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16 August 2013  
File No. 39429-001

TO: Donovan Hatem, LLP  
Kelly Martin Malone, Esq.  
Partner

FROM: Haley & Aldrich, Inc.  
John G. DiGenova, P.E. and John R. Kastrinos, P.G.

SUBJECT: Limited Geotechnical and Hydrogeologic Assessment  
Rapid Infiltration Basins  
Wolfeboro, New Hampshire

This memorandum summarizes the results of a limited geotechnical and hydrogeologic assessment to identify remedial measures for the Rapid Infiltration Basins (RIBs) in Wolfeboro, New Hampshire. The memorandum provides a description of hydrogeologic and geotechnical analyses performed, preliminary remedial recommendations, an assessment of permitting requirements, and some basic engineers' cost estimate information for the proposed remediation approach. The original Wright Pierce analysis of the RIBs indicated that the system was capable of accepting up to 600,000 gallons per day (gpd) of treated wastewater from the Town of Wolfeboro. During the very early course of operation the system experienced distress in the form of piping and slope failures. Our goal was to devise a remedial scheme that would reestablish that 600,000 gpd capacity. Haley & Aldrich's services were performed in accordance with our proposal dated 5 July 2013 and your subsequent authorization.

In summary, based on the results of the hydrogeological and geotechnical analysis, Haley & Aldrich concludes the following:

1. Modeling results indicate the RIBs at the site could be operated at up to the 600,000 gpd target rate following some additional engineering assessments and installation of the proposed remedial measures designed to address the observed soil piping and slope instability issues.
2. For the specific area investigated, Haley & Aldrich developed a remedial concept that comprises placement of a 3-ft thick layer of rip-rap over a 1 ft thick layer of filter sand or geotextile to mitigate the soil piping and/or stability issues. This design would provide a diffuse outlet for seepage from the affected slope areas, in a controlled manner designed to prevent loss-of-ground by soil piping.
3. Additional field investigations and engineering assessments may need to be undertaken to further refine the application of this approach to address other areas of the project site, and additional analysis of flows exiting the stabilized areas.
4. Regarding permitting, Haley & Aldrich found no permitting issues that would prevent the remedial measures from being implemented.

**THIS MEMORANDUM IS CONFIDENTIAL AND PREPARED FOR  
PURPOSES OF SETTLEMENT AND/OR MEDIATION ONLY.**

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## **BACKGROUND**

We understand that operation of the existing RIBs resulted in two conditions that are not acceptable to the Town of Wolfeboro, i.e., localized slope instability and piping of sands that result in deposition of sand materials into adjacent water bodies and wetlands. In view of these reported conditions, the purpose of our assessment was to:

- evaluate the hydrogeologic and geotechnical aspects of the slope instability and sand piping for a single cross-section located south of the RIBs at what appears to be the most problematic location,
- understand better the mechanisms that may be causing the instability and piping,
- assess remedial measures that may be employed to address the issues,
- confirm that the remedial measure(s) selected result in a stable slope condition and address the piping of soils,
- develop a schematic detail of the remediation,
- analyze the existing data and make an estimate of other areas that may require similar remediation,
- assess permitting requirements required for the remedial measures,
- develop “ballpark” cost data to implement the remediation.

This assessment has been performed for only one area of the site, albeit the area of most significant distress. The learning and insights derived from the assessment have been applied to other areas of the site for discussion purposes and to attain a “ballpark” cost estimate. Based on the known geology and variability of the subsurface conditions, specific assessments of other areas, possibly including additional subsurface explorations and testing, should be undertaken before implementing any remedial measures.

We note that the term piping refers to a specific hydrogeologic condition where excess fluid gradients impart soil movement. This memorandum uses the term generically to refer to the movement of soils from the subsurface to the surface.

## **CROSS SECTION SELECTION AND DESCRIPTION**

### **Site Setting**

The Whitten West RIB site is situated on an elevated upland classified as a kame deposit, a type of ice-contact glacial landform exhibiting typically stratified, layered, granular soils deposited by the action of glacial meltwater. Wetlands associated with Nineteenmile Brook are present at lower elevations to the southwest and south of the site. The area reviewed in this limited assessment for possible mitigation measures is shown on Figure 1.

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## Geologic Profile

Haley & Aldrich constructed a geologic profile (or cross-section) depicting subsurface site stratigraphy that was interpreted from existing test boring records, test pit records, and geotechnical laboratory test results. The profile was used to establish the critical condition for the slope-stability geotechnical model and hydrogeological seepage model analyses. The area investigated is presented on Figure 1.

The orientation of the geologic profile was drawn in a similar alignment to transect C-C' shown on Figure 2 of the 2007 Wright-Pierce (W-P) site plan<sup>(1)</sup> (see reference list at the end of this memorandum), and crosses the slump failure area observed near the area that W-P identified as the "Central Groundwater Discharge Area" in the southwestern portion of the site. The cross section incorporated explorations and data from test borings and monitoring wells designated MW-32 and MW-33 from the S.W. Cole Report (2011)<sup>(2)</sup>, and test borings and monitoring wells designated B-10/MW-8, B-17/MW-15, and TP-10, respectively, from the March 2007 W-P Report<sup>(3)</sup>.

The geologic profile's upper limit begins at approximate El. 635 and slopes downward with an approximate 6H:1V slope to El. 608, where the slope steepens (about 3H:1V) down to El. 570, then exhibits a flatter segment to approximate El. 550. The profile line crosses the slump feature scarp where ground surface is approximately El. 594.

Geologic conditions are represented by four distinct layers based on available information from the five explorations and the soil descriptions and observations made by others. We have assumed that the soil layers slope downwards to the southwest, in the direction of the slope. The four layers were identified based on their engineering properties and similar characteristics, described below proceeding from ground surface downward:

**Clean Sand** – Consisted typically of medium dense, poorly-graded and well-graded granular SAND. We have assumed that a small pocket of clean sand exists at the bottom of the slope of the profile at location B-17/MW-15 from approximately El. 562 to El. 557.

