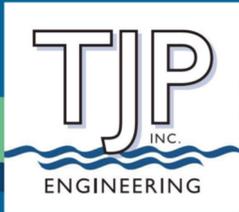


Appendix B

Life Support System Study



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NEW ZOO AT ELK GROVE LSS NARRATIVE

Approvals Phase – Part 1

March 31, 2023

SUMMARY

The New Zoo at Elk Grove will incorporate several aquatic exhibits requiring life support systems (LSSs). These systems will be designed to maintain suitable water quality for exhibit inhabitants and guest viewing situations. The LSS design criteria for each exhibit depends on the exhibit volume, pool configuration, environmental influences, food loadings, animal species and viewing arrangement.

Due to the scale and complexity of the project, the construction will be phased. The LSS design work has been organized in to Phase 1 Exhibits and Future Exhibits. Phasing beyond Phase 1 is indeterminate at this time.

To minimize water usage the LSS will integrate a campus wide freshwater recovery system. This system will collect and treat both LSS process water discharges and pool cleaning discharges. The process water discharges primarily consist of media filter backwash water. The cleaning water discharges include both pool drain down and pool vacuum.

PHASE 1 EXHIBITS

The Phase 1 exhibits include the following:

- Event/Lobby Aquarium
- Savanna Habitat
- Alligator
- Capybara
- Flamingo
- Gelada

Each of these exhibits is discussed in more detail below. A matrix summarizing the Phase 1 aquatic exhibits and their LSS design criteria is included in Attachment 1-1.

EVENT/LOBBY AQUARIUM

The Event/Lobby Aquarium contains approximately 1,000 gallons of freshwater and it will house a variety of small fish species. The associated LSS is a simple reservoir type aquarium process. Water will exit the exhibit through surface skimmers and flow to a reservoir containing fabric bag filters for particulate removal. Water will be pumped out of the reservoir and back to the deaeration tower through an ultraviolet sterilizer (UV) for disinfection. Water flows by gravity from the deaeration tower back to the exhibit. This exhibit will also have heating and chilling to maintain the appropriate water temperature.

As this is a fish exhibit all makeup water supplied to the tank will be dechlorinated potable water. The LSS will include activated carbon filters to pretreat the incoming water to remove chlorine and chloramine. It may be necessary to include a storage tank to all the incoming dechlorinated water to be tempered prior to adding to the exhibit. There are no process water discharges from this system, but there will be water lost when the tank is vacuumed or when the aquarist completed a partial water change. At this time we have assumed the vacuum or water change discharge will be directed to recovery; however, the practicality of this will depend on the final location of this exhibit and its associated system relative to the recovery area as this is a very small exhibit and the water losses are relatively small. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 3-1.

SAVANNA HABITAT WATER HOLES

The Savanna has three (3) watering holes that share the same LSS. The design intent is for these pools to look like a natural, healthy pond. These pools are each at different water levels. To prevent drain down between pools, water only exits the two higher pools through surface skimmers to flow to the lower water hole. Water exits the lower waterhole through sumps and skimmers and flows to a pump station wetwell with submersible pumps. The pumps transfer water to drum filters equipped with 30-micron mesh panels for mechanical filtration. The water exiting the drum filters flows through an UV to the upper two pools and to treatment wetlands associated with the pools. The pool water temperature will be ambient as the system has no heating or chilling. A bubble diagram of the process is presented in *Figure 1*.

The pools will be drained periodically for cleaning. The design intent is for one pool to be drained for cleaning at a time and the water from the drain down can be transferred to recovery. Refill water for the pool would be supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 3-2.

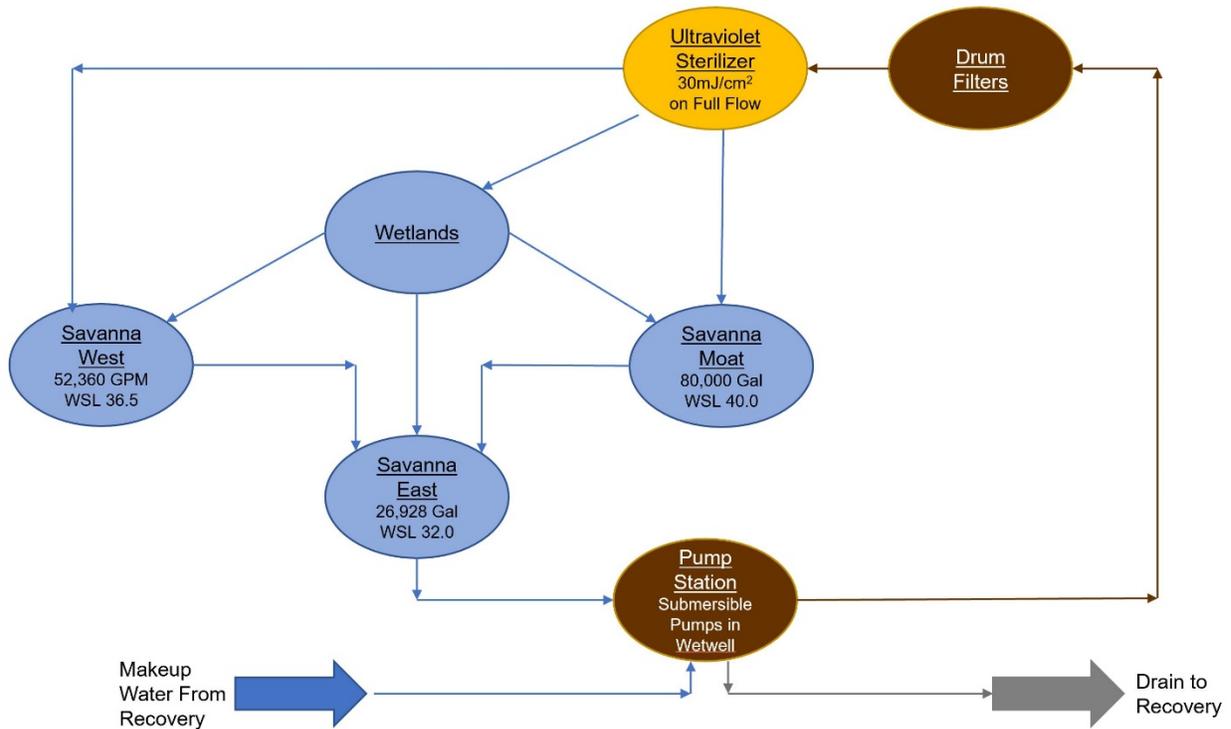


Figure 1: Savanna Water Hole LSS Bubble Diagram

ALLIGATOR

The Alligator Exhibit contains approximately 23,562 gallons and the guests view the water from above. The LSS is a traditional sand filter type system including sand filters, ultraviolet sterilization, chlorine addition for disinfection, and acid addition for pH control. The system also has heating to maintain 75 deg F water in the exhibit in winter. There is no chilling so summer water temperature will be ambient. A bubble diagram of the process is presented in Figure 2.

The pool is drained for cleaning and drain water is directed to recovery. Refill water for the pool is supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 3-3.

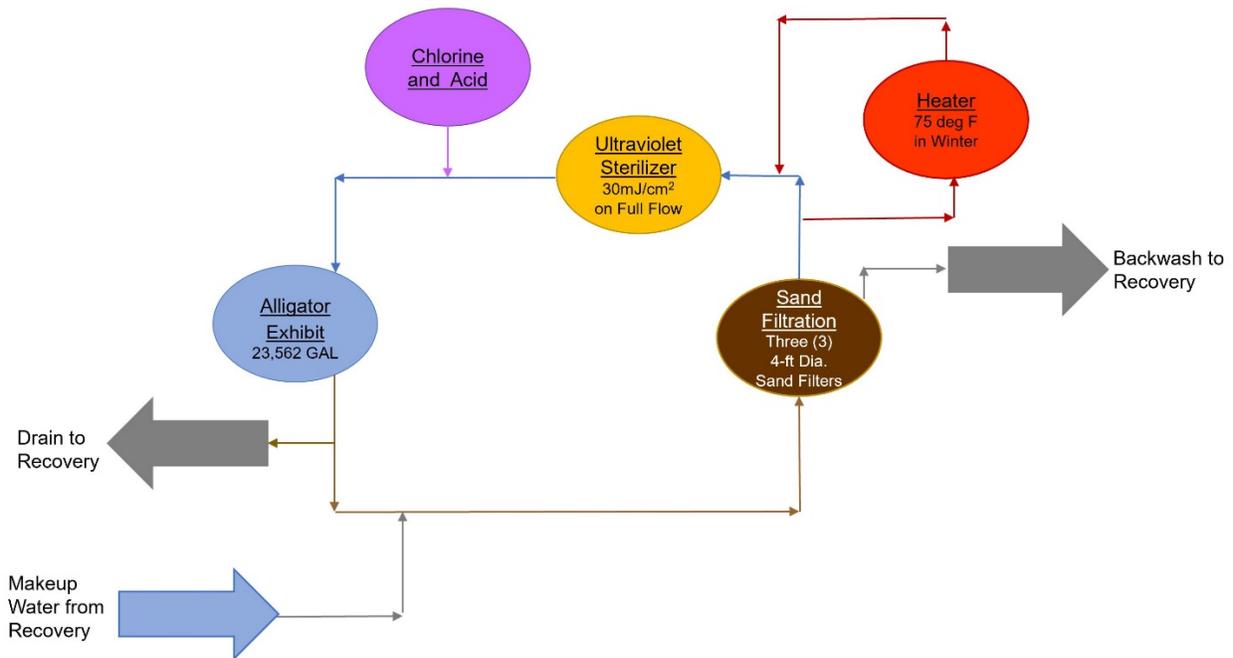


Figure 2: Alligator LSS Bubble Diagram

CAPYBARA

The Capybara Exhibit contains approximately 11,220 gallons and the guests view the water from above. The LSS is a traditional sand filter type system including sand filters, ultraviolet sterilization, chlorine addition for disinfection, and acid addition for pH control. The pool water temperature will be ambient as the system has no heating or chilling. A bubble diagram of the process is presented in Figure 3.

The pool is regularly drained for cleaning and drain water is directed to recovery. Refill water for the pool is supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 3-4.

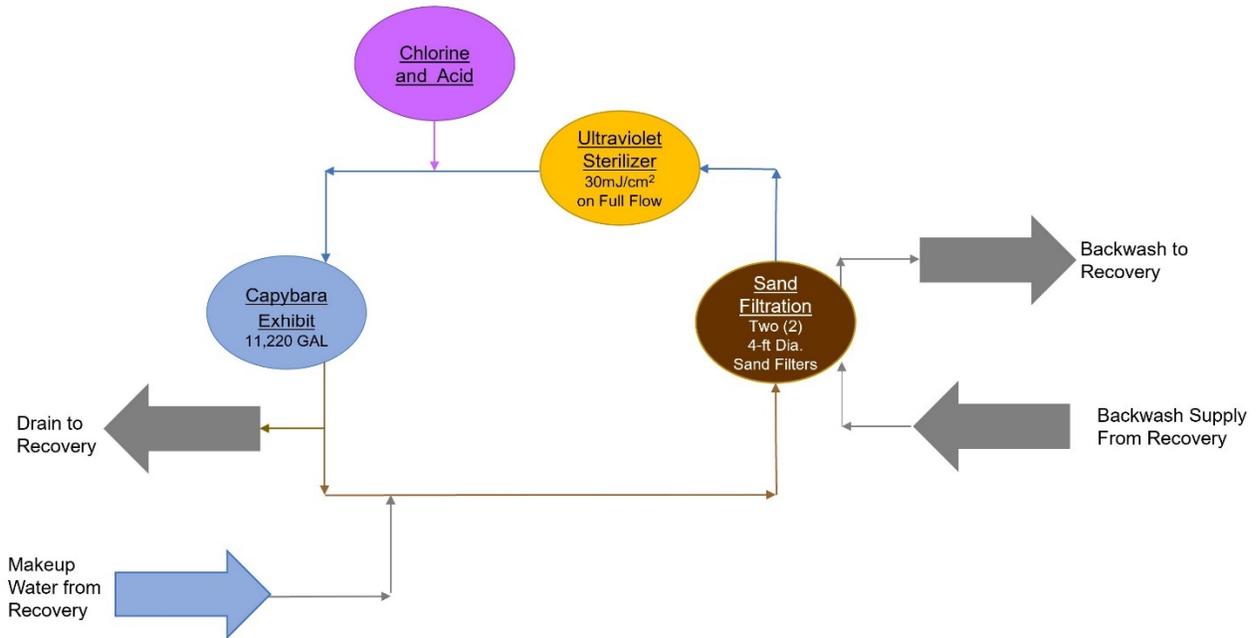


Figure 3: Capybara LSS Bubble Diagram

FLAMINGO

The Flamingo Exhibit contains approximately 35,000 gallons and the guests view the water from above. The LSS integrates a drum filter for an aggressive pool turnover and UV for disinfection. A portion of the drum filter discharge is processed through a sidestream polishing process including sand filters and ozone. The pool water temperature will be ambient as the system has no heating or chilling. A bubble diagram of the process is presented in Figure 4.

