,000 gpm. The 29 Pond temporarily stores contact water and regulates flows to the CWTP. The total capacity of the storage pond was assumed to be 29 million gallons in the model. (The

19 Pond currently holds up to 19 million gallons, but pond cells will be expanded to hold approximately 29 million gallons.)

3.2.7 Pit Depressurization Water

A system of production pumping wells will be used to depressurize groundwater around the pits and underground mine operations to facilitate mining. Depressurization of the pits is expected to be a significant source of fresh water throughout the project. It will be sent to the FWSA from where it can be used to meet any non-contact water need.

Depressurization rates used in the water balance were calculated by NewFields as a result of their detailed depressurization groundwater modeling (NewFields 2018). NewFields' modeling produced various depressurization rates for different times during planned mining operations. **Table 3.7** presents estimated pit depressurization rates used in this water balance model. Modeled monthly pit depressurization pumping rates listed below are estimated values at the beginning of the year. Daily values used in the water balance model were linearly interpolated from these listed values.

Table 3.7 Pit Depressurization Rates

Time	Modeled Pit Depressurization Rates (gpm)
Start of 2020	741
Start of 2021	686
Start of 2022	658
Start of 2023	414
Start of 2024	389
Start of 2025	483
Start of 2026	464
Start of 2027	446
Start of 2028	572
Start of 2029	640
Start of 2030	636
Start of 2031	334
Start of 2032	270

3.2.8 Fresh Water Storage Dam

A Fresh Water Storage Dam (FWSD) will be constructed on Haile Gold Mine Creek upstream of the pits to collect water in the FWSA. The FWSA will serve multiple purposes including:

- the main component of site water management that captures and diverts non-contact runoff around the open pits and protects the open pits from flooding in severe weather
- a storage area for managing non-contact and treated contact water generated and required by the mine and Mill operations
- a source of water to ensure that the mine can maintain the necessary minimum releases downstream of the mine

The various inputs to and outflows from the FWSA are shown below.

Inputs

- Rainfall/Runoff from the tributary basin
- Effluent from the CWTP
- Groundwater depressurization pumping

Outflows

- Evaporation
- Infiltration losses (assumed an average of 5% of water per annum)
- Bypass flows for minimum releases to Lower Haile Gold Mine Creek (set at 100 gpm)
- Dust suppression
- Mill fresh water requirements
- Construction water
- Water required for the underground concrete backfill
- Excess water discharge (maximum rate set at 34 cfs or approximately 15,200 gpm)

The facility has a dam crest at elevation 491 feet, an emergency spillway at 485 feet and is planned to be operated at a maximum normal water level of 470 feet. At a water surface elevation of 470 feet it has a storage capacity of approximately 3.72 million cubic feet (85 acre-feet). Water in excess of this level will be released to lower Haile Gold Mine Creek. The filling curve for the FWSA is presented in **Table 3.8**.

Table 3.8 Fresh Water Storage Area Geometry

Elevation (ft)	Area (ft^2)	Cumulative Volume (ft^3)	Cumulative Volume (gal)
454	0	0	0
455	7,550	2,517	18,827
456	15,751	13,919	104,122
457	29,611	36,239	271,084
458	49,129	75,199	562,528
459	74,318	136,489	1,021,012
460	139,839	241,856	1,809,210
461	163,352	393,299	2,942,084
462	190,832	570,213	4,265,493
463	223,411	777,121	5,813,272
464	261,092	1,019,129	7,623,611
465	364,182	1,330,339	9,951,630
466	405,496	1,714,994	12,829,044
467	448,905	2,142,010	16,023,350
468	494,407	2,613,483	19,550,212
469	542,013	3,131,511	23,425,330
470	639,041	3,721,373	27,837,802
471	712,958	4,397,035	32,892,107
472	788,681	5,147,537	38,506,247
473	874,220	5,978,621	44,723,187
474	969,574	6,900,107	51,616,383
475	1,079,278	7,924,043	59,275,958
476	1,170,231	9,048,491	67,687,412
477	1,266,597	10,266,587	76,799,408
478	1,369,747	11,584,423	86,657,503
479	1,480,055	13,008,968	97,313,838
480	1,649,406	14,572,934	109,013,117
481	1,766,226	16,280,417	121,785,977
482	1,886,849	18,106,623	135,446,944
483	2,012,223	20,055,823	150,027,973
484	2,142,882	22,133,033	165,566,582
485	2,281,556	24,344,889	182,112,417
486	2,427,999	26,699,287	199,724,536
487	2,569,618	29,197,761	218,414,421
488	2,716,913	31,840,685	238,184,862
489	2,870,059	34,633,821	259,078,971
490	3,029,540	37,583,261	281,142,315

491	3,169,092	40,682,315	304,324,852

3.2.9 Mine Dust Suppression and Minor Uses

The mine has indicated that it requires an average of 933 gpm for dust suppression. The model includes this demand. Non-contact water is required for dust suppression.

3.2.10 Construction Water

Water will be required for major construction activities at the mine including TSF expansions and OSA construction. These water demands will impact the overall site water balance; therefore, they were calculated and incorporated into the model. The exact timing of specific construction activities and their water demands will be determined as part of detailed scheduling. Best estimates of the major construction activities were generated by NewFields based on planned expansions and the nearly constant use of overburden as random fill in the TSF. Modeled construction water demands in the water balance model are summarized in **Table 3.9**. All major construction-related water is assumed to come from non-contact sources.

Table 3.9 Construction Water Estimates

Year	Estimated Construction Water Requirement (gpm)			
	Q1 (gpm)	Q2 (gpm)	Q3 (gpm)	Q4 (gpm)
2020	142	177	285	495
2021	33	33	33	33
2022	33	33	33	44
2023	33	33	186	186
2024	164	140	140	148
2025	140	140	140	140
2026	140	140	140	149
2027	140	140	276	276
2028	236	236	236	236
2029	236	236	236	236
2030	236	236	33	33
2031	0	0	0	0
2032	0	0	0	0

3.2.11 Water for Underground Concrete Backfill

The mine will be backfilling portions of the underground workings with concrete. This operation will require water. The model assumes that non-contact water from the FWSA will be used to meet backfill water demands.

The mine indicated that the concrete backfill will be 4% concrete by weight and have a 2:1 water to cement ratio. A total of 3,700,000 tons of ore will be removed from the underground leaving an approximately 1,827,000 cubic yard void to be filled. Based on the underground development schedule, the water balance model assumed that this void would be filled over a 42-month period from July 2023 to December 2026. A constant non-contact water demand of 38.5 gpm was assumed in the water balance model for this 42-month period to meet this demand.

