WISWALL DAM OPERATIONS AND PROCEDURES PLAN

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The purpose of the Wiswall Dam Operations And Procedures Plan is to provide an explanation of the UNH/Durham Water System's approach to balancing the use of the system's three water sources (soon to be four when the Spruce Hole Well comes on line in fall of 2014) with system demand in an attempt to stretch the available source capacity beyond October 15 without declaring a Stage 4 (water supply emergency). This Plan has been developed over a 9 year period, however it was only partially tested once in August-September 2010, which was prior to the reconfiguration of the Wiswall Dam outflow structures. Therefore, it is important to recognize that implementation of this Plan will require a certain degree of trial and error and adaptation, and all parties involved will need to be prepared to make adjustments when and where appropriate. This and other associated documents are stored in following electronic folder on the DPW computer network F://Engineering Division/Water/Wiswall Reservoir & Dam Procedures

I. INTRODUCTION

Balancing the use of the three (and soon to be four) drinking water sources belonging to UNH/Durham Water System (UDWS) with system demand becomes important when peak demand coincides with limited surface water availability. It will be necessary to be familiar with the UDWS Water Conservation Plan to maintain consistency with this Wiswall Dam Operations and Procedures Plan, while carefully monitoring of the capacity status of the two surface water sources (the Lamprey and Oyster Rivers) and the one groundwater source (the Lee Well). This becomes particularly critical between August 15th and October 15th when peak water system demand overlaps with limited surface water availability during droughts. Prior to August 15th, the summer population of Durham is relatively low because the UNH resident student population is reduced and system demand is typical less than about 60-70% of the available source water capacity. On or around August 15th, the UNH students begin returning for the fall semester and water system demand starts to noticeably increase. By September 1st, system demand typically reaches its peak and if drought conditions are being experienced the Lamprey River flow may be near or approaching "rare" instream flow conditions as defined by the Lamprey River Water Management Plan, and system demand has the potential to rise above 75% of the UDWS's maximum available source water capacity. October 15th is an important since this is about when the Lamprey River

flow increases significantly due to the start of NHDES Dam Bureau's release of water from Lake Pawtuckaway and Mendums Pond for their regular annual winter drawdown. This release typically causes an increases flow in the Lamprey River to above 100 cubic feet per second through October and into November. As the Spruce Hole Well is brought on line in the Fall of 2014, it is expected to significantly boost the UDWS's maximum available source water capacity and in particular during the months of August, September and October.

II. SYSTEM DEMAND

System Demand is calculated as the sum of the production from the Arthur Rollins Water Treatment Plant (WTP) and the production or withdrawal from the Lee Well. The Spruce Hole Well (once it comes on line) will not contribute to System Demand since it will be pumped directly to the WTP. System Demand has the units of gallon per day (gpd) and is based on an average of the previous 3 days of production. This method is used to smooth out operational high and lows (i.e. topping off water tanks for the weekend, filling heating and cooling systems, backwashing, etc.).

III. SOURCE CAPACITY

Maximum Available (Source Water) Capacity is a sum of the storage capacity in the Wiswall and Oyster River reservoirs, plus the available instream flow from the Lamprey or Oyster Rivers, plus the safe yield of the Lee Well. As the Spruce Hole Well is brought on line, this will contribute to overall sum of the Maximum Available Capacity calculation. Maximum Available Capacity, like System Demand, has units of gallons per day (gpd) and is calculated on a daily basis by estimating the total available storage volume on a given day in the top 18" of the Wiswall Reservoir and the top 5 feet of the Oyster River Reservoir, dividing this value by the number of days remaining until October 15 (to produce a gpd capacity); and, finally adding that to the combined available instream flow of the two rivers (in gpd) plus the combined daily yield of the Lee Well and the Spruce Hole Well (in gpd). An Excel spreadsheet calculator <Avail Cap Calc OR&Lamprey> was developed to assist in calculating the Maximum Available Capacity of the UDWS on any given day and may be found in the electronic folder referenced on page 1.

IV. WATER CONSERVATION PLAN

The person responsible for manipulation of the Wiswall Dam outlet structures must be familiar with and thoroughly understand the details of the most current UDWS Water Conservation Plan, and specifically the water conservation measures to be considered during times of limited water supply. The Responsible Person (RP) also needs to be familiar with the Lamprey River Water Management Plan including the three components specific to the Town of Durham: the Water Conservation Plan (Appendix A); the Water Use Plan (Appendix B); and the Wiswall Dam Management Plan (Appendix C). The Lamprey River Water Management Plan (WMP) is found in its entirety on the NHDES website at the following URL: http://des.nh.gov/organization/divisions/water/wmb/rivers/instream/lamprey/water-management-plan.htm#task12.