**Silty Sand** – Consisted typically of silty SAND, with some silt and clay beds. Laboratory testing on two samples collected in MW-33 indicated 33.8% fines (material passing a #200 sieve, indicative of silt/clay sized particles) at approximately El. 594 to El. 593.5, and 20% fines at approximately El. 585.5 to El. 583.5.

The silty sand was typically medium dense with some zones of loose sand. We have assumed that a thin, 2 to 3 ft thick layer of silty sand exists within the clean sand layer (above), as shown on the profile. We have also assumed that silty sand exists at and just below the ground surface along the geologic profile, reflecting the presence of naturally-occurring topsoil/loess deposits (subsoils).

**Stratified Sand** – Consisted typically of poorly-graded SAND stratified and interbedded with layers of silty SAND. The stratified sand was typically medium dense with some zones of loose sand, and exhibited a low silt content in the cleaner layers.

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**Glacial Till/Probable Bedrock** – Three of the five explorations (MW-32, B-10/MW-8, and B-17/MW0-15) encountered “refusal” to earth drilling equipment and/or difficult drilling advance at elevations ranging from El. 578 to El. 540, which was inferred to be glacial till or possibly bedrock. Linear interpolation was used to define the glacial till/possible rock surface in the profile between explorations.

## **HYDROGEOLOGIC EVALUATION**

### **SEEP/W Modeling**

Haley & Aldrich modeled seepage through the cross section using Geostudio’s SEEP/W program. SEEP/W is a 2-Dimensional finite-element model that simulates groundwater seepage through subsurface materials along hydraulic gradients, in both the X and Y directions. Four soil units were modeled in the cross-section. The resulting phreatic surface (water table) modeled by SEEP/W was translated into the geotechnical slope-stability model Slide to complete slope stability modeling of the cross-section.

Observed groundwater elevations along the profile were estimated at multiple RIB flow rates to model a wide range of wastewater discharge scenarios. Groundwater elevations were selected based on the groundwater elevation plots and the associated RIB flows. Based on transducer data, a representative groundwater elevation was determined for each of the aforementioned monitoring wells for RIB flows of 250,000 GPD (Transducer/Flow data from 19 January 2012 through 18 April 2012) and 375,000 GPD (Transducer/Flow data from 16 July 2011 through 15 August 2011). These flow rates were chosen because the Town has operated the RIBs at those flow rates for extended periods and they fall within the observed flow range since MW-32 and MW-33 were installed.

### **Groundwater Elevation Determination**

To support the seepage modeling, Haley & Aldrich assigned groundwater levels along the cross section based on water-level data from MW-32 S&D, MW-33S&D, and MW-8. MW-15 was not included due to its relatively large off-set to the profile (58 ft) as compared to the other locations included on the profile. In addition, MW-15 was drilled up-slope of the mapped wetland that the cross section transects; however, the water table in the vicinity of MW-15 (as it appears on the profile) was set equal to ground surface because this location falls within the mapped Central Wetland. Generally, observed groundwater head pressures are lower at the base of the aquifer as compared to heads at higher elevations in the aquifer. This observed condition was maintained throughout the modeling process.

### **Model Calibration**

The SEEP/W model was calibrated using the groundwater elevations observed in MW-32S&D, MW-33S&D and MW-8. The hydraulic properties of each of the modeled soils were adjusted iteratively until the differences between the modeled and observed groundwater elevations were approximately 1 ft or less. The elevations were determined from the model by selecting the closest model node to the center point of each well screen. The modeled hydraulic properties and representative soil layers are included in Appendix A.

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250,000 GPD			375,000 GPD		
Monitoring Location	Estimated Observed Elevation (ft)	Modeled Elevation (ft)	Monitoring Location	Estimated Observed Elevation (ft)	Modeled Elevation (ft)
MW-32S	596.0	595.3	MW-32S	601.5	601.6
MW-32D	595.0	595.0	MW-32D	600.5	601.1
MW-8	592.5	591.8	MW-8	597.6	596.7
MW-33S	589.5	590.3	MW-33S	593.8	594
MW-33D	587.5	587.8	MW-33D	591.5	591.6

Throughout the model calibration there was some difficulty calibrating to head pressures observed at MW-8. This may be due to longer well screen in MW-8 (compared to the MW-32 & 33 couplets), or it may indicate that the geology in the vicinity of MW-8 is considerably more complex than the generally simplified model stratigraphy. Based on the boring logs, the stratigraphy in the area is variable.

### Model Validation

Following the calibration of soil parameters, Haley & Aldrich modeled three additional scenarios as a means of model validation. The first scenario was a pre-construction scenario wherein the observed groundwater elevation at MW-8 was 581.1 ft (Wright Pierce Phase III). The constant head boundary condition on the upgradient side of the model was adjusted until the modeled and observed groundwater elevation at MW-8 were similar. The resulting phreatic surface intersected the ground surface at approximately El. 572, which is within the wetland boundary. The resulting groundwater discharge area seems realistic given the general shape and extent of the central wetland area.

The second and third model validation runs were conducted at average observed flow rates of approximately 642,000 GPD and 777,000 GPD respectively. The reported daily RIBs flow rates were averaged from April 13<sup>th</sup> through April 17<sup>th</sup> 2009. The flow estimates are based on two separate sources of information due to differences in the reported data. The calculated average RIBs discharge for the aforementioned dates reported in 2010 RIBs Status Report was approximately 642,000 GPD, while the August 12, 2009 Town of Wolfeboro Letter reported flows averaging approximately 777,000 GPD over the same time period. The observed groundwater elevation in MW-8 on April 20<sup>th</sup> 2009 was approximately 602.2 ft. The slope failure in the central wetland area was first observed on April 20<sup>th</sup> 2009. This condition is considered to represent the failure condition along the cross section. Similar to the pre-construction model run, the upgradient boundary was adjusted until the modeled groundwater elevation at MW-8 was similar to the observed groundwater elevation. The resulting phreatic surfaces for both conditions are equal and intersected the ground surface at El. 593.7.