4.0 Operational Assumptions

How the mine manages water systems on site will impact the overall water balance. This section describes two significant operating assumptions; (1) the priority of water used in the process at the Mill and (2) how the CWTP will reduce contact water volumes in the system.

4.1. Water Use Priorities

Based on fresh water Mill demands described in **Section 3.2**, a minimum of 245 gpm of fresh water is required and 80 gpm comes from natural ore moisture. A maximum of 1,575 gpm of the Mill water demand can be met using reclaim from the TSF or other contact water in the system. The model assumes a combination of reclaim and contact water will be used to meet this 1,575 gpm demand, when available.

The water balance prioritized the type of water used in the Mill. When available, water from the TSF Reclaim Pond was assumed to be the first water sent to the Mill. (However, reclaim water from the TSF Reclaim Pond was assumed to be limited to free water stored above a dead pool depth of 10 feet; if the TSF Reclaim Pond depth is less than 10 feet, the model assumes water will not be taken from the reclaim pond. The 10-foot dead pool criterion is based on the need to have a minimum depth of water so that the reclaim pumps do not draw tailing solids into the reclaim line.)

In the event that water from the TSF Reclaim Pond is not available in sufficient quantity to meet the 1,575 gpm demand, runoff and seepage from contact water sources was then assumed to be used for Mill process water, where available. In the event that reclaim water and contact water are not available in sufficient quantity to meet the

1,575 gpm demand, all deficits were assumed to be met using non-contact water from the FWSA. In addition to providing fresh makeup water to the Mill as needed, non-contact water from the FWSA also is used for dust suppression, construction water, and miscellaneous water.

4.2. Pretreatment Storage and Water Treatment

Contact water from PAG ponds, the pits, and underground mine operations will be captured and sent to the 29 Pond. Contact water not used to meet Mill water demands will be treated at the CWTP with effluent released to the FWSA. The 29 Pond will be used to reduce peak treatment rates by temporarily storing runoff during peak wet periods. The peak contact water held in the 29 Pond will be stored so that it may be treated during drier periods when the CTWP has treatment capacity, and will be managed to minimize water stored in the 29 Pond. In the event of major storms, water from PAG ponds will be pumped to the 29 Pond prior to dewatering the pit sumps to ensure sufficient capacity is retained in the PAG ponds.

The CWTP is assumed to operate at the maximum capacity of 2,000 gpm when required, and the 29 Pond is planned to provide approximately 29 million gallons of storage. The CWTP capacity and size of the 29 Pond are increases over existing conditions, which presently include a treatment capacity of 1,200 gpm and approximately 19 million gallons of storage in the 19 Pond.

5.0 Meteorological and Hydrologic Parameters

5.1. Precipitation

Daily precipitation values were required to run the daily time step model. ERC utilized recorded daily precipitation as the basis for this input. Daily data was obtained from the Kershaw station (USC00384690) and the site's meteorological station.

Data from the Kershaw station was relatively complete from May 1916 to November 2005. **Table 5.1** lists missing data.

Table 5.1 Missing Kershaw Daily Precipitation

Year	Missing Dates
1919	March 1-4, 7, 9-17, 19-26, 28-30
1923	October 1-2, 4-18, 20-23, 25-30
1925	June 1-9, 11-13, 16, 20-24, 27, 29-30; July 2-4, 6, 8-11, 15-23, 28-31; December 1, 4-14, 18-19, 21, 23-31
1926	January 9-17, 19-24, 26-30; February 1-2, 5-9, 11-14, 16-17, 20-24, 26-28
1928	August 1-4, 7-10, 13-14, 18-19, 21-21, 24-25, 28-30; September 7-11, 14-17, 20, 22-30
1934	July 1-2, 5-6, 8-9, 12-18, 21-24, 28; September 1-4, 8-12, 17-28
1937	Jan 1-31; November 1-30
1938	November 1-30; December 1-31
1939	January 1-31
1942	August: 1-4, 6-8, 14-15, 20, 22-23, 26-30
1944	July 10-11, 13, 17, 19, 23-28, 30; November 1-9, 11-15, 17-19, 22-25, 27
1947	July 1-6, 7-16, 22-31
1950	July 1-31
1953	May 1-31
1955	April 1-30
1959	August 6-11; October 23-31; November 1 – December 21
1960	January 1 – 31; March 3
1961	July 26-August 10
1964	August 1-7
1965	September 4-8
1966	January 25-31
1968	January 10-31
1969	February 16-17; March 1-6
1972	July 3-7
1973	Jan 1 - February 22; October 1 – December 31
1974	April 1 – August 30; October 1 – December 31
1975	January 1 – January 31
1976	July 26-30
1987	December 1-4
1994	January 1 – December 31
1995	January 1 – December 31
1996	January 1 – November 30; December 29-31
1998	August 1-31
1999	June 1-July 14

2000	September 2
2001	June 25; September 8-9
2002	April 13-14; June 22-23; August 24-25; September 1; November 2-3; December 7-9, 21-23
2005	March 1-6, 8-12, 14, 17-21, 23-26, 28-29, 31; April 2-6, 4-11, 13-30; May 1-9, 11-14, 16-19, 21-28; July 29-30; November 21-22, 28-30

Data from the Haile site's station was relatively complete from January 2000 to April 2016. **Table 5.2** lists missing data.

Table 5.2 Missing Site Daily Precipitation

Year	Missing Dates
2000	March 2; April 28-30
2005	June 30
2009	February 20
2014	April 30-May 1
2016	February 20-21

A synthetic site daily precipitation dataset was developed based on data from these two stations. First, site data was used. Missing site data in 2000 and 2005 were filled with precipitation at Kershaw on those days. The five missing dates from 2009 – 2016 were filled with zeros. Next ERC evaluated the Kershaw data to identify years with the most missing values to remove. In general years with data missing for a majority of a month or years, with significant numbers of individual days missing and low annual totals for remaining days, were removed. Missing data on the remaining years were filled as zero rainfall days. Based on this ERC was able to generate 77 years of daily site precipitation for use in the model.

The 77-year data set has an average annual precipitation of 46.14 inches. The peak individual day modeled produces 9.85 inches of rain.

The water balance model was run so that each model realization randomly started at one of the 77 potential January 1st dates in the precipitation dataset and utilized the following 13 years of daily data for the run. One thousand different scenarios were run in the Monte Carlo simulation to achieve probabilistic results.

5.2. Evaporation

Evaporation data used in the water balance model were based on data collected at the Sand Hill Research Station in Elgin, South Carolina, located approximately 29 miles southwest of the mine site. Evaporation measurements at that station are "pan evaporation," which is the amount of evaporation recorded in a standard pan instrument. The period of record for the Sand Hill Research Station evaporation data is 1963 to 1992 (ERC 2012).