The UDWS Water Conservation Plan includes a section on Water Conservation Status, which consists of a "normal" status, and 4 water conservation stages that are based on the status of system demand, maximum available capacity, and/or operational or environmental problems (i.e. mechanical failure or environmental disaster, etc.) that may deem a source or sources unusable. A description of the water conservation stages and the operation measures to be employed at the Wiswall Dam during each stage are as follows:

A. **Stage 1** is declared when the Lamprey River flow approaches 16 cubic feet per second (cfs), no substantial rain is in the near or extended forecast, and system demand is at or approaching 75% of the maximum available source water capacity. The trigger flow of 16 cfs corresponds with the rare flow from July 5 to October 6 in Table 1 in the WMP. Whether the WTP is drawing from the Oyster or Lamprey River at this stage is at the discretion of the WTP Operator. However, it is expected that the WTP will choose to draw from the Oyster River to preserve the storage in the Wiswall Reservoir at which time the Oyster River is used to supply the WTP. The addition of the Spruce Hole as a new water source is expected to factor into

this decision. The following operational measures are recommended if the Lamprey River is utilized as water source during Stage 1:

1) Flow Monitoring – The RP shall monitor the flow rate of the Lamprey River at least daily as published online by the US Geological Survey for USGS Gage known as 01073500 LAMPREY RIVER NEAR NEWMARKET, NH at the following website:
http://waterdata.usgs.gov/nh/nwis/uv/?site_no=01073500&PARAmeter_cd=00065,00060,72020

2) Low Flow Reservoir Withdrawals – If the flow rate in the Lamprey is above 16 cfs or the Lamprey Pump Station is not withdrawing water from the Wiswall Reservoir no management or manipulation of the Wiswall Dam outlet structures is necessary. If the Lamprey River flow rate is below 16 cfs and the Lamprey River Pump Station is withdrawing from the Wiswall Reservoir, then management of the Wiswall Dam outlet structure(s) will be required to maintain "inflow to the reservoir effectively equal to outflow" in accordance with the WMP. The UDWS may also at any time use 0.2 cfs of the instream flow, which is what the WMP refers to as the "de minimus flow".

The general approach of maintaining inflow to the Wiswall Reservoir effectively equal to outflow during low flow reservoir withdrawals may be accomplished by releasing a volume of water from reservoir storage approximately equal to the volume of water withdrawn by the Lamprey River Pump Station. This ensures that the instream flow of the river passes the Wiswall Dam essentially undetained. The operative word "effectively" is important and was incorporated into the compliance language of the WMP to provide for flexibility when operating the pump station since it allows for the release to be performed over a multi-day period such that the volume released is effectively equal to the volume withdrawn when averaged over multiple days. There is additional flexibility built into this approach since the USGS gage only reports variations in flow to the single digit down to 10 cfs (below 10 cfs it reports to the 0.1 cfs). Therefore, the USGS gage will not effectively recognize a variation in a rate of withdrawal or release on the order of 0.4 cfs.

To accomplish a reduction in reservoir storage during low flow reservoir withdrawals it is necessary to physically lower the reservoir water surface elevation (pool elevation) as determined by Figure 1 by manipulating one or more of the Wiswall Dam outlet structures. In 2006, the Town Engineer estimated the incremental storage volume of the upper 18" of the Wiswall Reservoir and Figure 1 was developed. The Excel spreadsheet containing the calculation that produced Figure 1 is stored in the electronic folder referenced above. The details of how to gradually reduce reservoir storage and effectively maintain instream flow undetained are as follows:

i. Close communication (at least daily) must be maintained with the WTP staff to (1) accurately track the volume of water being withdrawn from the Wiswall Reservoir via the Lamprey River Pump Station, and (2) monitor the pool elevation at any given time. The WTP maintains a continuous record of volume withdrawn using a source meter at the Lamprey Pump Station, as well as a continuous record of pool elevation by means of a pressure transducer linked to their SCADA system. It is also possible to physically monitor pool elevation by visually checking the staff gage that is installed on the upstream side of the east abutment of the Wiswall Bridge. It is necessary to carefully scramble down the rip rap slope all the way to the water's edge on the upstream side of the east end of the bridge to read this staff gage.

ii. For simplicity, is recommended that only the stop logs in the stop log bay of downstream fish migration notch near the right (west) abutment of the Wiswall Dam be manipulated to adjust/control reservoir outflow during low flow reservoir withdrawals. The benefit of using the stop logs for controlling reservoir outflow is the "self-regulating" nature of a weir configuration. If one stop log is pulled, the pool elevation will only be lowered by the thickness of that stop log and no more.