This result is generally consistent with observations of the central wetland area described in the 2010 RIB Site Status Report:

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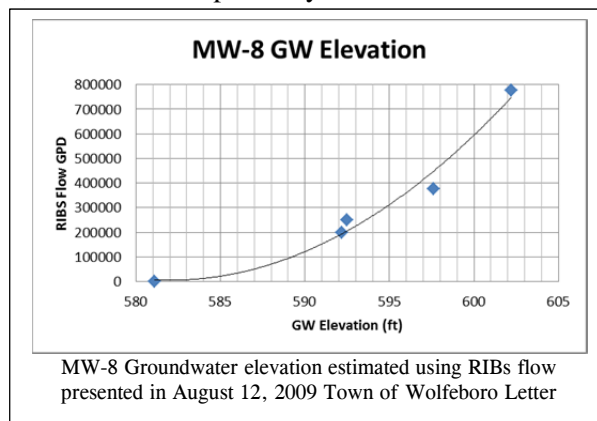
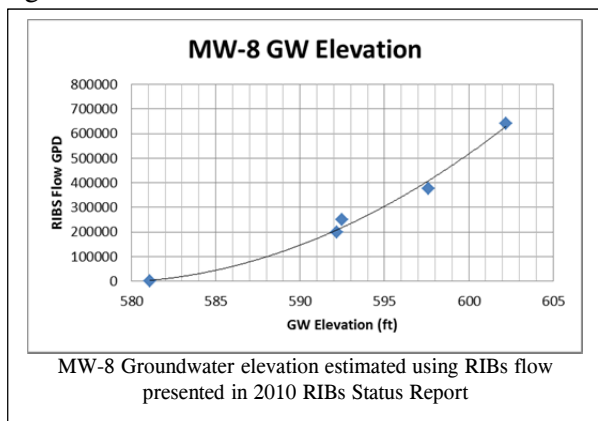
“The “unexpected issues” first observed on April 20, 2009 included the U- shaped slope failure above the Central Groundwater Discharge Area. This “crack” in the hill began at elevation 591 on the east side, ran on a northwesterly direction to top of slope to elevation 600, ran across top of slope for about 40 feet, then went down the slope in a southwesterly direction for about 80 feet to an elevation of 577. This issue, which first developed as a crack, has very slowly developed into a slope failure, where the land below the crack at top of slope has separated and has been moving downhill since.”

The Town’s 2010 RIB Status Report also indicates that sand migration was not observed until June 8, 2009 when a “sink hole” developed to the west of the central wetland.

The modeled seepage elevation is generally above the area of the lower observed seepage area, and below the slump face. This seems generally consistent with the observed slope failure in the Central Groundwater Discharge Area at the site.

### Predictive Simulation

Based on the modeling scenarios described above, a best fit curve was used to approximate the two groundwater elevations at MW-8 assuming a RIBs flow 600,000 GPD. Two separate best fit curves were developed assuming different average loading rates from April 13<sup>th</sup> through April 17<sup>th</sup> 2009 based on the RIBs discharge rates presented in the 2010 RIBs Status Report and the August 12, 2009 Town of Wolfeboro Letter. The resulting curves indicate that at approximately 600,000 GPD the modeled groundwater elevation at MW-8 would be El. 601.5, and El.600 respectively.



Two model runs were completed by adjusting the upgradient constant head boundary in the SEEP/W model until the modeled groundwater elevation was similar to the estimated groundwater elevation of 601.5 ft, and El. 600. Both modeled scenarios resulted in a phreatic surface (water table) that intersected the ground surface at El. 593.7, which is consistent with the observations.

### Discussion



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The model results may not precisely represent the observed sand piping at the site. Specifically, although evidence of piping (in the form of sand boils) has been observed in the slope failure area, none of the model runs revealed exit gradients that exceeded threshold values above which piping would be expected. A likely explanation is that there may be other piping mechanisms at work, such as localized variations in seepage gradients due to inter-bedded stratigraphy, which could not be confirmed without additional explorations.

## GEOTECHNICAL EVALUATION

Slope stability analyses were conducted using the geologic profile described above. As the existing slope, prior to failure, was at about 3H:1V or slightly steeper, we assume that our assessment would be applicable to existing slopes at the site near 3H:1V that have similar subsurface conditions.

Soil properties, including the angle of internal friction and unit weight for each soil layer, were estimated using the following references:

- Correlations of strength characteristics for granular soils from the Naval Facilities Engineering Command *Soil Mechanics Design Manual 7.01*
- Relationships between the angle of internal friction,  $\phi$  and values of N from the Standard Penetration Test displayed in *Foundation Engineering* by Peck, Hanson, and Thornburn.

An apparent cohesive strength of 50 psf, was used in modeling the Silty Sand layer based on the presence of thin clay and silt beds noted in some of the borings. The soil properties were estimated based on information on the existing boring logs and laboratory test data for the referenced explorations, and our experience.

Groundwater elevations for the pre-loading and the RIB water loading conditions were consistent with those described above in the HYDROGEOLOGIC EVALUATION.

The soil property assumptions and groundwater levels used in the slope stability analysis are presented in Appendix B.

### Slope Stability Analysis

Slope stability analyses, using the computer software Slide by RocScience, were performed to assess the pre-failure and RIB water loading conditions as follows:

- Pre-Failure Condition – no RIB loading
- 250,000 GPD RIB Loading
- 375,000 GPD RIB Loading
- 600,000 GPD RIB Loading – GW elevation using 2010 RIB Status Report
- 600,000 GPD RIB Loading – GW elevation using 12 August 2009 Town of Wolfeboro Letter
- 642,000 GPD RIB Loading – GW elevation using 2010 RIB Status Report
- 777,000 GPD RIB Loading – GW elevation using 12 August 2009 Town of Wolfeboro Letter

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The slope stability analyses assumed a minimum failure surface depth of 3 ft. The modeled cross-section is presented in the hydrogeologic SEEP\W model outputs and slope stability Slide model outputs found in Appendices A and B, respectively. The model outputs from Slide including the calculated factor of safety for each condition are presented in Appendix B.