For use in water balance modeling, ERC used the total annual pan evaporation value of 64.10 inches. Actual evaporation from different surfaces was taken by multiplying the monthly pan evaporation values by different evaporation coefficients. The average monthly evaporation rates used in the water balance model are provided in **Table 5.3**. The modeled evaporation coefficients for pond surface areas (TSF Reclaim Pond and 29 Pond) and beach areas are 0.70 and 0.40, respectively. Daily evaporation rates were assumed to be uniform throughout the month.

Table 5.3 Monthly Pan Evaporation

Month	Evaporation (in)	Percent of Annual (%)
Jan	1.80	2.81
Feb	2.72	4.24
Mar	4.76	7.43
Apr	7.34	11.45
May	7.81	12.18
Jun	8.23	12.84
Jul	8.49	13.24
Aug	7.12	11.11
Sep	5.88	9.17
Oct	4.79	7.47
Nov	3.19	4.98
Dec	1.98	3.09
Annual	64.10	100

5.3. Runoff Calculations

Runoff from different land types were calculated by the model. The Natural Resource Conservation Service (NRCS) Curve Number (CN) method was used to calculate daily runoff from daily precipitation values and land types. The following CN values were used:

- Pits: 94
- Undisturbed Ground: 84
- OSAs: 75
- Pit Backfill Areas: 80

6.0 Model Results

The water balance model was run using a daily time step. The model has a start date of January 1, 2020 and ran through December 31, 2032.

The water balance was run using a Monte Carlo simulation. In the Monte Carlo simulations, the model was run 100 different times, each time with a different, equally likely sequence of daily precipitation based on the synthetic daily site precipitation that was generated. Running the model with a range of precipitation produces a range of results (probabilistic results) rather than a specific value (deterministic result). Monte Carlo simulations allow for the model to evaluate uncertainty that is inherent to the water balance.

6.1. Interpreting Statistical Results

Stochastic results are presented on the figures below with a range of statistical values shown in various colors.

- Top of the upper blue shading corresponds to the upper bound result
- Top of the upper yellow shading corresponds to the 95th percentile result
- Top of the green shading corresponds to the 75th percentile result
- Red dots represent the mean results
- Black line presents the median
- Top of the lower yellow shading (bottom of the green) is the 25th percentile result
- Top of the lower blue shading (bottom of the yellow) is the 5th percentile result
- Top of the white shading (bottom of the blue) is the lower bound result

6.2. Probabilities

When considering results, the percentiles discussed above and presented in the results below can be related to probabilities. Upper bound results are based on the greatest result in 100 realizations. They therefore have a 1% probability of occurrence in a given day. The 95th percentile result is a result that is exceeded 5 percent of the time or 5 times during the 100 model runs. The 95th percentile results therefore have a probability of being exceeded of 5%. **Table 6.1** summarizes the relationship between percentiles, number of exceeded and probabilities.

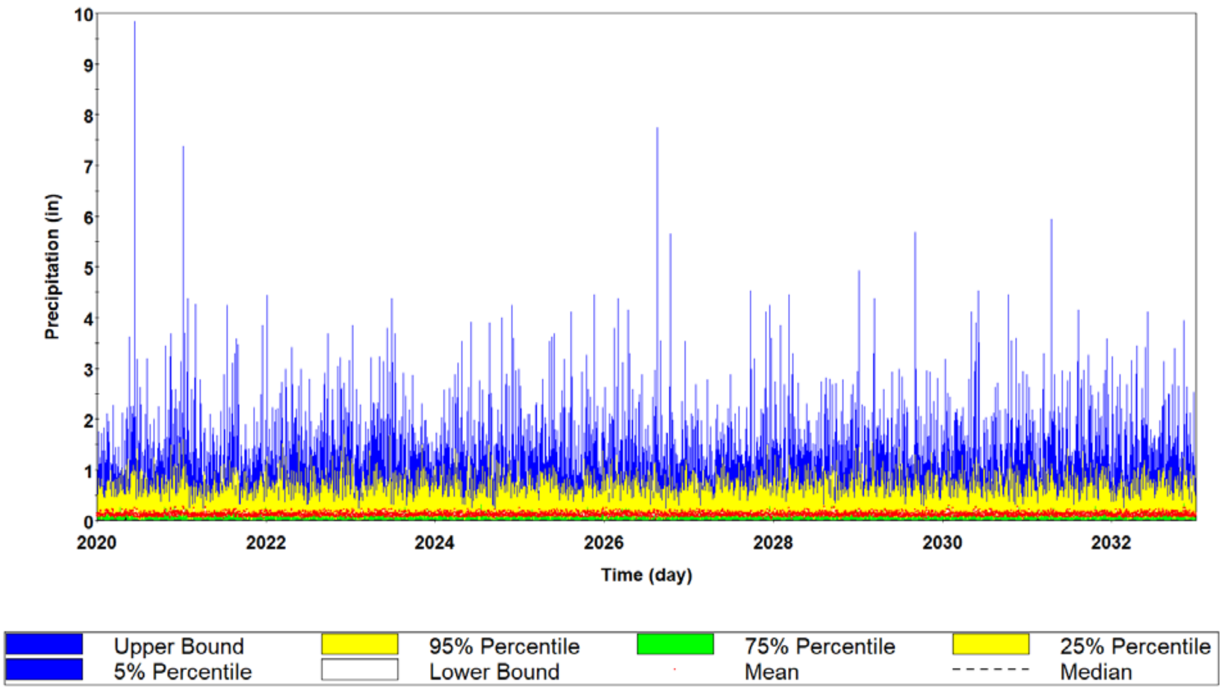
Table 6.1 Summary of Statistical Parameters

Model Result	Number of Times Equaled or Exceeded in 100 Scenarios	Probability of Being Equaled or Exceeded (%)
Upper Bound	Equaled 1 Time, Never Exceeded	Equaled 1% of the Time, Never Exceeded
95th Percentile	Equaled or Exceeded 5 Times	5%
75th Percentile	Equaled or Exceed 25 Times	25%
Mean	Average of All Results	Average of All Results
Median	Equaled or Exceeded 50 Times	50%
25th Percentile	Equaled or Exceeded 75 Times	75%
5th Percentile	Equaled or Exceeded 95 Times	95%
Lower Bound	Equaled or Exceeded All 100 Times	99%

6.3. Precipitation

Daily precipitation values derived from the Monte-Carlo simulations in the GoldSim model are presented in **Figure 6.1**. The single peak daily precipitation is 9.85 inches. The variability shown in this figure is the basis for stochastic nature of other model results.