NOTE - It is NOT recommended to open the large low level gates located in the gate structure of the Wiswall Dam's left (east) abutment nor should the fish ladder weir gate be operated for the purpose of reducing storage during low flow reservoir withdrawals. The large low level gates should ONLY be used for emptying the reservoir for inspections and

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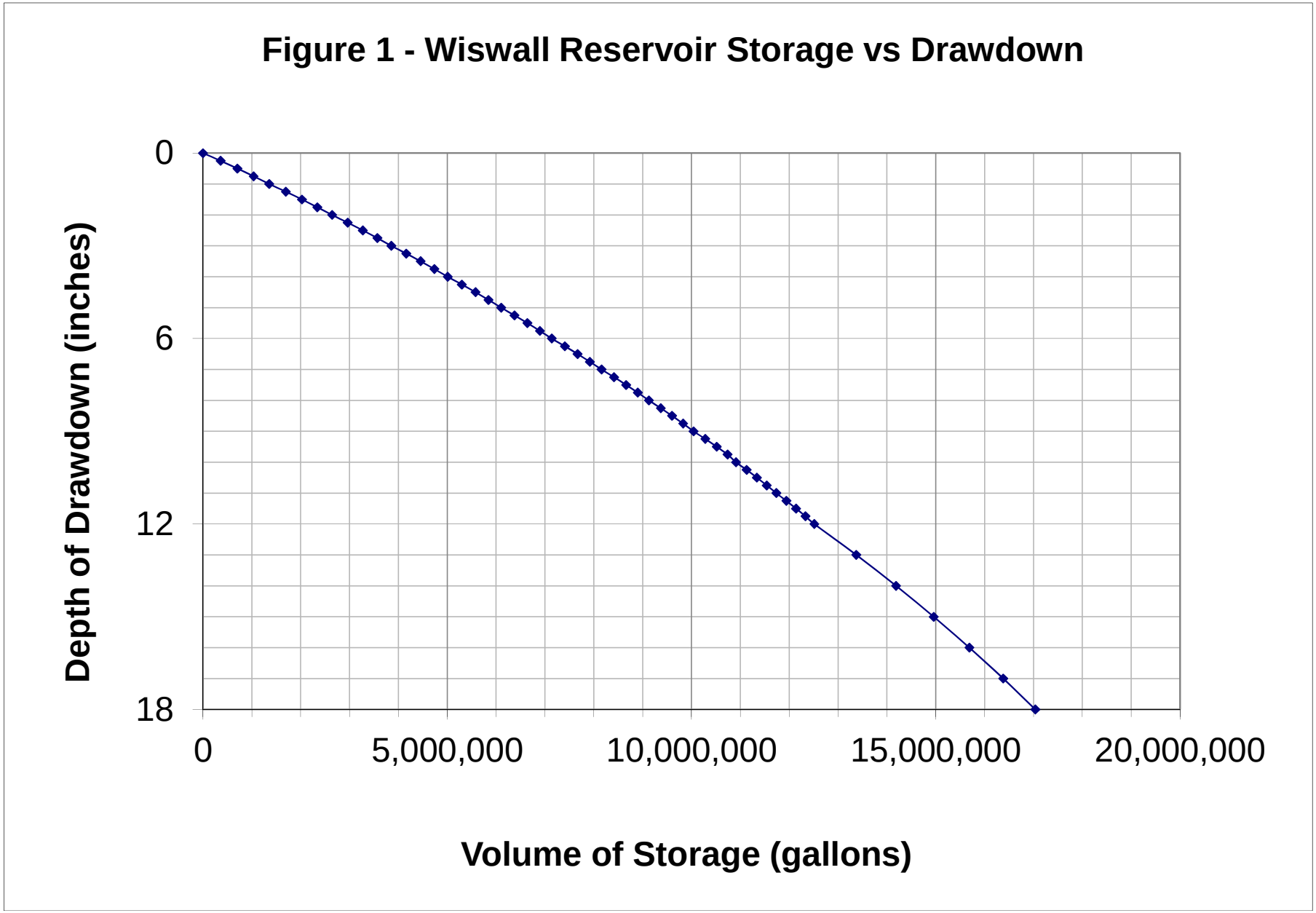