The following table summarizes the calculated factor of safety for the various conditions:

<b>Loading Condition</b>	<b>Calculated Factor of Safety</b>
Pre-Failure – 0 GPD	1.6
Approximately 250,000 GPD	1.1
Approximately 375,000 GPD	0.9
Approximately 600,000 GPD (RIB Status Report)	0.9
Approximately 600,000 GPD (Wolfeboro Letter)	0.9
Approximately 642,000 GPD (RIB Status Report)	0.9
Approximately 777,000 GPD (Wolfeboro Letter)	0.9

It is important to note that many slopes exist in nature with calculated factors of safety that are less than 1.0, in other words the state-of-the-practice for the analytical tools and algorithms that engineers use to evaluate slopes are not always capable of predicting what actually occurs in nature. A factor of safety below 1.0, is generally considered to be a failure condition; a factor of safety between 1.0 and 1.3 is considered to be a marginally stable condition. When designing a slope, a factor of safety of 1.3 or greater is considered to be adequate. For purposes of our analysis, a RIB loading of about 250,000 GPD resulted in a marginal factor of safety of 1.1. Higher RIB loading resulted in a factor of safety of less than 1. We believe this to be a conservative assessment from which to launch the remedial design process.

### **Slope Remediation Design Alternatives**

Various alternative measures to improve the stability of the impacted area and similar areas at the site were assessed. Consideration was given to providing additional drainage conduits in various configurations cut into the slope in order to spread the ground water over larger areas and reduce the exit gradients out of the slope. This option was discarded based on the relatively high groundwater levels in the slope at the RIB loading rates considered. One identified measure that would be readily constructible would be to stabilize the ground surface in the affected area by placement of an appropriately sized graded sand filter or geotextile overlain by rip-rap. The system would increase the resistance of the slope to surface and deeper instabilities, and enable seepage to exit the face without inducing piping. Various configurations and thicknesses of rip-rap were assessed for each of the water loading conditions. A minimum factor of safety of 1.3 was found for the loading conditions presented below.

- 600,000 GPD (RIB Status Report) –1 ft thick graded sand filter overlain by 3 ft thick rip-rap layer
- 600,000 GPD (Wolfeboro Letter) –1 ft thick graded sand filter overlain by 3 ft thick rip-rap layer



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Lesser flows could be accommodated by thinner rip-rap sections. For conceptual planning and cost estimating, the extent of the fill placement for remediation was assumed to be at least 5 ft upslope of the area of the modeled seepage (water breakout level El. 593.7 for 600,000 GPD from model outputs) and at least 5 ft downslope of the lower failure limit (observed at approximate El. 571 for 600,000 GPD from model outputs) and taper for some distance beyond the calculated toe of the failure zone (on the order of 10 to 30 ft). The rip-rap toe (prior to the taper) should be keyed into the slope.

Detailing of the sand filter/geotextile and the rip-rap is beyond the scope of this initial assessment and should be considered in the final design. We expect that 4 to 8 in. sized rip-rap could be used along the face of the slope, and about 8 to 15 in. diameter rip-rap could be used in the key at the toe of the slope.

The model outputs from Slide that show the remedial alternatives for the various loading conditions are presented in Appendix B. A preliminary schematic of the slope remedial alternative described above is presented in Figure 2.

## REMEDICATION COST ESTIMATES

Based on our preliminary assessment, areas of the site that have slope angles of about 3H:1V or steeper should be remediated. Also some magnitude of remedial measures should be implemented where soil piping was observed. In most cases these areas overlap. The quantities and limits of work were estimated based on soil slope angles and observations of soil piping and/or erosion noted in the field and include the following areas:

- approximately 0.5 acres in the area southwest of the RIBS and west of the roadway
- approximately 0.56 acres in the area southwest of the RIBS and east of the roadway

Steep slopes and soil piping have been observed at other localized areas of the site to the southeast and northeast of the RIBs. We have estimated that these other areas may be about 0.5 acres in aggregate.

At this time the areas have only been approximated. A more thorough survey and analyses would need to be undertaken to identify possibly additional remediation areas requiring treatment. A prudent approach to the remediation would be to address the two most severely affected areas of the site first, i.e., southwest of the RIBs. When and if additional areas of distress manifest themselves then they could be addresses at that time.

Haley & Aldrich completed an engineer's estimate of the costs of the remedial measures described above. We utilized a simple unit cost approach with unit cost information collected from a document found on the NHDOT website titled "NH Department of Transportation Weighted Average Unit Prices," and from our past experiences with similar construction projects. The estimated costs to treat the above areas are as follows:

Additional Investigations, Engineering, Contract Documents	\$450K
Construction of approximately 1.06 acres at two southwest locations	\$700K
Construction of approximately 0.5 acres at various locations	\$300K

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As authorized and indicated in our proposal, our assessment has focused on the stability of the slope, the observed piping and potential remedial measures for the water loading from the RIBs, for a single cross section across the Central Groundwater Discharge Area. Haley & Aldrich did not assess transport of the water or impacts of the transport after it exits the reinforced area and associated impacts to wetlands or restoration of previous impacts to wetlands and other areas affected by operation of the RIBs. We note that as more effluent is disposed of at this site, one would expect some continued morphological adjustments to the wetlands to accommodate the increased inflow. Some additional erosion control measures may need to be implemented downslope, depending on the observed post remediation conditions. Further, Haley & Aldrich did not assess the potential influence of the impacts of precipitation or snow melt on the overall system capacity.