Figure 6.1 Daily Stochastic Precipitation



6.4. TSF Free Water Storage

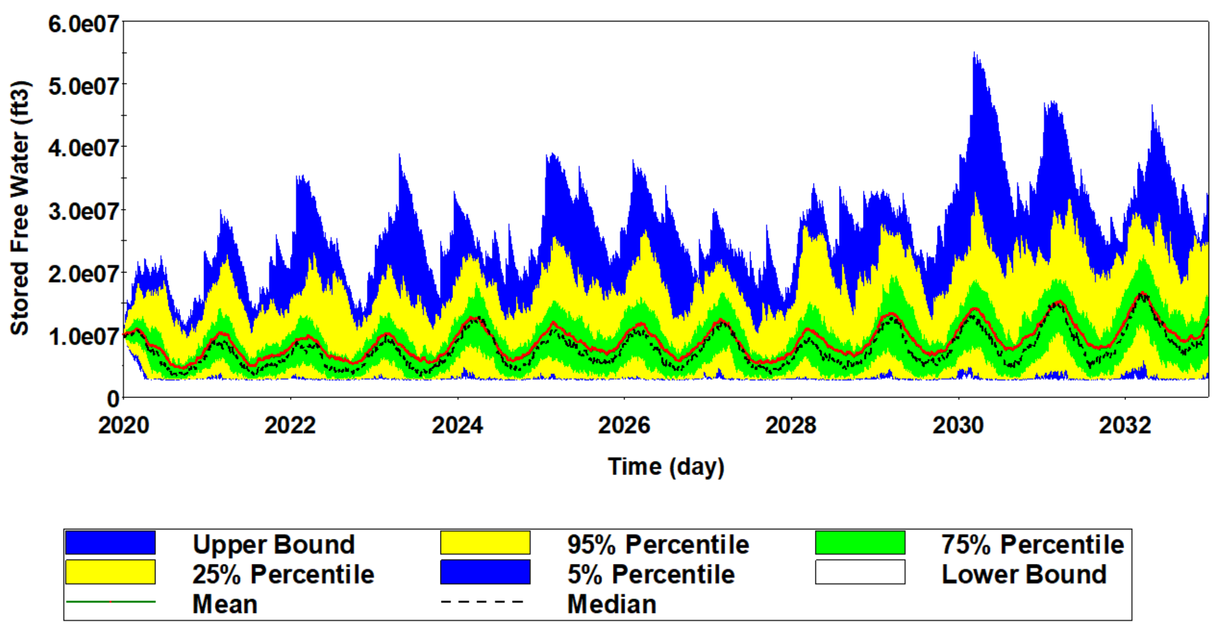
Figure 6.2 shows the amount of free water predicted to be stored in the TSF Reclaim Pond. For modeling purposes, it is assumed that 10 million cubic feet (230 acre-feet) of free water was in the Reclaim Pond when the model starts on January 1, 2020. Results indicate that the volume of stored free water is expected to follow seasonal trends with more water in the pond during winter months when evaporation is lowest and less free water during the summer.

For mean precipitation conditions (red line), results suggest that the volume of free water in the TSF Reclaim Pond will be maintained at less than or equal to roughly 15 million cubic feet. For upper bound wet conditions (top of blue shading), the peak volume of stored water would be approximately 55 million cubic feet (1,263 acre feet). Given drought conditions, the reclaim pond could be drawn down to its minimum 10-foot deep pond depth, which equates to 2.9 million cubic feet (67 acre feet).

Based on the reclaim pond geometry presented in **Table 3.1**, a total of approximately 275 million cubic feet of storage is expected to be available in the pond. Based on the upper bound result of 55 million cubic feet the pond will maintain approximately 220 million cubic feet of storage. A Probable Maximum Precipitation (PMP) event would result in approximately 48 inches of rainfall. Four feet of water over the full TSF basin equals approximately 66 million cubic feet of water. This shows that even for the predicted upper bound storage result the TSF will have sufficient capacity to store the PMP.

It is worth noting that the predicted volume of water in the TSF Reclaim Pond is highly dependent on reclaim rates. The model assumes that, when available, 1,575 gpm is reclaimed from the Pond to the Mill. Taking less than this amount when it is available would result in additional free water in the TSF.

Figure 6.2 Free Water Stored in the TSF Reclaim Pond

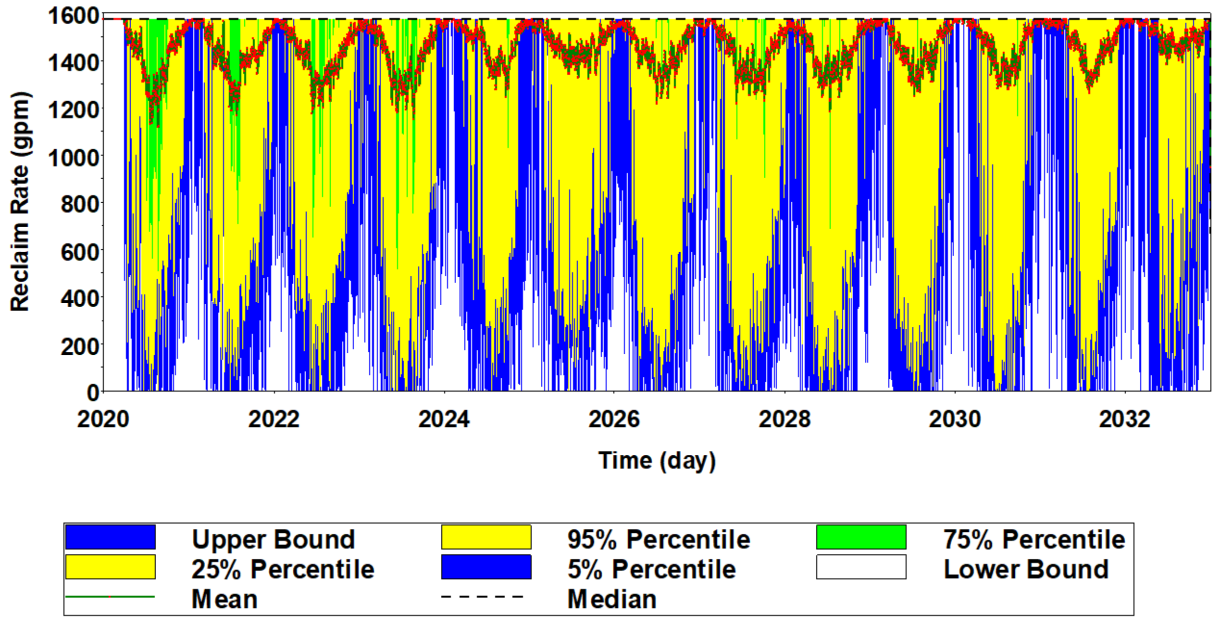


6.5. Reclaim Rate

Figure 6.3 shows the rate at which the model predicts water will be recycled from the TSF Reclaim Pond back to the Mill. The available volume of reclaim water is limited by the dead pool depth in the TSF of 10 feet required for reclaim pumping. The upper bound value of 1,575 gpm shown on the graph occurs when sufficient water is available to meet the maximum reclaim rate needed at the Mill.