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maintenance of the dam or the Wiswall Bridge. NH Fish & Game has also recommended against using the fishladder weir gate for outflow control during late summer or fall due to the fact that fish are migrating downstream during this time and they prefer to use the downstream fish migration notch for this purpose. Also, other creatures such as eels might enter the fish ladder and become trapped when the flow in the fish ladder ceases after the gate is closed.

iii. The stop log bay consists of a 5' x 5' notch in the west end of the Wiswall Dam's concrete spillway with cast-in-place slots in either side that retain stacked arrangements of 4" x 4" and 4" x 6" pressure treated boards (the actual dimensions are 3.5" x 3.5" or 5.5"). There is also a modified 4" x 4" which has had the middle section cut down to a height of approximately 2" for placement on top of the stack to make intermediate flow adjustments. By pulling one full 4"x4" stop log or the modified stop log, a controlled amount of water may be released from reservoir storage and the result is a relatively controlled lowering of the pool elevation to a maximum depth equal to the thickness of the stop log(s) removed. Depending on the thickness of the stop log(s) being pulled, it may take multiple days for the desired volume of water to be released to the point where the pool elevation has dropped below the crest of spillway, and all the river flow is passing through the stop log bay and the pool elevation to equilibrate.

iv. Once a stop log is removed and water from storage in the reservoir begins to be released and the pool elevation begins to drop, it will be necessary to pay close attention to the pool elevation by monitoring the staff gage on the upstream side of the east Wiswall Bridge abutment and/or check the continuous record from the pool elevation transducer maintained by the WTP staff. The goal is to balance the volume released from storage so that it is effectively equal to the volume withdrawn by the Lamprey Pump Station. This is accomplished by comparing the daily withdrawal totals recorded by the pump station flow meter with the Volume vs Drawdown values in Figure 1. For example – if the volume of water withdrawn by the Lamprey Pump Station on a given day in 1 Million gallons, based on Figure 1 it will be necessary to lower the pool elevation by approximately 1 inch. If the withdrawal was a constant 1 Million gallons per day for an entire week, it would be

necessary to remove a full 3.5" x 3.5" stop log every 3.5 days. It will also be important to account for an adequate depth of water to maintain weir flow through the stop log bay and provide for ALL the flow in the river. If the instream flow is at say 16 cfs, it will be necessary to make provisions for adequate depth of at least 6 inches of weir flow above the top stop log in order to pass all the river flow through the stop log bay (consult with the rating curve developed by Stephens Associates and provided in Sheet 4 of the 2011 Wiswall Dam Improvement Plans). Once the pool elevation has equilibrated (which may take multiple days and a fair amount of trial and error the first time), weir flow through the stop log bay will be self-regulated and the stop logs may be left unattended until it is necessary to reduce storage again as additional water is withdrawn by the pump station.

v. At no time during Stages 1, 2 or 3 shall the pool elevation be drawn down greater than a total of 18 inches below the crest of the Wiswall Dam Spillway, and the rate of drawdown shall not exceed 1 inch per day when average over multiple days.

B. **Stage 2** is declared when the Lamprey River flow has been below 16 cfs for 10 or more days, no substantial rain is in the near or extended forecast, and system demand (as defined above) is $\geq$ 80% of the maximum available source water capacity. If prior to declaring State 2 the WTP is drawing water from the Oyster River Reservoir and not operating the Lamprey Pump Station a decision would need to be made whether or not to cease using the Oyster River and switch to withdrawing from the Lamprey River. Once Stage 2 is declared, it is expected that the Lamprey River Pump station would be activated if it has not been already, and the monitoring procedures described in parts A.1) and A.2) above must be implemented and strictly followed. Only water from available storage in the Wiswall Reservoir plus the de minimus amount of 0.2 cfs (as defined by the WMP) may be used for water supply in order to effectively not make use of any instream flow (i.e. maintaining reservoir inflow effectively equal to outflow) with a maximum drawdown of the Wiswall Reservoir of 18 inches (1.5 feet) below the spillway crest.