### **PERMITTING CONSIDERATIONS**

Haley & Aldrich anticipates that the following State permits will be required for remedial construction at the RIBS:

- **Groundwater Discharge Permit:** A Groundwater Discharge Permit (GDP) in accordance with Env-Wq 402 (Groundwater Discharge Permit and Registration) is required for discharge of wastewater on to or into the ground or groundwater. A permit for the remediated RIBS will likely involve modification of the Town of Wolfeboro's existing GDP (GWP-200707014-W-002) for the discharge of the design capacity of the remediated RIBS. The current GDP was issued by the New Hampshire Department of Environmental Services (NHDES) on 21 September 2012 for the disposal of up to an annual average daily flow of 340,000 GPD with a daily discharge volume not to exceed 425,000 gallons. Based on a conversation with NHDES, we understand that modification of the existing GDP to reflect the proposed discharge quantity from the remediated RIBs will be acceptable to NHDES.
- **Alteration of Terrain:** An Alteration of Terrain Permit in accordance with Env-Wq 1500 (Terrain Alteration) is required for earthmoving or excavation with an impact greater than 100,000 square feet or an impact of greater than 50,000 square feet for land located within 250 feet of water bodies protected by the Shoreland Water Quality Protection Act. Earthwork for remedial construction would likely affect greater than 100,000 square feet in the area of the RIBS. In addition Nineteen Mile Brook may be protected under the Shoreland Water Quality Protection Act.
- **Wetlands Permit:** A Wetlands Permit in accordance with Env-Wt 300-700 (Wetlands Program Rules) will likely be required for impacts to or alteration of State jurisdictional wetlands that would result from excavation or filling for slope stabilization and stabilization of the unnamed tributary.
- **Shoreland Impact Permit:** A Shoreland Impact Permit in accordance with Env-Wq 1400 (Shoreland Protection) is required for earth moving or excavation with a total impact greater than 50,000 square feet on land within 250 of water bodies protected by the Shoreland Water Quality Protection. A Shoreland Protection Permit (in addition to an Alteration of Terrain

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Permit) would be required if Nineteen Mile Brook is protected by the Shoreland Water Quality Protection.

Local permits and approvals, particularly by the Wolfeboro and Tuftonboro Conservation Commissions relative to potential impacts to and alteration of wetlands and streams, may be required in addition to the State permits described above.

Haley & Aldrich understands that The Town of Wolfeboro and W-P had discussions with NHDES regarding remedial measures that were similar in concept to the remedy proposed herein, and further that NHDES gave no indication that the remedial measures could not be permitted. We also understand that NHDES indicated to The Town of Wolfeboro and W-P that the remedy should not include pipes that are arranged to collect seepage and discharge them to site surface waters, which would constitute a point-source discharge that is prohibited in the Lake Winnepesaukee watershed.

## **CONCLUSIONS AND RECOMMENDATIONS**

Based on the hydrogeological and geotechnical analyses described herein, it appears that the existing site for the RIBs in Wolfeboro, New Hampshire could be operated at up to 600,000 GPD flow rate without slope instabilities or piping if remedial measures are implemented. For the specific area investigated, a remedial scheme of providing a nominal 3-ft thick layer of rip-rip placed over a layer of filter sand and/or a geotextile could mitigate soil piping and slope stability issues. Additional field investigations and engineering assessments would need to be undertaken to further evaluate the feasibility of using this approach to remediate other areas of the project site, including additional analysis of flows exiting the stabilized areas.

Regarding permitting, Haley & Aldrich found no permitting issues that would prevent the remedial measures from being implemented.

## **LIMITATIONS**

The limited geotechnical and hydrogeologic assessment summarized in this memorandum has been performed for specific application to the Rapid Infiltration Basin Area in Wolfeboro, New Hampshire. The analyses and comments herein are based in part upon data obtained by others, and are limited by the authorized scope of the assessment. The remediation measure described herein is considered conceptual, and further investigations and engineering evaluations are required for design of any remediation measure.

## **REFERENCES**

1. Figure 2, Site Plan, Groundwater Discharge Permit, Town of Wolfeboro, NH, dated January 2007, from the Wright-Pierce report titled, "Subsurface Wastewater Disposal Feasibility Study - Whitten West Site - Wolfeboro, New Hampshire - Phase 3 Hydrogeologic Report" dated March 2007

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2. “Hydrogeological and Geotechnical Engineering Services – Explorations, Testing, and Data Compilation – Rapid Infiltration Basin Facility – Wolfeboro, New Hampshire” report by S.W. Cole, dated 30 November 2011
3. B-10/MW-8, B-17/MW-15, and TP-10 from the Wright-Pierce Report titled, “Subsurface Wastewater Disposal Feasibility Study – Whitten West Site – Wolfeboro, New Hampshire – Phase 3 Hydrogeologic Report” dated March 2007.
4. Town of Wolfeboro, “Status Report”, Rapid Infiltration Basin (RIB) Site, 6 December 2010.

Attachments:

Figure 1 – Project Locus

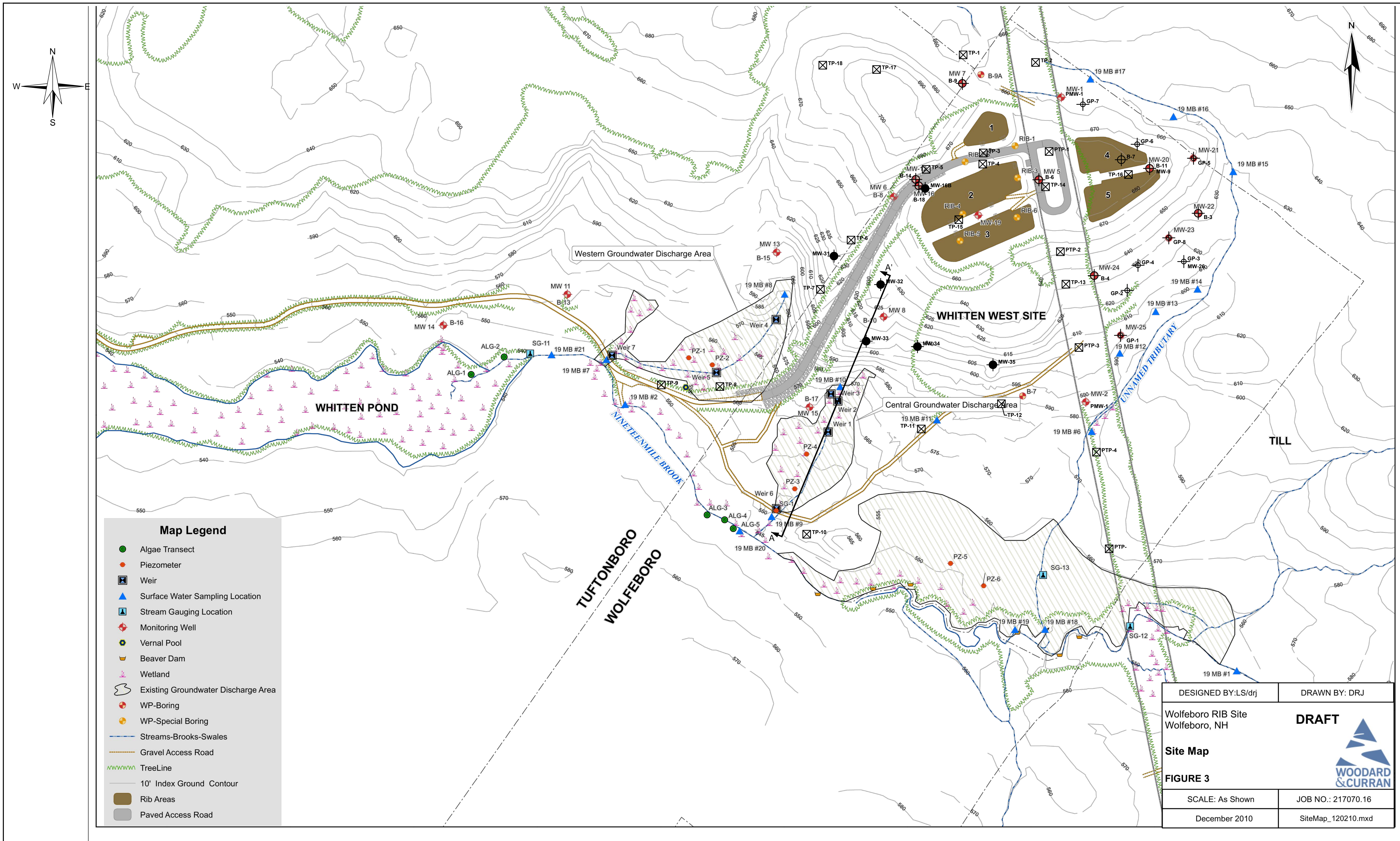
Figure 2 – Preliminary Slope Remediation Schematic

Appendix A – SEEP-W Model Outputs

Appendix B – Slide Model Outputs

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**HALEY & ALDRICH LEGEND:**

- TP-1 [Symbol] DESIGNATION AND APPROXIMATE LOCATION OF TEST PIT BY WRIGHT-PIERCE (TP AND PTP SERIES) (SEE NOTE 2)
- B-3 [Symbol] DESIGNATION AND APPROXIMATE LOCATION OF TEST BORING BY WRIGHT & PIERCE (B, MW AND PMW SERIES) (SEE NOTE 3)
- GP-1 [Symbol] DESIGNATION AND APPROXIMATE LOCATION OF GEOPROBE BY WESTON & SAMPSON (GP AND MW-21 TO MW-26 SERIES) (SEE NOTE 3)
- MW-31 [Symbol] DESIGNATION AND APPROXIMATE LOCATION OF TEST BORING BY S.W. COLE ENGINEERING, INC. (MW-31 TO MW-35 SERIES) (SEE NOTE 3)
- A-A' [Symbol] CROSS SECTION LOCATION

**NOTES:**

1. BASE PLAN CREATED FROM PLAN TITLED "WOLFEBORO RIB SITE, WOLFEBORO, NEW HAMPSHIRE, SITE MAP", FIGURE 3, DATED DECEMBER 2010 PREPARED BY WOODARD & CURRAN.
2. TEST PIT LOCATIONS TAKEN FROM PLAN TITLED "SITE PLAN, GROUNDWATER DISCHARGE PERMIT, TOWN OF WOLFEBORO, WOLFEBORO, NEW HAMPSHIRE", FIGURE 2, DATED JANUARY 2007 PREPARED BY WRIGHT-PIERCE AND PLAN TITLED "PLAN & PROFILE, STA 193+00 TO STA 205+00", DRAWING C-13, DATED MARCH 2007 AND PREPARED BY WRIGHT-PIERCE.
3. TEST BORING AND GEOPROBE LOCATIONS TAKEN FROM PLANS TITLED "TOWN OF WOLFEBORO, NEW HAMPSHIRE, DEPARTMENT OF PUBLIC WORKS, RAPID INFILTRATION BASIN SITE, SITE VISIT PHOTO LOCATIONS PLAN", FIGURE C-1, UNDATED, PREPARED BY WESTON & SAMPSON, "POTENTIOMETRIC SURFACE 07/21/11 SHALLOW WELLS/PIEZOMETERS," DATED NOVEMBER 2011 AND PREPARED BY S.W. COLE ENGINEERS, INC. AND "C-2 RAPID INFILTRATION BASINS #4 & #5 GRADING PLAN," DATED OCTOBER 2009, PREPARED BY WRIGHT-PIERCE.