Mean results show that reclaim is predicted to reach 1,575 gpm in winters and dip to approximately 1,200 gpm in the middle of summer. In wetter than average conditions, reclaim may stay at or near 1,575 gpm throughout the year. Only in extreme drought conditions is reclaim expected to drop below about 800 gpm.

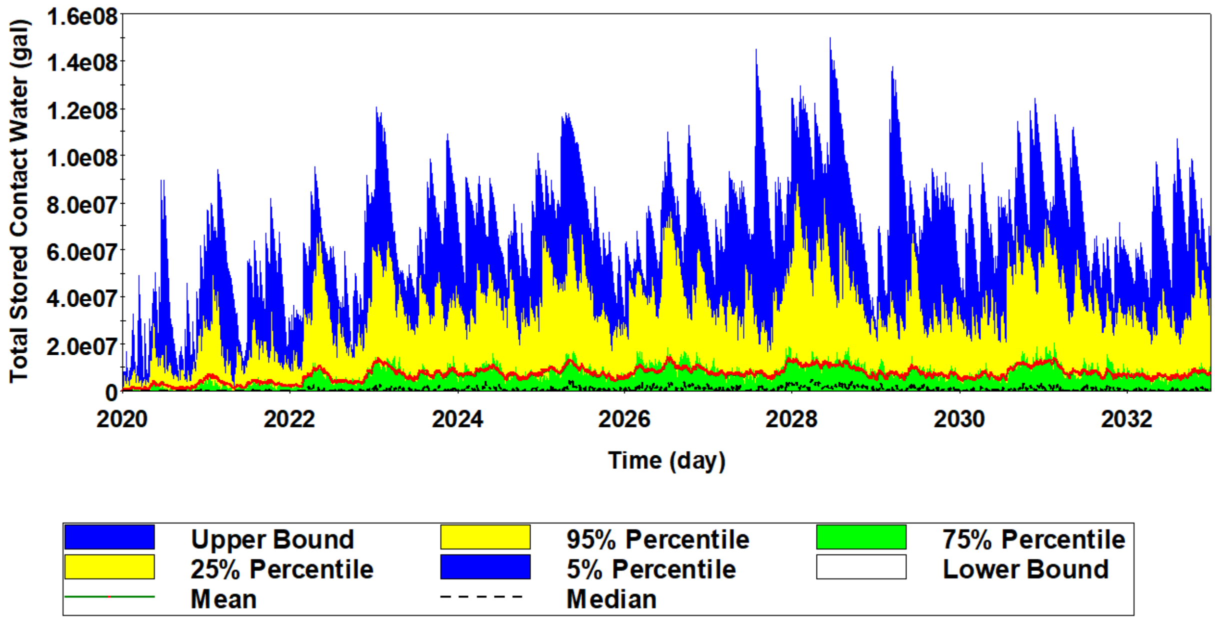
Figure 6.3 Reclaim Rate



6.6. Total Contact Water

The water balance model tracks the amount of contact water that is expected to be generated at the mine. Contact water is classified as runoff and seepage from PAG facilities, water pumped to dewater the underground workings, and all surface water collected in and pumped from the pit sumps. **Figure 6.4** presents the amount of contact water expected to exist at the site throughout the life of mine. The increase in contact water over time is the result of the increased footprint of the pits and the increasing seepage predicted through the PAG facilities. Based on average conditions, about 5-15 million gallons (668,000 – 2,000,000 cubic feet) of contact water will exist. For peak wet conditions the maximum amount of contact water predicted to be stored at any time is approximately 150 million gallons. This water is stored in the 29 Pond, PAG ponds and pit sumps.

Figure 6.4 Total Contact Water

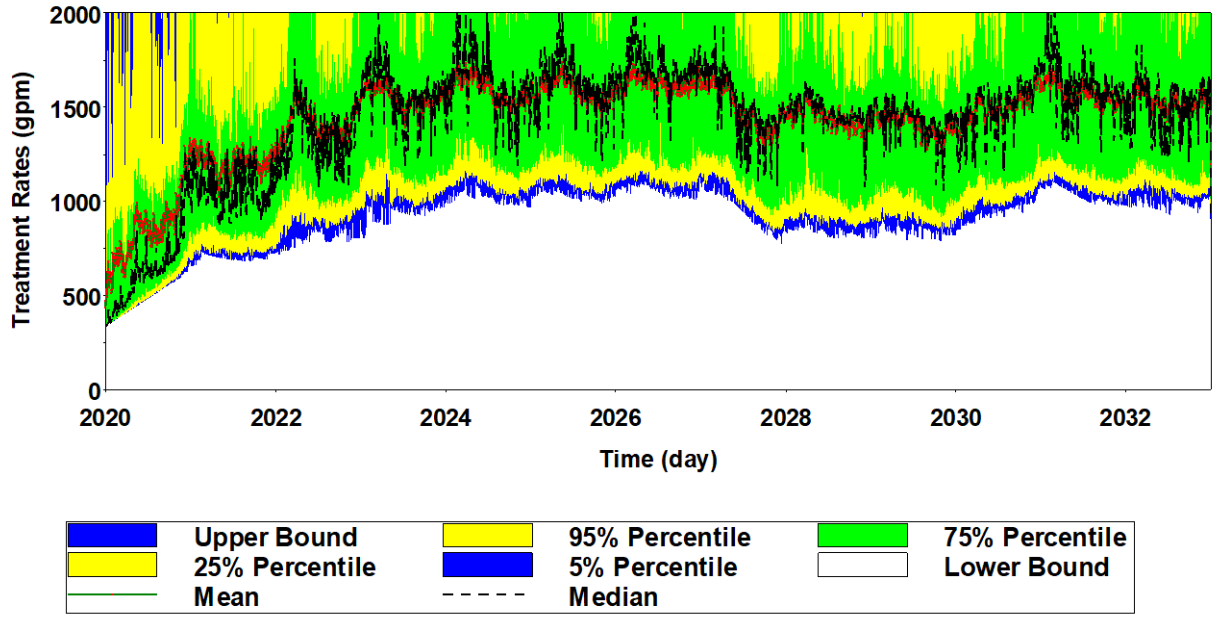


6.7. Contact Water Treatment Rates

Contact water not used at the Mill will require treatment at the CWTP. **Figure 6.5** shows the anticipated rate at which contact water will be treated.