The pool is regularly drained for cleaning and drain water is directed to recovery. Refill water for the pool is supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 3-5.

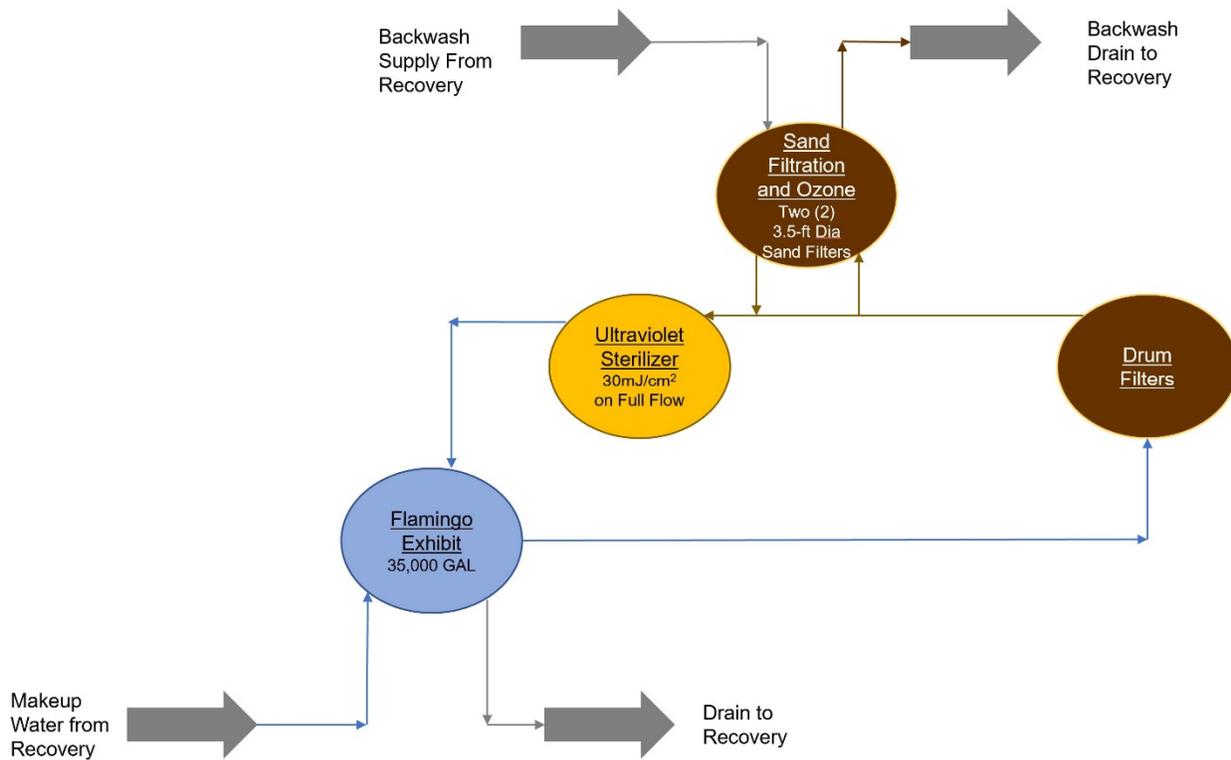


Figure 4: Flamingo LSS Bubble Diagram

GELADA

The Gelada has three (3) aquatic exhibits that share the same LSS. The design intent is for these pools to look like a natural, healthy pond. The LSS process is similar to Flamingo. The water from the pools circulates through drum filters and UVs. A portion of the drum filtered water is further polished through sand filters. The pool water temperature will be ambient as the system has no heating or chilling. A bubble diagram of the process is presented in Figure 5.

The pools will be drained periodically for cleaning. The design intent is for one pool to be drained for cleaning at a time and the water from the drain down can be transferred to recovery. Refill water for the pool would be supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 3-6.

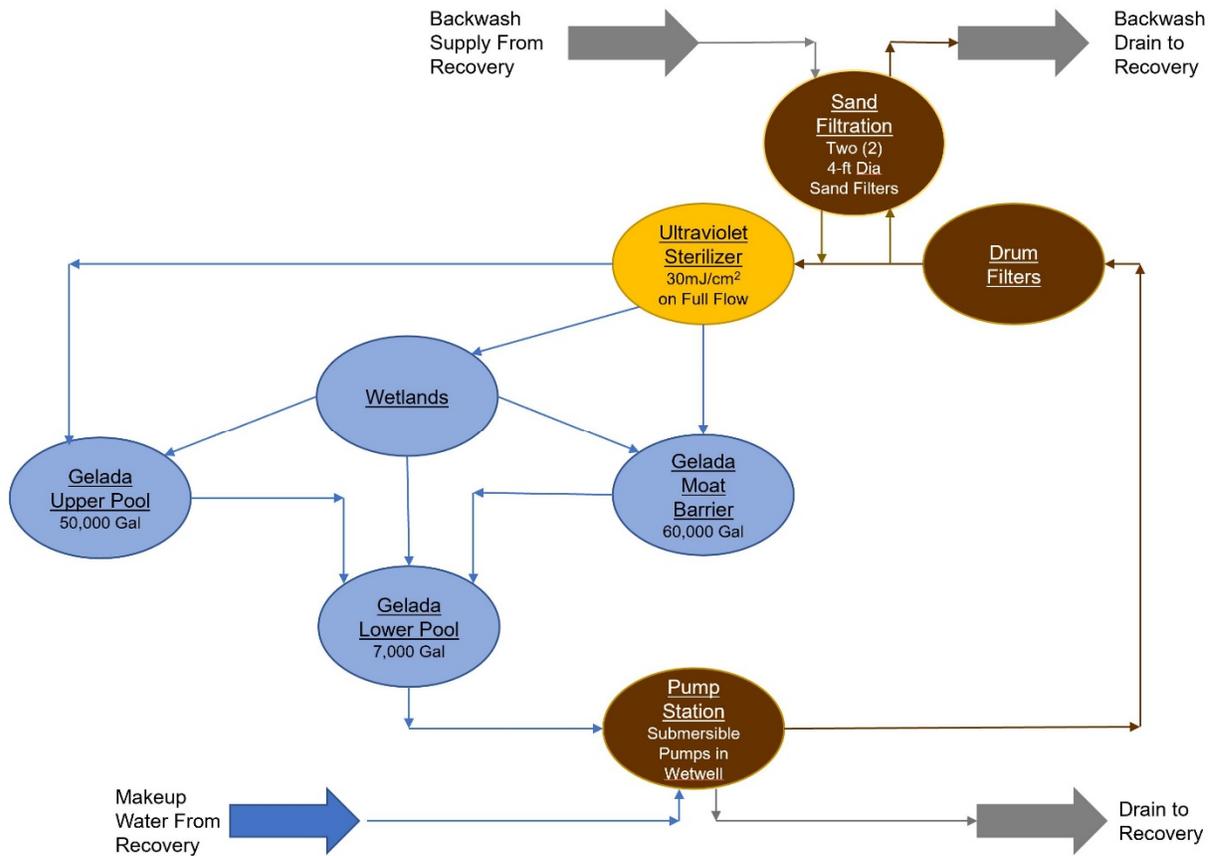


Figure 5: Gelada LSS Bubble Diagram

FUTURE EXHIBITS

The future exhibits include the following:

- Hippo
- Wild Dog
- Beaver
- Eagle and Fish
- Elk Meadow
- Grizzly Bear
- Otters
- Sturgeon
- Turtles, Rainbow Fish, and Archer Fish
- Babirusa

- Orangutan Forest/Asian Small Clawed Otter
- Tiger Forest

Each of these exhibits is discussed in more detail below. A matrix summarizing the future aquatic exhibits and their LSS design criteria is included in Attachment 1-2.

HIPPO

The Hippo LSS serves multiple pools: Hippo Springs, Hippo River, and three (3) back of house holding pools. The combined volume for these pools is approximately 190,600 gallons. The only exhibit with underwater viewing is Hippo Springs and none of the pools will support fish. The system approach is to provide premium, polished water to the exhibit with underwater viewing only and to provide screened water to the pools with no underwater viewing. The water exiting the Hippo Springs pool with underwater viewing will flow into the Hippo River with look down viewing. All of the water discharged from Hippo River and the Holding Pools is pumps to drum screens. The discharge from the drum screens passes through UVs. A portion of the UV discharge is further polished though sand filters, ozone, and a deaeration tower to supply Hippo Springs. The rest of the discharge from the UVs flows to Hippo River and the Holding Pools. The pool will be heated to maintain the water temperature at 70 to 75 deg F through winter. There is no chilling and in the summer pool water temperature will be ambient. A bubble diagram of the process is presented in Figure 6.

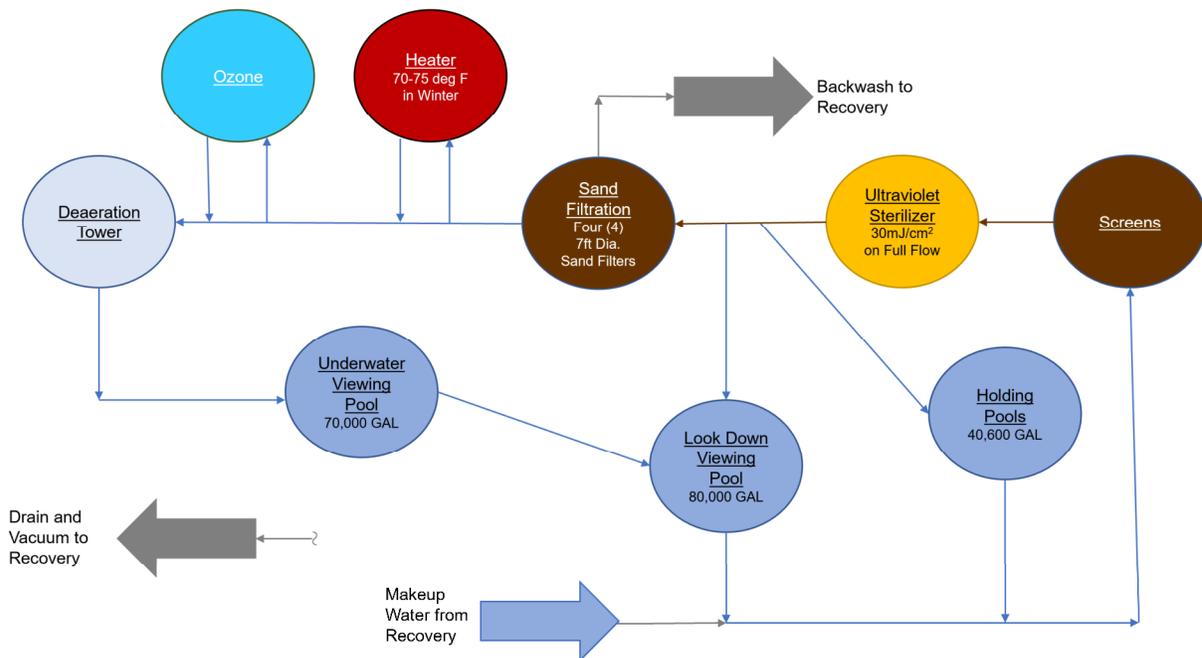


Figure 6: Hippo LSS Bubble Diagram

The pool with underwater viewing will be vacuumed regularly to remove settled solids. The other pools will be drained periodically for cleaning. The design intent is for one pool to be drained for cleaning at a time and the water from the drain down can be transferred to recovery. Refill water

for the pools would be supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-1.