**HALEY & ALDRICH** DONOVAN HATEM, LLP  
HYDROGEOLOGY AND ENGINEERING WORK  
WOLFEBORO, NEW HAMPSHIRE

**SITE AND SUBSURFACE EXPLORATION LOCATION PLAN**

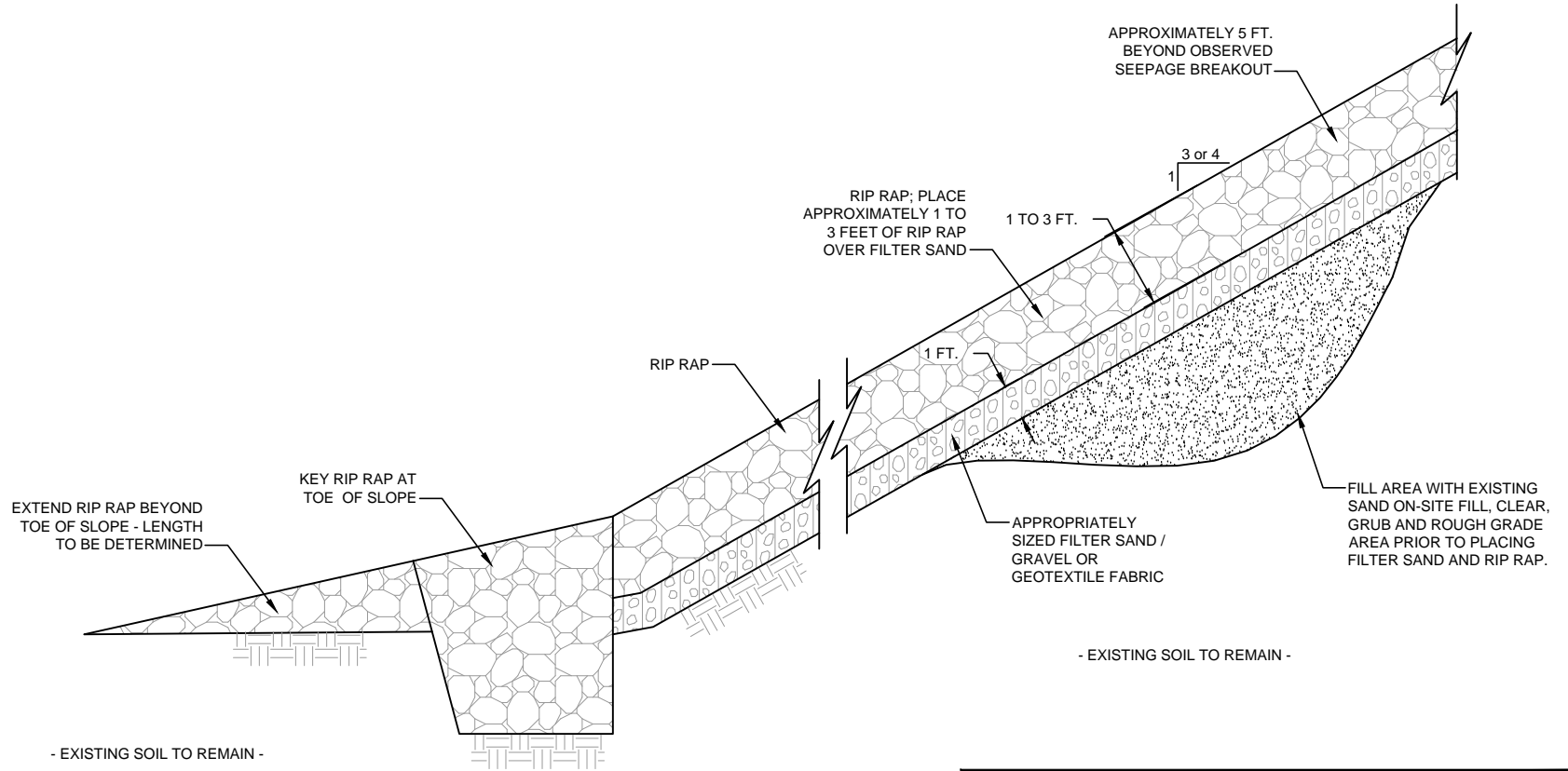
SCALE: AS SHOWN  
AUGUST 2013

FIGURE 1

C:\394229\CAD\394229-000-ELP.DWG



G:\39429\CAD\39429-001-0002\_SKCH.DWG