Results suggest that required treatment will grow steadily from 2020 to about 2024 with average rates increasing from about 600 gpm to 1,600 gpm over this time period. This increase is the result of increased seepage collected from the PAG facilities as they develop and contact water inputs from underground mining operations. Treatment requirements are expected to have seasonal variability with more water treatment occurring in the winter and less in the summer. Other than the first months of 2020, the upper bound results suggest treatment will be 2,000 gpm. The figure also shows that at times the 75th percentile result equals the CWTP capacity of 2,000 gpm. These results indicate the expectation that the CWTP will need to operate at full capacity at times during operations more than just following large precipitation events.

Figure 6.5 Contact Water Treatment

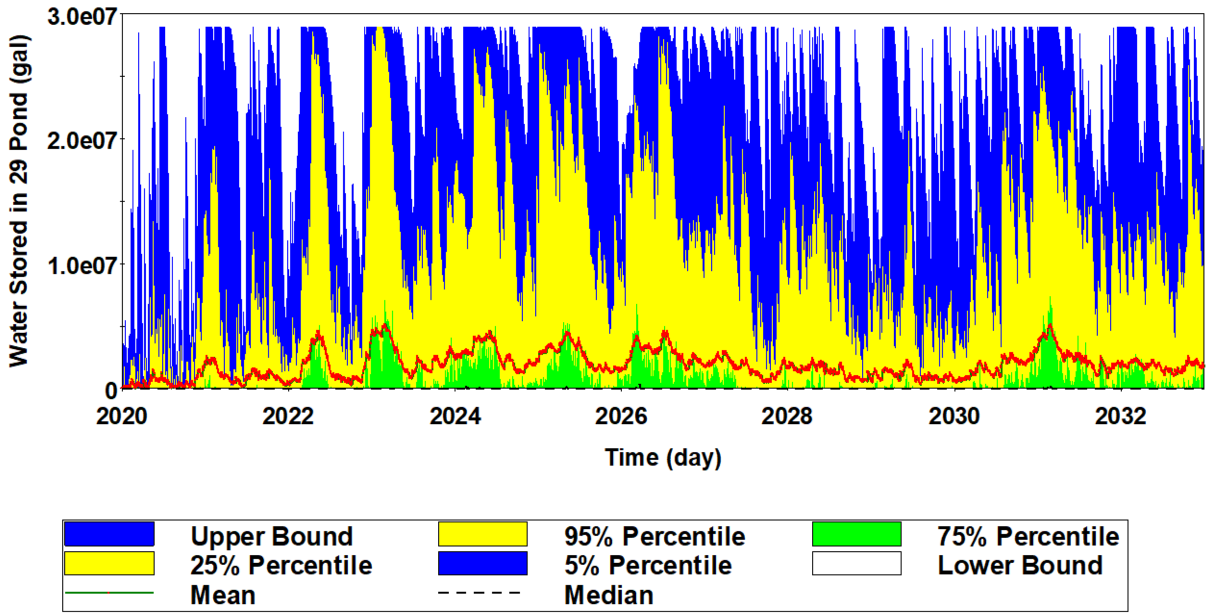


6.8. 29 Pond Water Storage

The model evaluated the amount of water that can be expected in the 29 Pond. This assessment was done assuming the prior of pumping to the 29 Pond was groundwater from the underground operations, pumping from the PAG Ponds and pumping from pit sumps. Results of the evaluation are shown on **Figure 6.6**.

Average results indicate that the 29 Pond volume will typically range between empty and up to about 5 million gallons stored. The pond is predicted to be full over the course of operations for upper bound results and some 95^{th} percentile conditions in 2023.

Figure 6.6 Calculated Storage in the 29 Pond



6.9. Contact Water Stored in Pits

Due to the finite size of the 29 Pond and the CWTP capacity, there will be times when contact water is temporarily stored in the pit sumps until sufficient capacity exists for this water to be evacuated. The water balance model calculated the amount of water estimated to be in the pit sumps throughout operations. **Figure 6.7** shows the results.

Of more importance to the mine is the frequency at which water can be expected in the pit floors. The model tracked the number of days per year when more than a minimal amount of 1,000 gallons of excess water was predicted in any of the pit floors. Results of this analysis are given on **Figure 6.8**. The figure indicates that for average meteorological conditions, water can be anticipated on the pit floor for about 20-30 days per year. In extreme wet conditions there may be 40-50 days per year when water would persist on the pit floor.