WILD DOG

The Wild Dog Exhibit contains approximately 12,000 gallons and the guests view the water from above. The LSS is a traditional sand filter type system including sand filters, chlorine addition for disinfection, and acid addition for pH control. The pool is drained for cleaning and drain water is directed to recovery. Refill water for the pool is supplied from recovery. The exhibit filters will backwash with recovery water and the backwash drain will discharge to recovery. The pool water temperature will be ambient as the system has no heating or chilling. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-2.

BEAVER

The Beaver Exhibit contains approximately 20,000 gallons and the guests view the water from above and below. The LSS is a traditional sand filter type system including sand filters, ozone, and ultraviolet sterilization. The exhibit filters will backwash with recovery water and the backwash drain will discharge to recovery. The pool is drained for cleaning and drain water is directed to recovery. Refill water for the pool is supplied from recovery. The pool water temperature will be ambient as the system has no heating or chilling. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-3.

EAGLE AND FISH

The Eagle and Fish Exhibit contains approximately 19,000 gallons and the guests view the water from above and below. The LSS is a traditional sand filter type system including sand filters, heating, chilling, ultraviolet sterilization, and provisions for gas exchange. The pool is vacuumed for cleaning and vacuum water is directed to recovery. The exhibit filters will backwash with recovery water and the backwash drain will discharge to recovery. As the exhibit contains fish all makeup water will be dechlorinated potable water. The LSS is equipped with an activated carbon filter to remove chlorine and chloramine from the incoming potable water. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-4.

ELK MEADOW

The Elk Meadow Pool is intended to look like a natural, healthy pond. The LSS process is similar to the Savanna LSS. The water from the pool circulates through drum filters and UVs. A portion of the discharge from the UVs is directed treatment wetlands, and the balance flows directly to the pool. The pool water temperature will be ambient as the system has no heating or chilling. The pool will be drained periodically for cleaning. The design intent is for the water from the drain down to transferred to recovery. Refill water for the pool would be supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-5.

GRIZZLY BEAR

The Grizzly Bear Exhibit contains approximately 67,000 gallons and the guests view the water from above and below. The LSS is a traditional sand filter type system including sand filters, ozone, chlorine addition, and ultraviolet sterilization. The pool water temperature will be ambient as the system has no heating or chilling. The exhibit filters backwash to recovery. The pool is drained for cleaning and drain water is directed to recovery. Refill water for the pool is supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-6.

OTTER

The Otter Exhibit contains approximately 35,000 gallons and the guests view the water from above and below. The LSS is a traditional sand filter type system including sand filters, ozone, and ultraviolet sterilization. The pool water temperature will be ambient as the system has no heating or chilling. The exhibit filters backwash to recovery. The pool is drained for cleaning and drain water is directed to recovery. Refill water for the pool is supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-7.

STURGEON

The Sturgeon contains approximately 24,000 gallons and the guests view the water from above and below. The LSS is a traditional sand filter type system including sand filters, chilling, heating, ultraviolet sterilization, and provisions for gas exchange. The pool is vacuumed for cleaning and vacuum discharge water is directed to recovery. The exhibit filters backwash with recovery water and the backwash drain will discharge to recovery. As the exhibit contains fish all makeup water will be dechlorinated potable water. The LSS is equipped with an activated carbon filter to remove chlorine and chloramine from the incoming potable water. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-8.

TURTLE, RAINBOW FISH, AND ARCHER FISH

The Turtle, Rainbow Fish, and Archer Fish contains approximately 6,000 gallons and the guests view the water from above and below. The LSS is a traditional sand filter type system including sand filters, heating, chilling, ultraviolet sterilization, and provisions for gas exchange. The pool is vacuumed for cleaning and vacuum discharge water is directed to recovery. The exhibit filters backwash with recovery water and the backwash drain will discharge to recovery. As the exhibit contains fish all makeup water will be dechlorinated potable water. The LSS is equipped with an activated carbon filter to remove chlorine and chloramine from the incoming potable water. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-9.

BABIRUSA

The Babirusa Pool is intended to look like a natural, healthy pond. The LSS process is similar to the Savanna and Elk Meadow LSSs. The water from the pool circulates through drum filters and UVs. A portion of the discharge from the UVs is directed treatment wetlands, and the balance flows directly to the pool. The pool water temperature will be ambient as the system has no heating or chilling. The pool will be drained periodically for cleaning. The design intent is for the water from

the drain down to transferred to recovery. Refill water for the pool would be supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-10.

ORANGUTAN FOREST/ASIAN SMALL CLAWED OTTER (ASCO)

The Orangutan Forest/ASCO contains approximately 24,000 gallons and the guests view the water from above and below. The LSS is a traditional sand filter type system including sand filters, ozone, and ultraviolet sterilization. The pool water temperature will be ambient as the system has no heating or chilling. The exhibit filters backwash to recovery. The pool is drained for cleaning and drain water is directed to recovery. Refill water for the pool is supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-11.

TIGER FOREST

The Tiger Forest Exhibit contains approximately 15,000 gallons and the guests view the water from above and below. The LSS is a traditional sand filter type system including sand filters, chlorine, and ultraviolet sterilization. The pool water temperature will be ambient as the system has no heating or chilling. The exhibit filters will backwash with recovery water and the backwash drain will discharge to recovery. The pool is drained for cleaning and drain water is directed to recovery. Refill water for the pool is supplied from recovery. The annual water usage and exchange with the recovery system for this LSS is summarized in Attachment 4-12.

RECOVERY SYSTEM

Historically LSS process water use and pool cleaning water use have accounted for a significant portion of total water use at many existing zoos. In an effort to address sustainability goals and respectfully utilize a limited resource in California the new Zoo will integrate a campus wide recovery system to capture, treat, and redistribute this water. The LSS recovery system will collect the following wastewater sources:

- Exhibit LSS media filter backwash water
- Pool vacuum discharge
- Pool drain down when a pool is dumped for cleaning

For pool drain down we have assumed that only the water removed from the pool prior to cleaning will go to LSS recovery. The pool washdown from cleaning activities after drain down will go to sewer.

LSS wastewater from the sources identified above is collected onsite and transferred to a dirty collection tank located near the Flamingo exhibit. Water exits the dirty collection tank and flows through drum filters and UVs to the wetlands treatment cells. The drum filters remove particulate larger than 30 microns. The wetlands remove finer particulate and dissolved organic material, and they remove nutrients. The wetlands can also provide extra short term water storage for processing a large pool drain down or capturing rainwater. Flooding a 10,000 square foot

wetlands with 1 foot of water above the top of soil will store approximately 75,000 gallons for a short period of time.

Water exiting the wetlands cells is captured in storage tanks where it is polished utilizes pressure media filters with glass media. The water is also ozonated, chlorinated, and passed through an UV for disinfection. The finished product water is circulated through the campus to be used for LSS makeup water and as a filter backwashing source for some exhibit LSS. A graphic presenting the recovery process is provided in Attachment 2-1.

Once the entire Zoo is built the recovery system will process approximately 113,000 gallons per day on average. On a peak day when one of the large pools is drained for cleaning the system would process closer to 200,000 gallons. Utilizing this process is expected to reduce LSS related water use to 10,000 to 20,000 gallons per day. This represents an 80 to 90% reduction in water use associated with LSS. This estimate does not account for evaporative losses.

The recovery system could be built with Phase 1 and then expanded as additional areas of the Zoo are constructed, or construction of recovery could be deferred until the next phase of construction. As the Hippo facility will be the most impactful on site LSS water use, the recovery system should be online before the Hippo exhibit is completed. If construction of the recovery system is deferred, the site piping to integrate the Phase 1 exhibits on the system must be constructed with Phase 1. This is the piping to transfer the LSS wastewater to recovery and clean recovered water to the exhibit. The water use in Phase 1 with no recovery system in place is expected to be approximately 20,000 gallons per day on average.

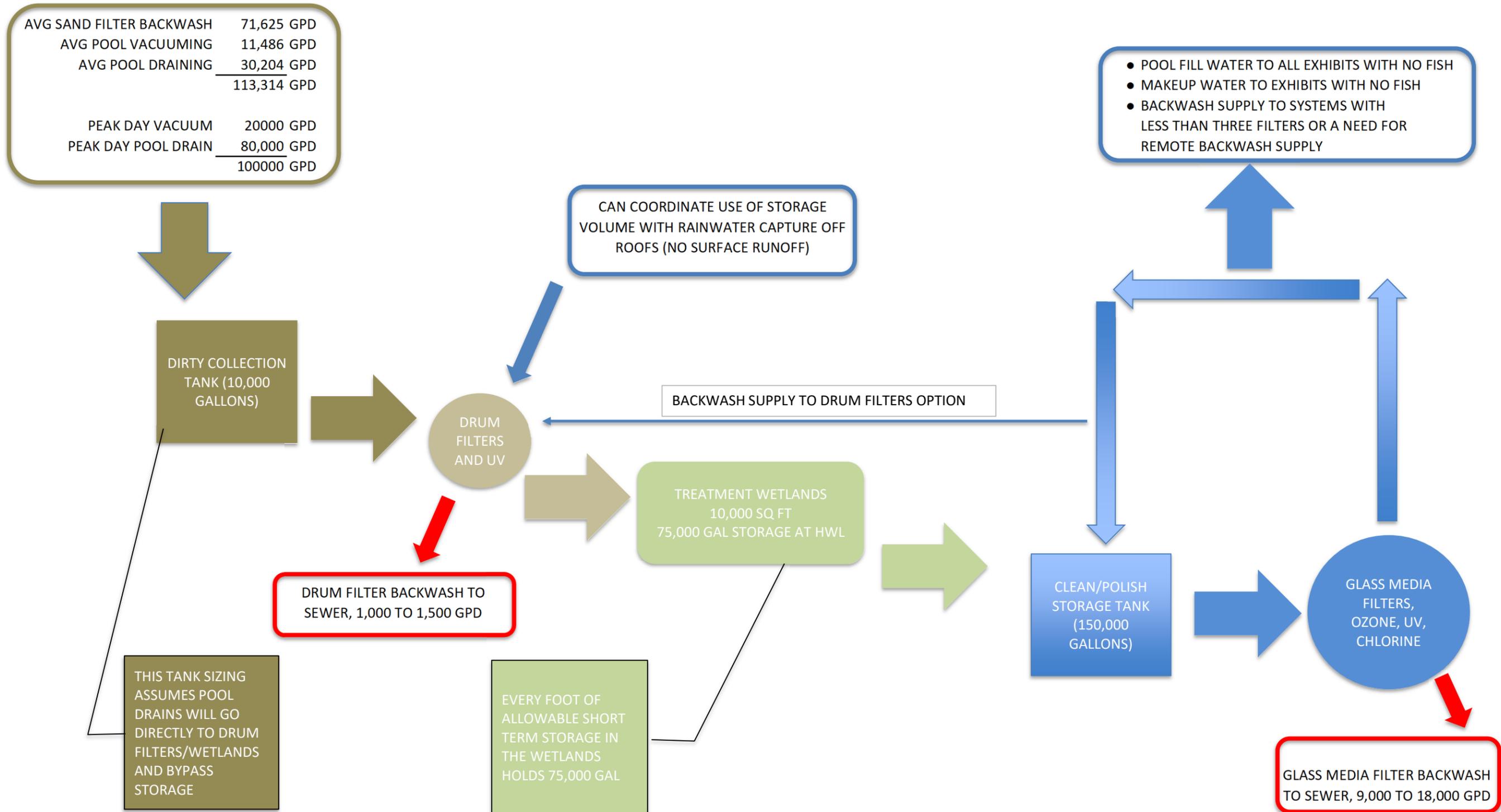
PHASE 1 EXHIBITS LSS DESIGN CRITERIA

EXHIBIT	VOLUME (GAL)	VIEWING	POOL WATER TEMP (°F)	LOCATION	SYSTEM TYPE	MAKEUP WATER SOURCH	UV STERILIZER	CHEMICAL DISINFECTION	OZONE	DEAERATION
EVENT/LOBBY AQUARIUM	1000	UNDERWATER	70 TO 75 DEG F (CHILLING AND HEATING)	INDOOR	RESERVOIR TYPE FISH SYSTEM	DECHLORINATED POTABLE WATER	Y	N	N	Y
SAVANNA HABITATS	159288	LOOK DOWN	AMBIENT	OUTDOOR	DRUM FILTERS WITH WETLANDS	RECOVERED WATER	Y	N	N	N
SAVANNA WEST WATER HOLE	52360									
SAVANNA EAST WATER HOLE	26928									
SAVANNA MOAT	80000									
ALLIGATOR	23562	LOOK DOWN	75 DEG IN WINTER (HEATING ONLY), AMBIENT IN SUMMER	OUTDOOR	MEDIA FILTER SYSTEM	RECOVERED WATER	Y	Y	N	N
CAPYBARA	11220	LOOK DOWN	AMBIENT	OUTDOOR	MEDIA FILTER SYSTEM	RECOVERED WATER	Y	Y	N	N
FLAMINGO	35000	LOOK DOWN	AMBIENT	OUTDOOR	DRUM FILTER WITH POLISH/OZONE	RECOVERED WATER	Y	N	Y	N
GELADA	117000	LOOK DOWN	AMBIENT	OUTDOOR	DRUM FILTER WITH WETLANDS/POLISH	RECOVERED WATER	Y	Y	N	N
GELADA MOAT BARRIER	60000									
GELADA UPPER POOL	50000									
GELADA LOWER POOL	7000									