It will be necessary to carefully anticipate the stop log configuration needed to gradually affect a drawdown of no more than 18 inches while making a good faith effort to keep pace with the

daily withdrawal as well as taking into consideration the depth of flow necessary to maintain all the instream flow of the Lamprey River as weir flow over the top stoplog. Since there is so far limited history of using the Wiswall Dam's stop log bay for outflow control, it would be instructive to maintain detailed daily data record (i.e. depth of flow over the stop logs, and discharge as measured by the USGS gage) to allow for the development of a stage vs discharge rating curve for future predictions of weir flow through the stoplog bay. As mentioned previously, a preliminary stage vs discharge rating curve is provided in the 2011 Wiswall Dam Improvement Project Construction Plans.

Each day as the Wiswall Reservoir pool elevation is drawn down the RP will need to evaluate the Maximum Available Capacity using the "Avail Cap Calc" spreadsheet, and when this is compared to System Demand it becomes possible to estimate how many days of water is available to adequately meet the daily demand through to October 15th. Adjustments may need to be made to "elevate" the maximum available capacity in order to stretch the available capacity and satisfy the demand for an extended period of time. An example might be an reduction in the reliance of a surface water source over an groundwater source; such as, decreasing the rate of withdrawal from the Wiswall Reservoir and subsequently increasing the withdrawal rate from the Lee Well. Any effort to reduce the daily demand through employing more active water conservation measures is another consideration. As October 15th approaches, the likelihood of rain occurring significantly increases. In accordance with the WMP, if enough rain occurs and causes the flow in the Lamprey River to increase above 16 cfs for two consecutive days it is at this point in which the UDWS may begin to use some of the instream flow (above the de minimus flow) to refill the Wiswall Reservoir.

The above approach was implemented once in 2010 when the Wiswall Reservoir pool elevation was lowered a total of about 11 inches. However, since this event occurred before the 2011 Wiswall Dam Improvements Project the old low level gates of the Wiswall Dam were used to maintain inflow effectively equal to outflow. An Excel spreadsheet used to track the Stage 2 drawdown in 2010 is stored in the electronic folder referenced above. The Wiswall Dam's new stop log bay will make for much simpler outflow control the next time a drought occurs.

Stage 3 is declared when the Wiswall Reservoir pool elevation is drawn down a total of 18 inches below the spillway crest, the Lamprey flow has been below 16 cfs for 15 or more days, no substantial rain is in the near or extended forecast, system demand is ≥ 85% of the maximum available capacity, and the withdrawal from Lee Well is at its maximum safe yield. At this time, the agreed upon approach is for the WTP to cease withdrawing from the Lamprey River and to switch to withdrawing from the Oyster River. The Oyster River Reservoir would be drawn down to a maximum of 5 feet below the spillway crest while continuing to release enough flow to sustain an acceptable instream flow downstream from the reservoir.

If the Lamprey River Pump Station is not withdrawing from the Wiswall Reservoir then no further manipulation of the Wiswall Dam outflow structures is necessary, and the stop log bay can be left alone to "self-regulate" outflow. There is little to no history of the UDWS ever significantly drawing down the Oyster River Reservoir in response to drought conditions, and therefore the decision makers may need to be prepared to adapt this Plan if problems become apparent. It is very likely that degraded water quality in the Oyster River, or some other environmental issue becomes cause to conclude drawdown of the Oyster River Reservoir before reaching the 5 foot maximum.

C. **Stage 4** (Water Emergency) is declared when the forecast of no substantial rain continues, system demand is ≥ 90% of the maximum available capacity and the Oyster River Reservoir is drawn down 5 ft, or some other issue becomes apparent such as the Oyster River water quality has degraded to the point where the WTP has trouble treating it. Declaring Stage 4 is effectively declaring a "water emergency" with respect to the current WMP. In accordance with the WMP, the RP would immediately notify NHDES of the "water emergency" condition, and begin drawing down the storage in the Wiswall reservoir greater than 18 inches below the Wiswall Dam spillway crest, and the monitoring procedures described in parts A.1) and A.2) above must be implemented and strictly followed. The RP will need to maintain detailed documentation as to the factors involved in declaring Stage 4 and how it could be prevented in the future, and a full report will need to be submitted to NHDES in accordance with the WMP.