Figure 6.7 Contact Water in Pits

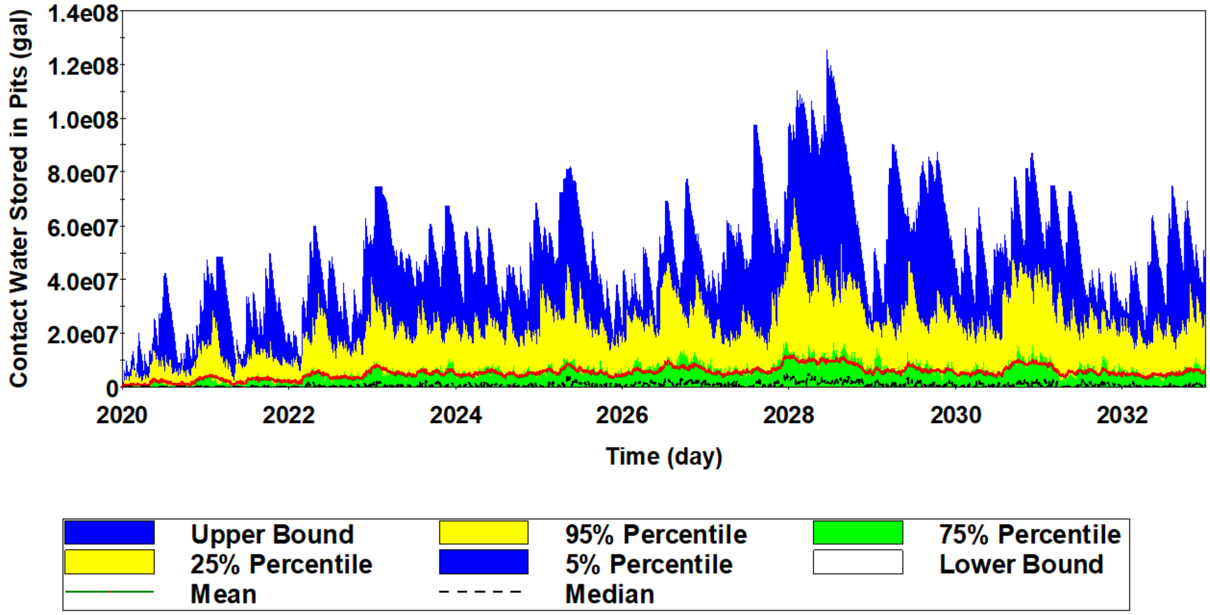
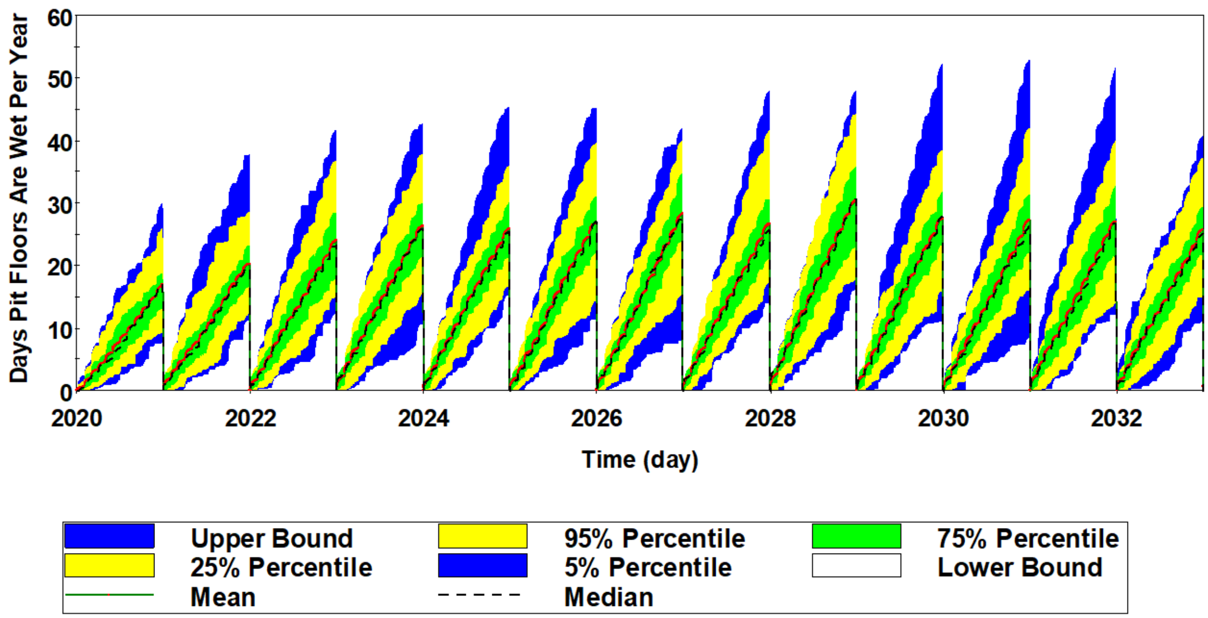


Figure 6.8 Days Pit Floor is Wet



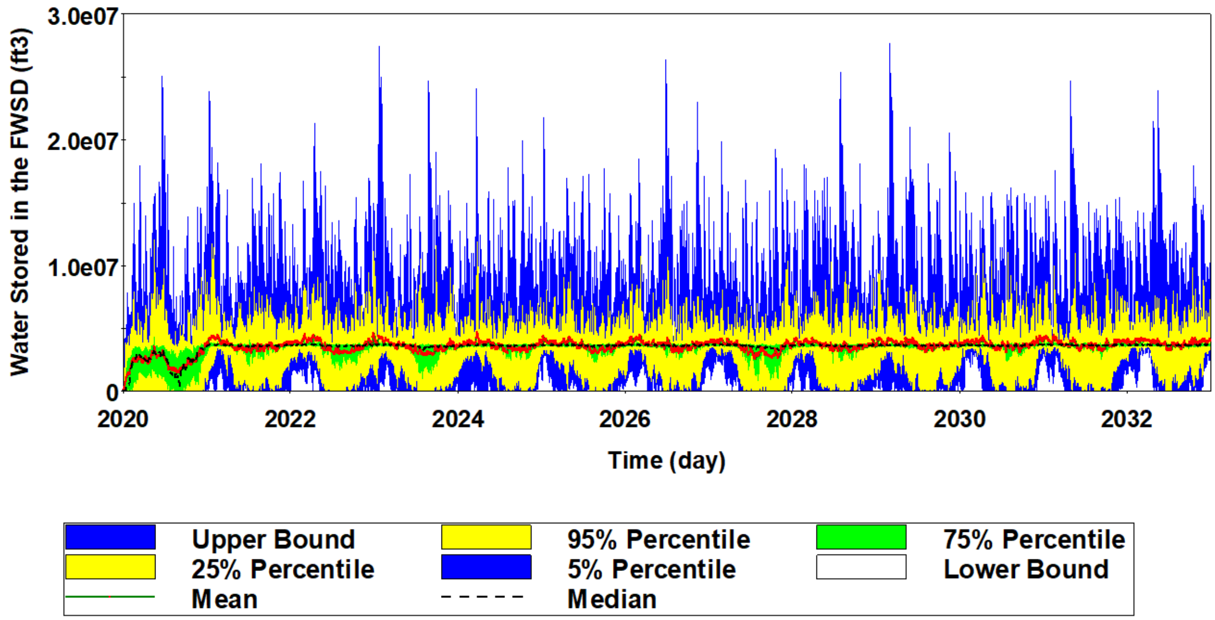
6.10. Fresh Water Storage Area

The amount of water stored in the FWSA was determined by the model. Inputs include direct precipitation, runoff from the upstream basin, pit depressurization water, effluent from the CWTP, and some retention of flow from Haile Gold Mine Creek. Outputs from the reservoir include evaporation, infiltration, Mill and mine demands for non-contact water, minimum flow releases (100 gpm) and other water releases.

The maximum amount of water stored in the FWSA was set at about 3.72 million cubic feet which equates to a water surface elevation of 470 feet. This value was taken from the facility's stage-storage capacity developed by NewFields. An initial Reservoir storage value of 100,000 cubic feet at the start of the model run on January 1, 2020 was assumed. Throughout operations, water in excess of the 3.72 million cubic feet was modeled to be released downstream of mine workings subject to a maximum assumed release rate of 34 cfs (15,200 gpm). This release rate is based on the hydraulics of the reservoir outlet piping system. **Figure 6.9** shows the amount of water stored in the FWSA as predicted by the model. The result does not limit storage to the freeboard elevation of 485 but rather illustrates total volumes above the controlled maximum release rate of 34 cfs.