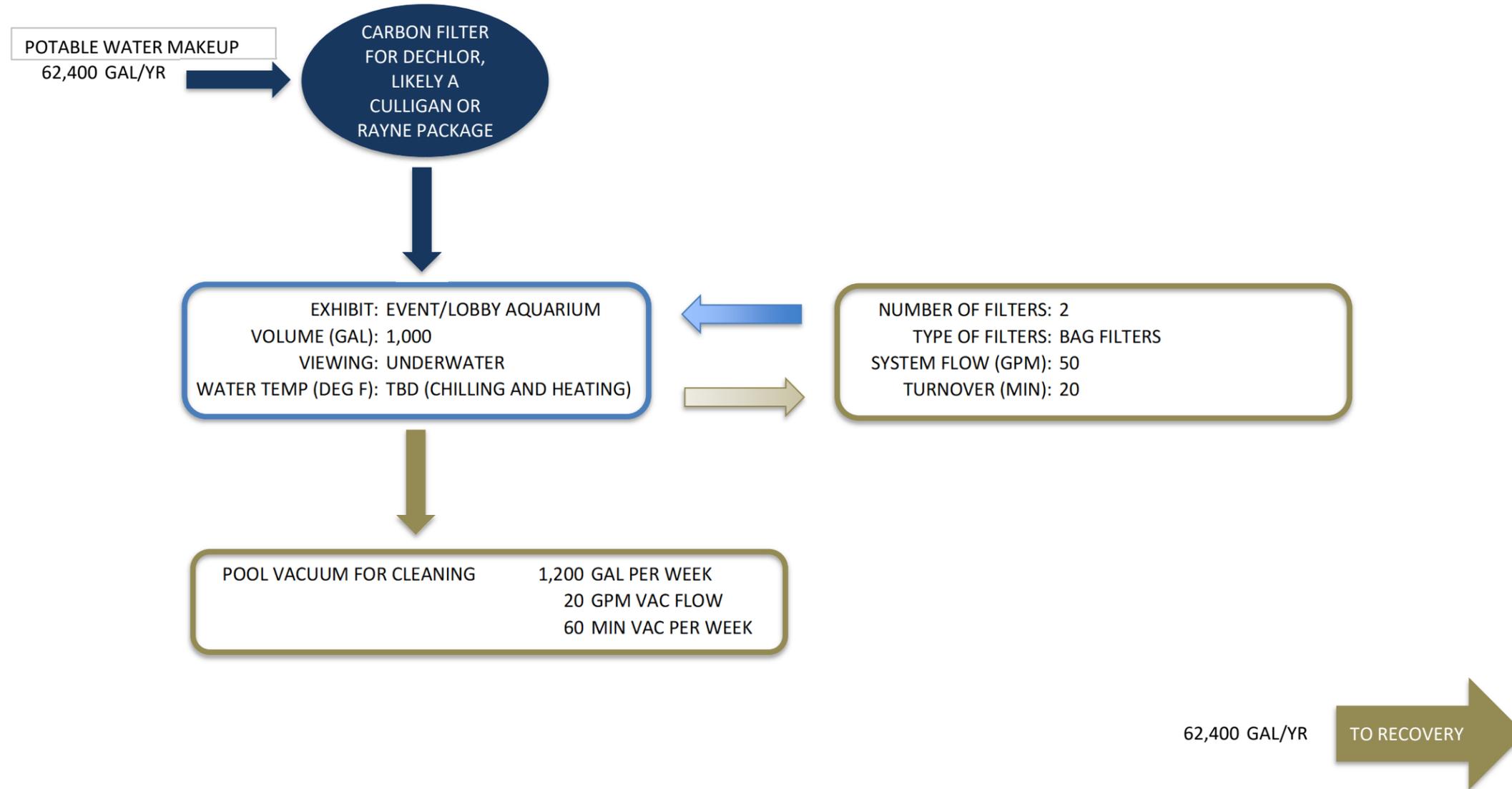
FUTURE EXHIBITS LSS DESIGN CRITERIA

EXHIBIT	VOLUME (GAL)	VIEWING	POOL WATER TEMP (°F)	LOCATION	SYSTEM TYPE	MAKEUP WATER SOURCE	UV STERILIZER	CHEMICAL DISINFECTION	OZONE	DEAERATION
HIPPO EXHIBITS AND HOLDING	190600	UNDERWATER AND LOOK DOWN	70 TO 75 DEG IN WINTER (HEATING ONLY), AMBIENT IN SUMMER	OUTDOOR	SCREENS WITH POLISH FILTER/OZONE	RECOVERED WATER	Y	N	Y	Y
HIPPO SPRINGS	70000	UNDERWATER								
HIPPO RIVER	80000	LOOK DOWN								
HOLDING 1	15300	NONE								
HOLDING 2	15300	NONE								
YARD POOL	10000	NONE								
WILD DOG	12000	LOOK DOWN	AMBIENT	OUTDOOR	MEDIA FILTER SYSTEM	RECOVERED WATER	N	Y	N	N
BEAVER	20000	UNDERWATER	AMBIENT	OUTDOOR	MEDIA FILTER SYSTEM	RECOVERED WATER	Y	N	Y	N
EAGLE AND FISH	19000	UNDERWATER	55 TO 60 DEG F (CHILLING AND HEATING)	OUTDOOR	MEDIA FILTER SYSTEM	RECOVERED WATER	Y	N	N	Y
ELK MEADOW	60000	LOOK DOWN	AMBIENT	OUTDOOR	DRUM FILTERS WITH WETLANDS	RECOVERED WATER	Y	N	N	N
GRIZZLY BEAR	67000	UNDERWATER	AMBIENT	OUTDOOR	MEDIA FILTER SYSTEM	RECOVERED WATER	Y	Y	Y	N
OTTERS	35000	UNDERWATER	AMBIENT	OUTDOOR	MEDIA FILTER SYSTEM	RECOVERED WATER	Y	N	Y	N
STURGEON	24000	UNDERWATER	60 TO 70 DEG F (CHILLING AND HEATING)	OUTDOOR	MEDIA FILTER SYSTEM	RECOVERED WATER	Y	N	N	Y
TURTLES, RAINBOW FISH, AND ARCHER FISH	6000	UNDERWATER	75 TO 80 DEG F (CHILLING AND HEATING)	INDOOR?	MEDIA FILTER SYSTEM	RECOVERED WATER	Y	N	N	Y
BABIRUSA	300000	LOOK DOWN	AMBIENT	OUTDOOR	DRUM FILTER WITH WETLANDS/POLISH	RECOVERED WATER	Y	N	N	N
ORANGUTAN FOREST/ASCO	24000	UNDERWATER	AMBIENT	OUTDOOR	MEDIA FILTER SYSTEM	RECOVERED WATER	Y	N	Y	N
TIGER FOREST	15000	UNDERWATER	AMBIENT	OUTDOOR	MEDIA FILTER SYSTEM	RECOVERED WATER	Y	Y	N	N

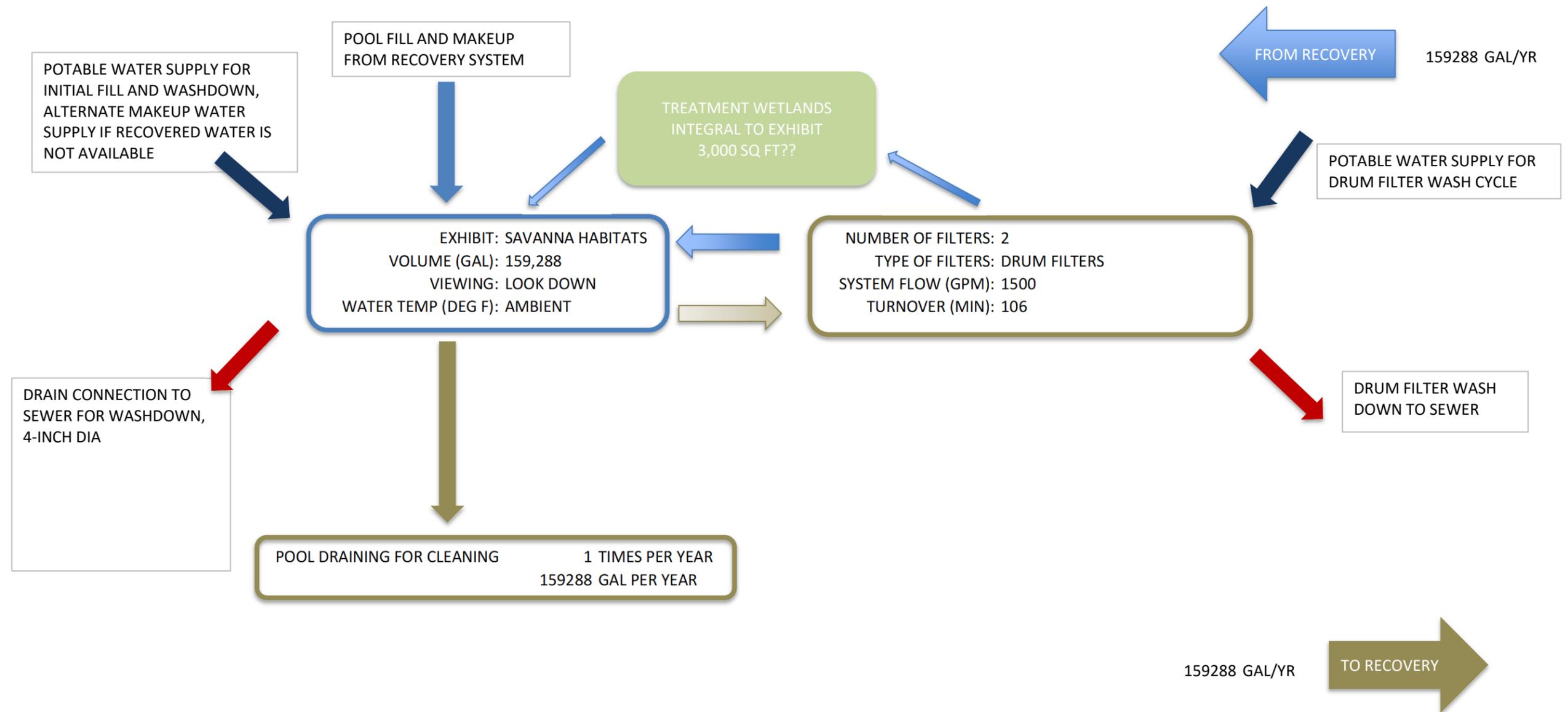
RECOVERY SYSTEM DIAGRAM



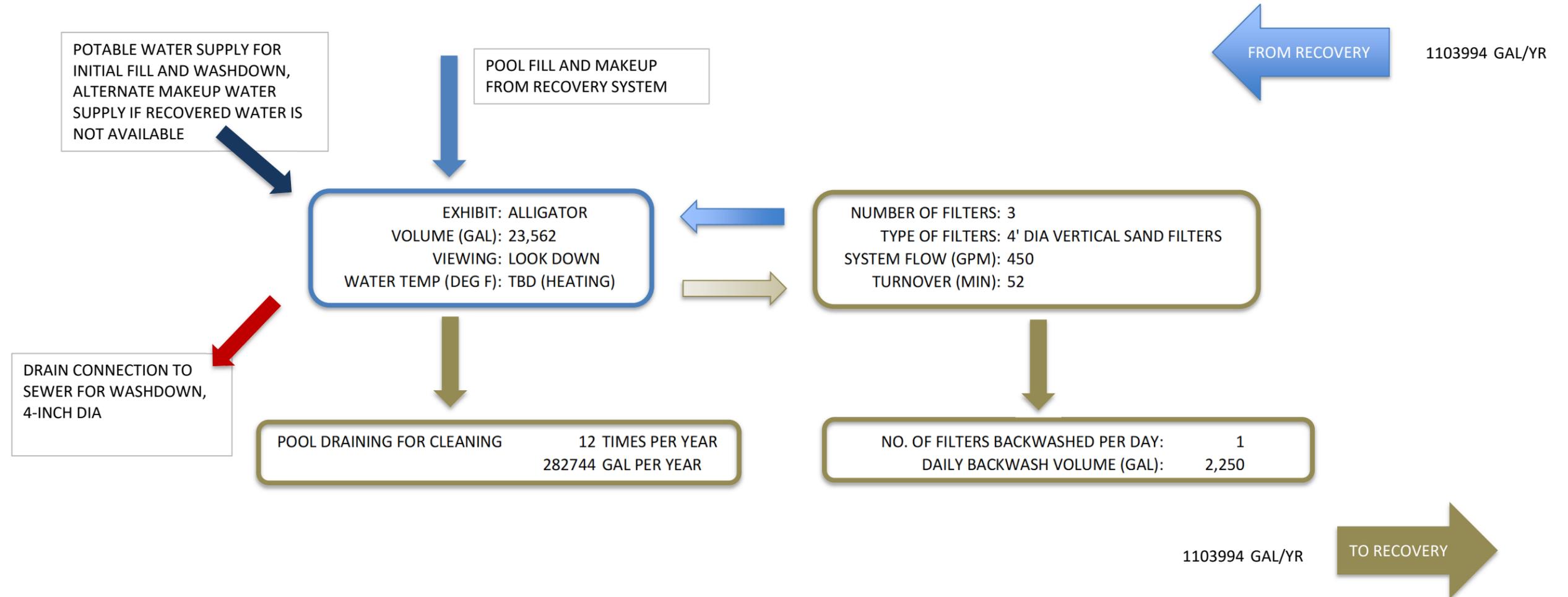
EVENT/LOBBY AQUARIUM



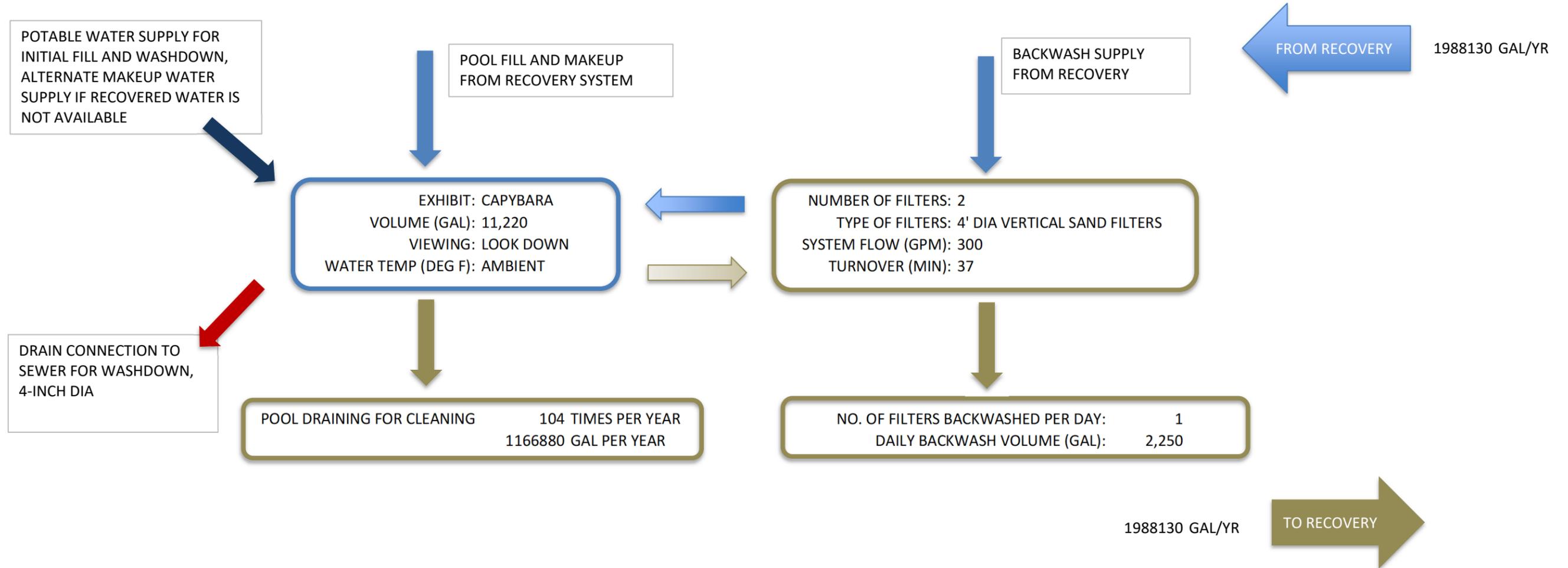
SAVANNA HABITATS



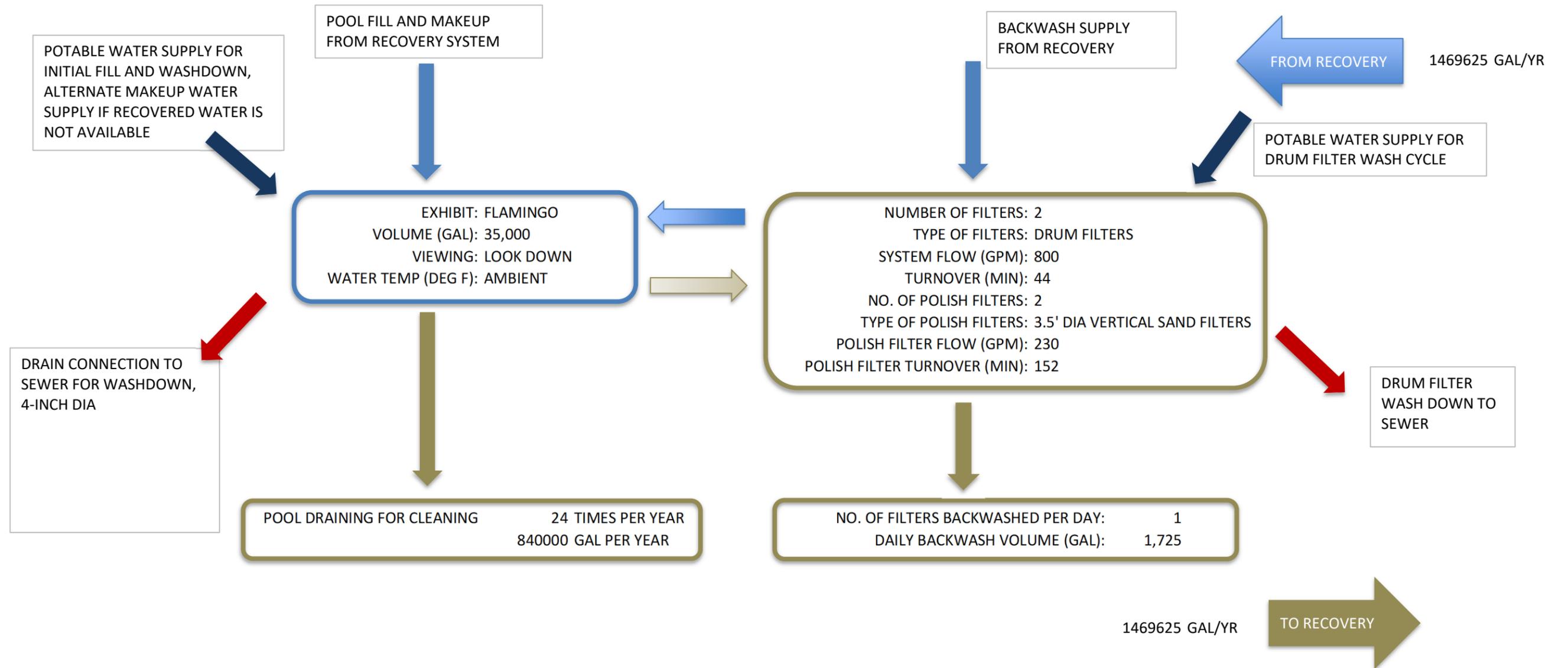
ALLIGATOR