As the figure indicates, it is expected to take a little over a year for the reservoir to fill. Once it initially fills, the reservoir is expected to remain at or near full throughout operations for most meteorological conditions. For the 95th percentile result, the maximum predicted storage volume is approximately 13 million cubic feet, which equates to a water surface elevation of approximately 479 feet or six feet below the spillway crest. At the spillway crest elevation of 485 feet, the reservoir can hold approximately 24.3 million cubic feet. Upper bound results are predicted to exceed this value only occasionally indicating that there is only slight change water will flow through the spillway. In extreme drought conditions results suggest there is the potential that the FWSA would empty.

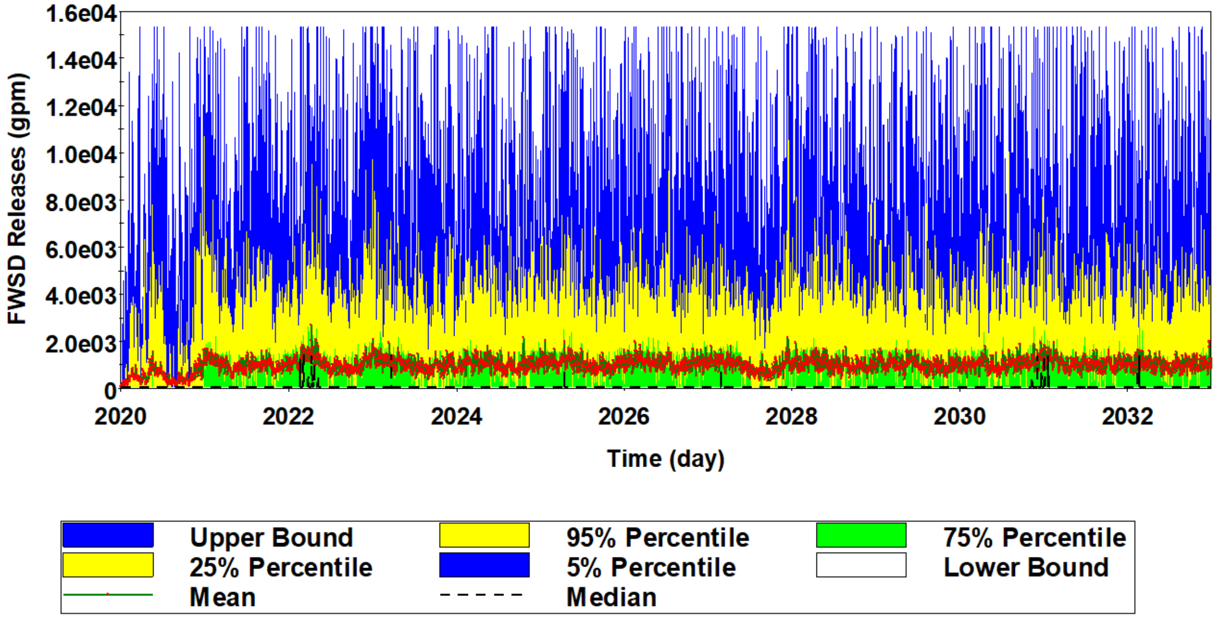
Figure 6.9 Predicted Fresh Water Storage Reservoir Contents



Excess water from the FWSA not needed at the mine will be released via outlet pipes that run through dam and along pit benches. Predicted release rates are presented on **Figure 6.10**. Minimum required releases of 100 gpm occur at all times, so this is the minimum amount released.

Figure 6.10 indicates that releases are predicted to range up to approximately 15,200 gpm (34 cfs) for upper bound results. Average releases are expected to range from approximately 200 gpm to 1,800 gpm.

Figure 6.10 Releases from the FWSA



7.0 Conclusions

The water balance model is an important tool to allow the mine to understand anticipated volumes of water generated, required, stored and treated over the life of mine operations. This report presents results of a probabilistic water balance that estimates water volumes from January 1, 2020 through December 31, 2032 based on a daily time scale. The following main conclusions can be drawn from the water balance.

- The TSF Reclaim Pond has adequate capacity to store all process and meteorological water predicted to occur for the full range of precipitation conditions. Free water volumes in the TSF Reclaim Pond are expected to show seasonal variability with more water stored in the cooler winter months when evaporation losses are less.
- The TSF Reclaim Pond will be a significant source of water for Mill water requirements. The maximum amount of reclaim that can be used at the Mill is 1,575 gpm. Mean results predict that reclaim is predicted to reach 1,575 gpm in winters and dip to approximately 1,200 gpm in the middle of summer. In wetter than average conditions, reclaim may stay at or near 1,575 gpm throughout the year. Only in extreme drought conditions is reclaim expected to drop below about 800 gpm.

- A significant amount of contact water will be produced from the PAG facilities, the pits and groundwater pumping (excluding pit depressurization pumping, which is considered non-contact water). Only minor amounts of contact water is required for operations, so much of this water will need to be stored, treated and released to the FWSA. A CWTP capacity of 2,000 gpm and 29 million gallons of storage at the 29 Pond are recommended. With these capacities excess contact water will still exist in the pits for about 20-25 days per year throughout operations for average precipitation conditions and up to approximately 50 days per year for extreme wet conditions.
- With the amount of non-contact water produced at the mine and the amount of water treatment occurring, a significant amount of water will be sent to the FWSA. After the FWSA initially fills, it is expected that it will remain at or near full throughout operations. Adequate water is always expected to meet the minimum required release of 100 gpm. After the FWSA initially fills, typical releases are expected to range from about 200 gpm to 1,800 gpm.

8.0 References

American Meteorological Society. 1959. Glossary of Meteorology. Huschke, Ralph E., ed. Boston, MA. 1959.

Ecological Resource Consultants, Inc. (ERC). 2018. Haile Surface Water Direct and Indirect Flow Impact Assessment Report. November 2018.

Ecological Resource Consultants, Inc. (ERC). 2012. Surface Water Existing Conditions Report, Haile Gold Mine, Lancaster County, South Carolina, June 22, 2012.

Maidment, David R. 1992. Handbook of Hydrology, McGraw-Hill, Inc., New York, NY.

NewFields. 2018. Haile Groundwater Modeling Summary Associated with Optimized Mine Plan. November 2018.