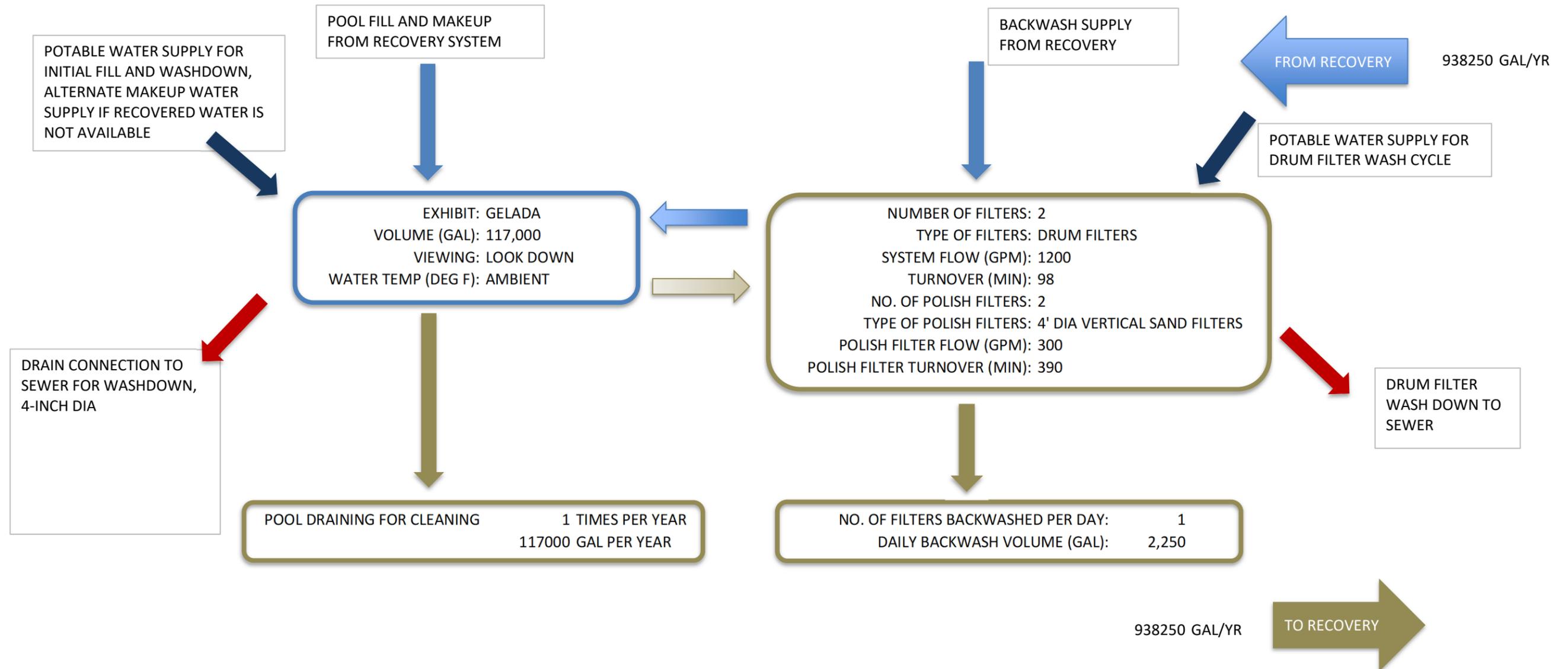
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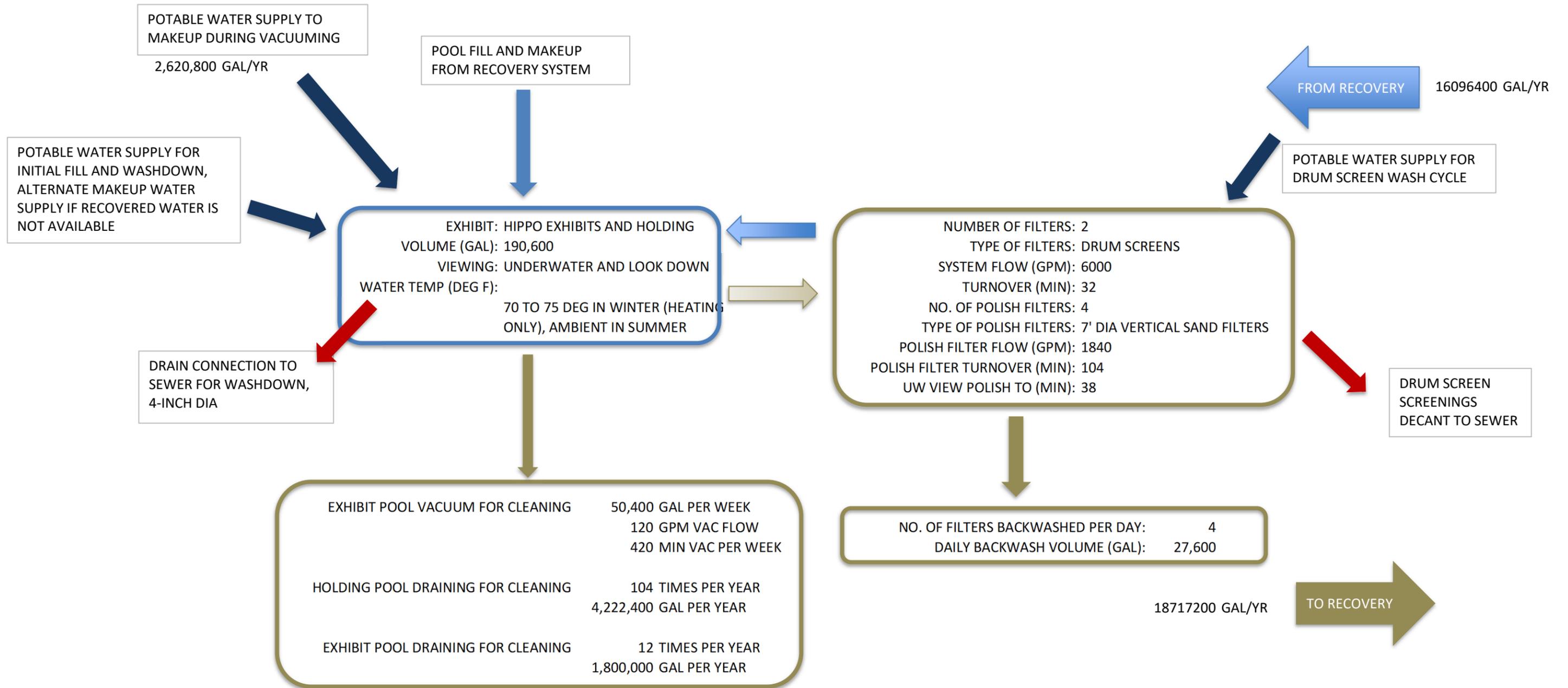
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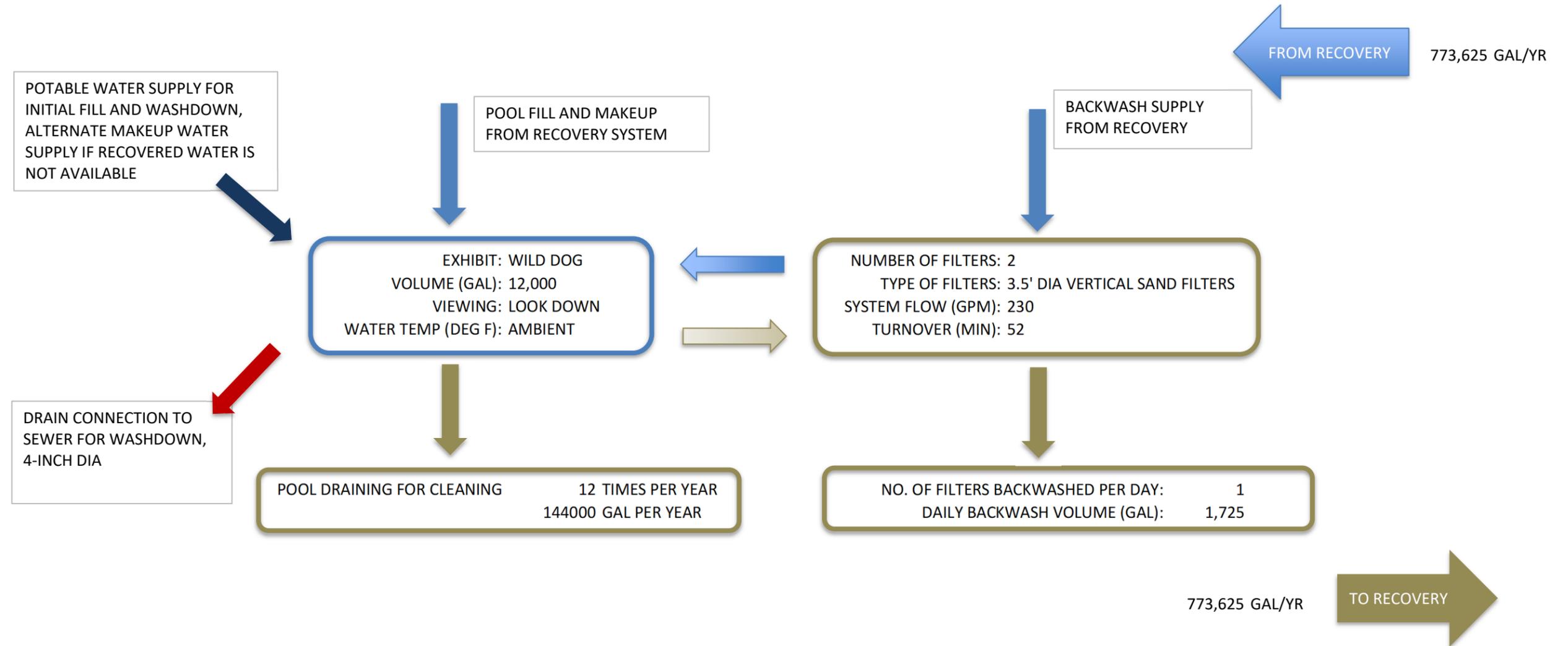
GELADA



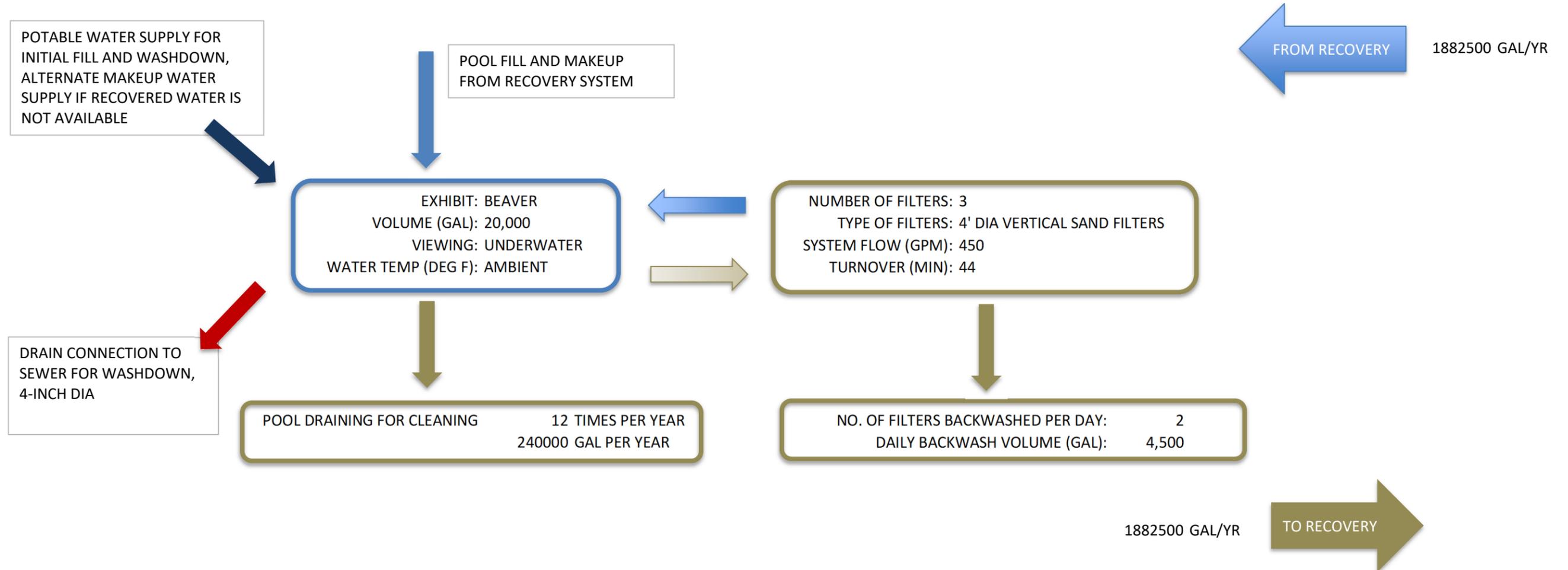
HIPPO EXHIBITS AND HOLDING



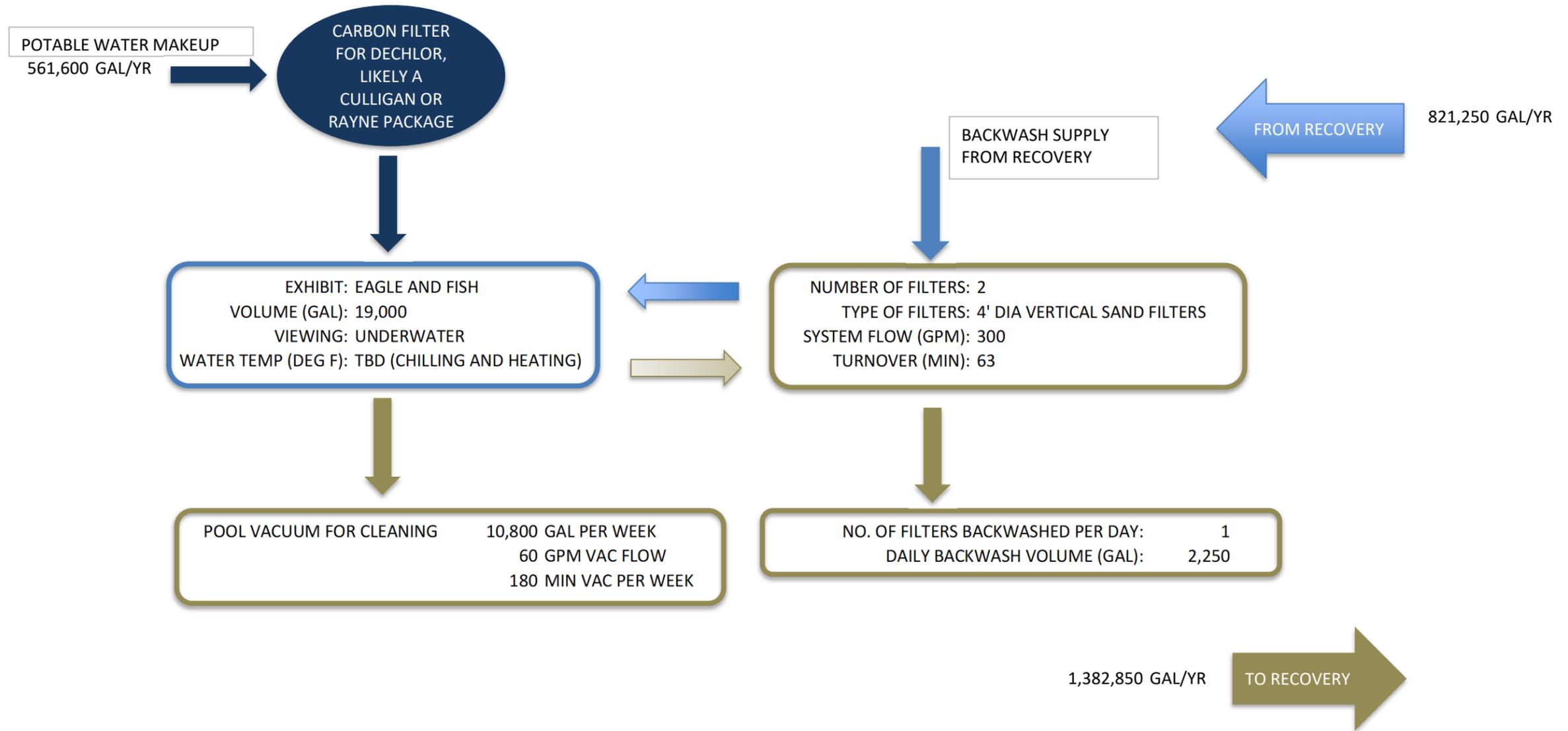
WILD DOG



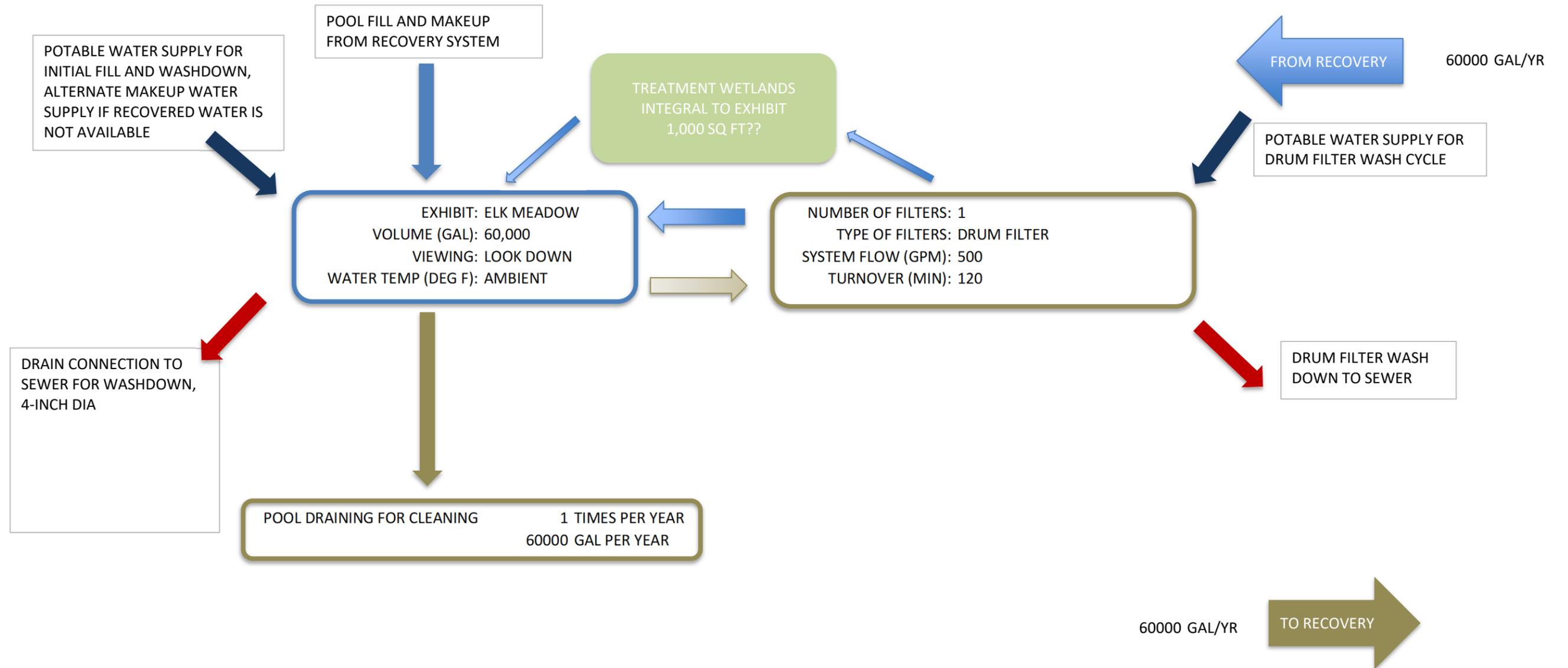
BEAVER



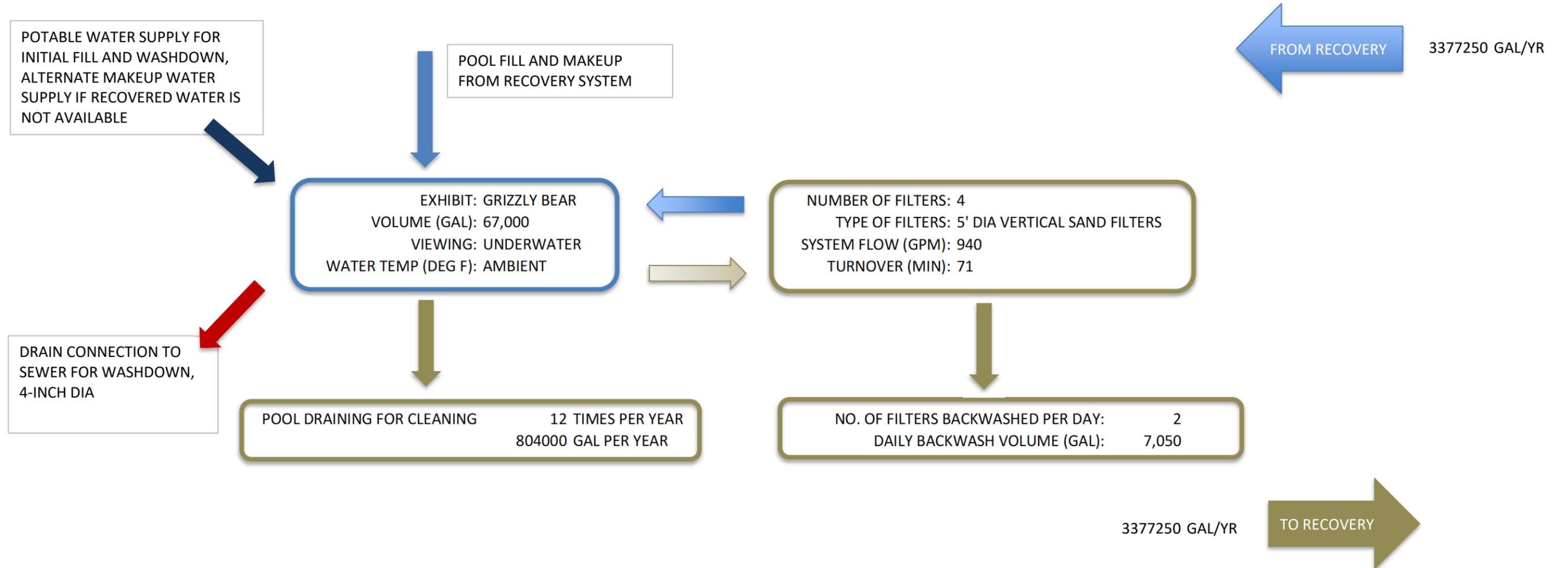
EAGLE AND FISH



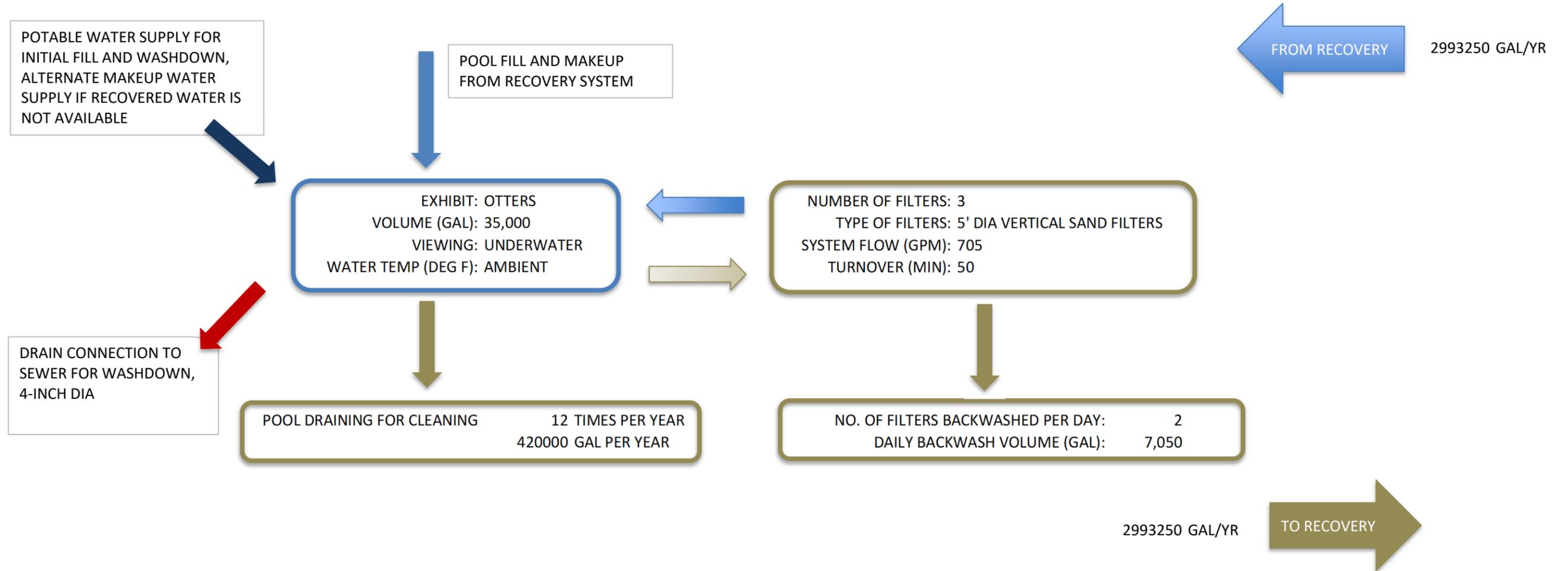
ELK MEADOW



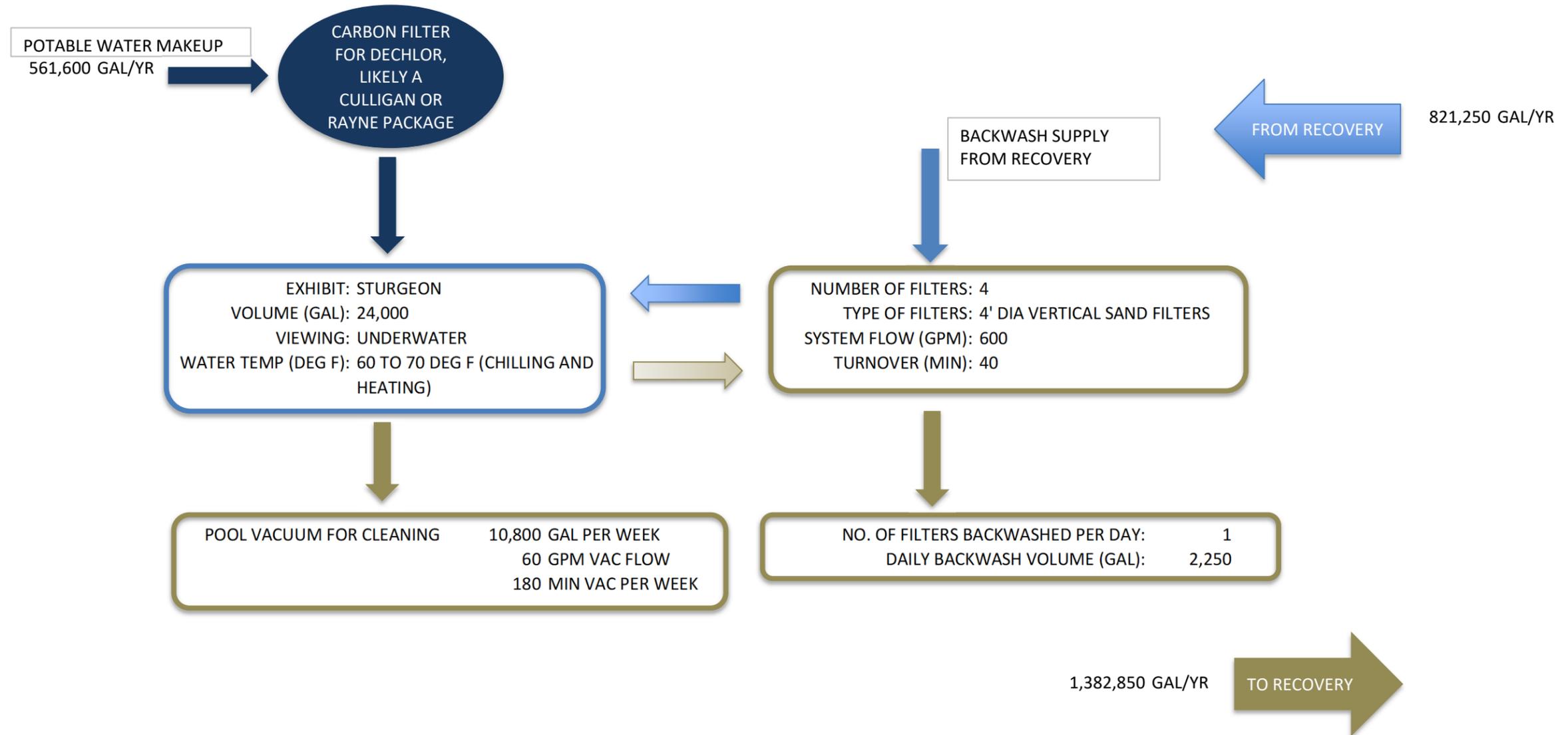
GRIZZLY BEAR



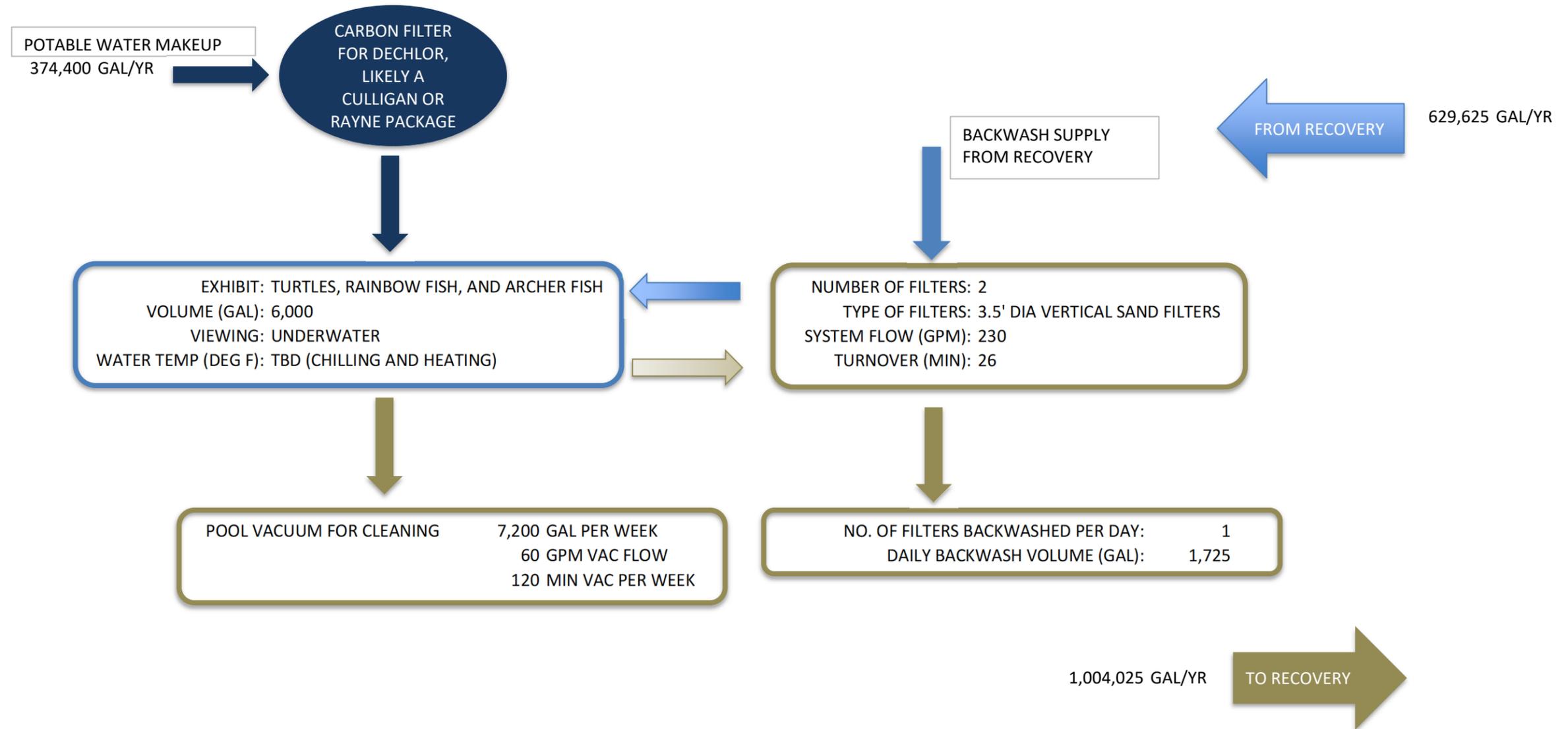
OTTERS



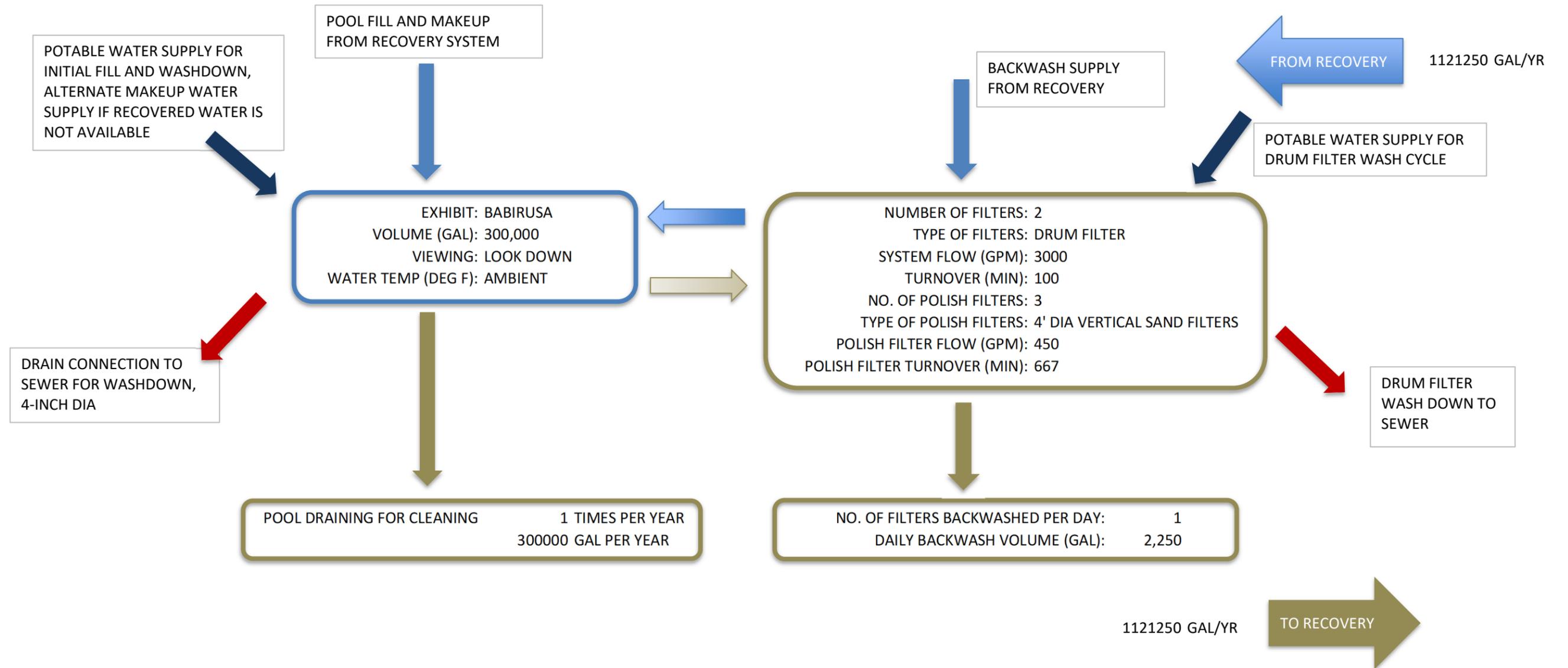
STURGEON



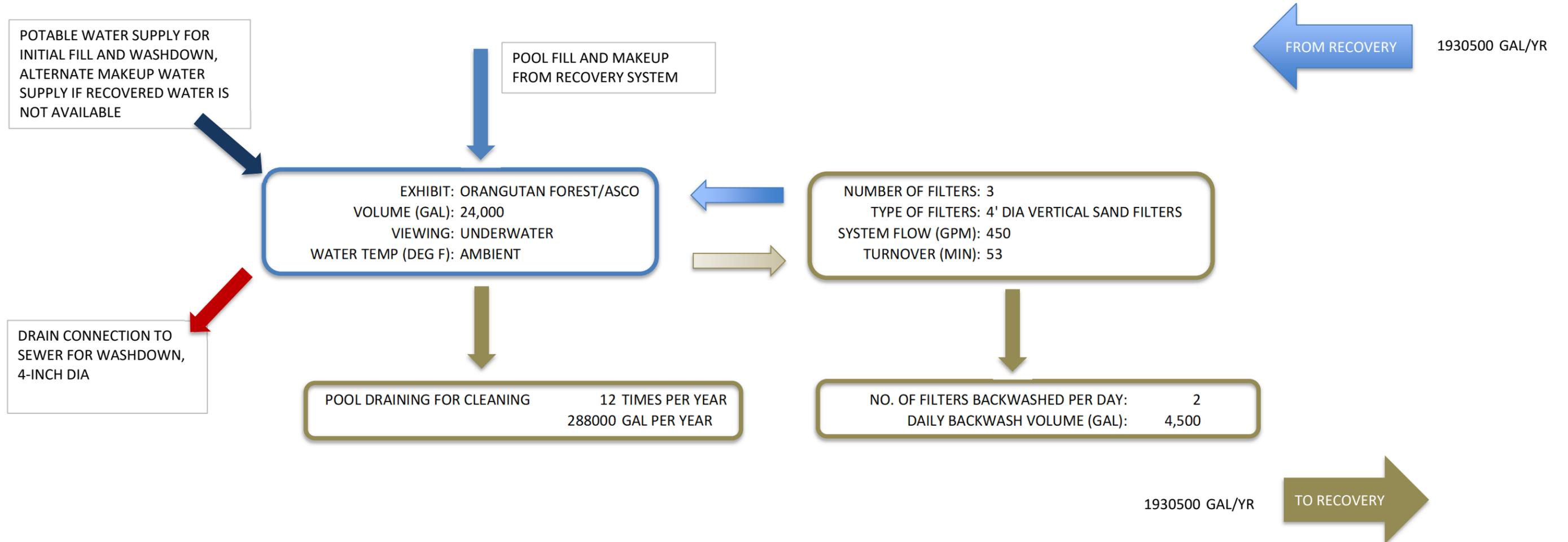
TURTLES, RAINBOW FISH, AND ARCHER FISH



BABIRUSA



ORANGUTAN FOREST/ASCO



TIGER FOREST