**HALEY & ALDRICH**

DONOVAN HATEM, LLP  
HYDROGEOLOGY AND ENGINEERING WORK  
WOLFEBORO, NEW HAMPSHIRE

PRELIMINARY SLOPE REMEDIATION  
SCHEMATIC

SCALE: NONE  
AUGUST 2013

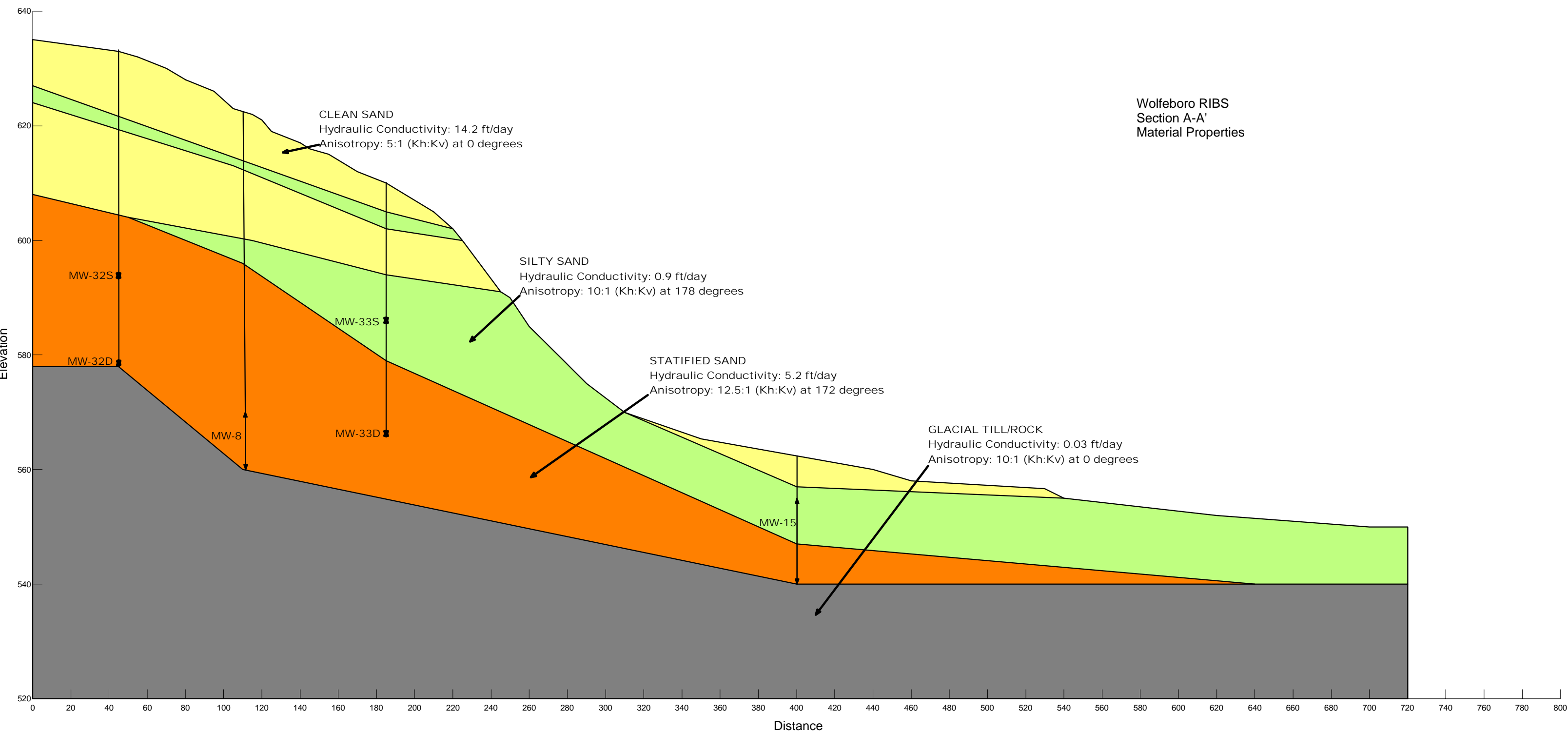
FIGURE 2

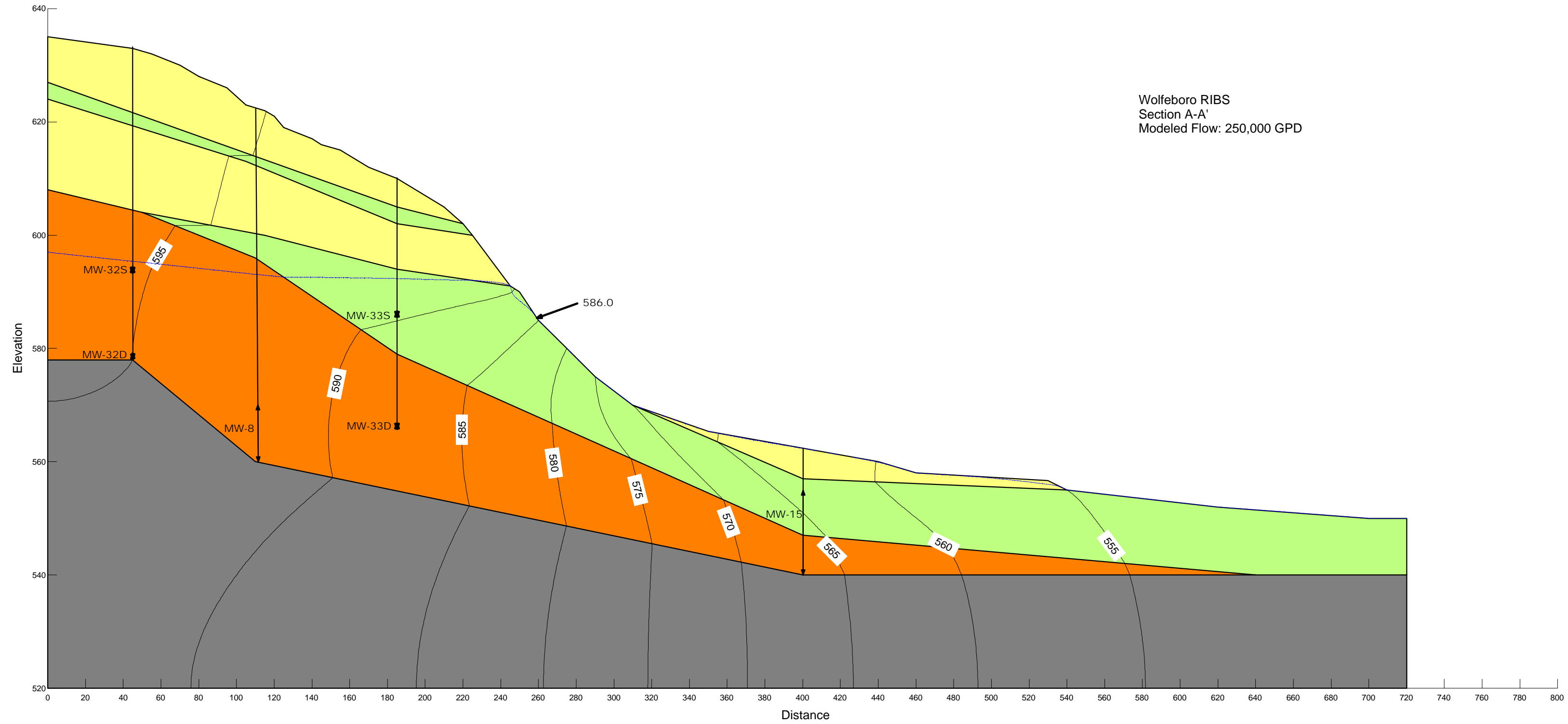


**APPENDIX A**

**SEEP-W Model Outputs**

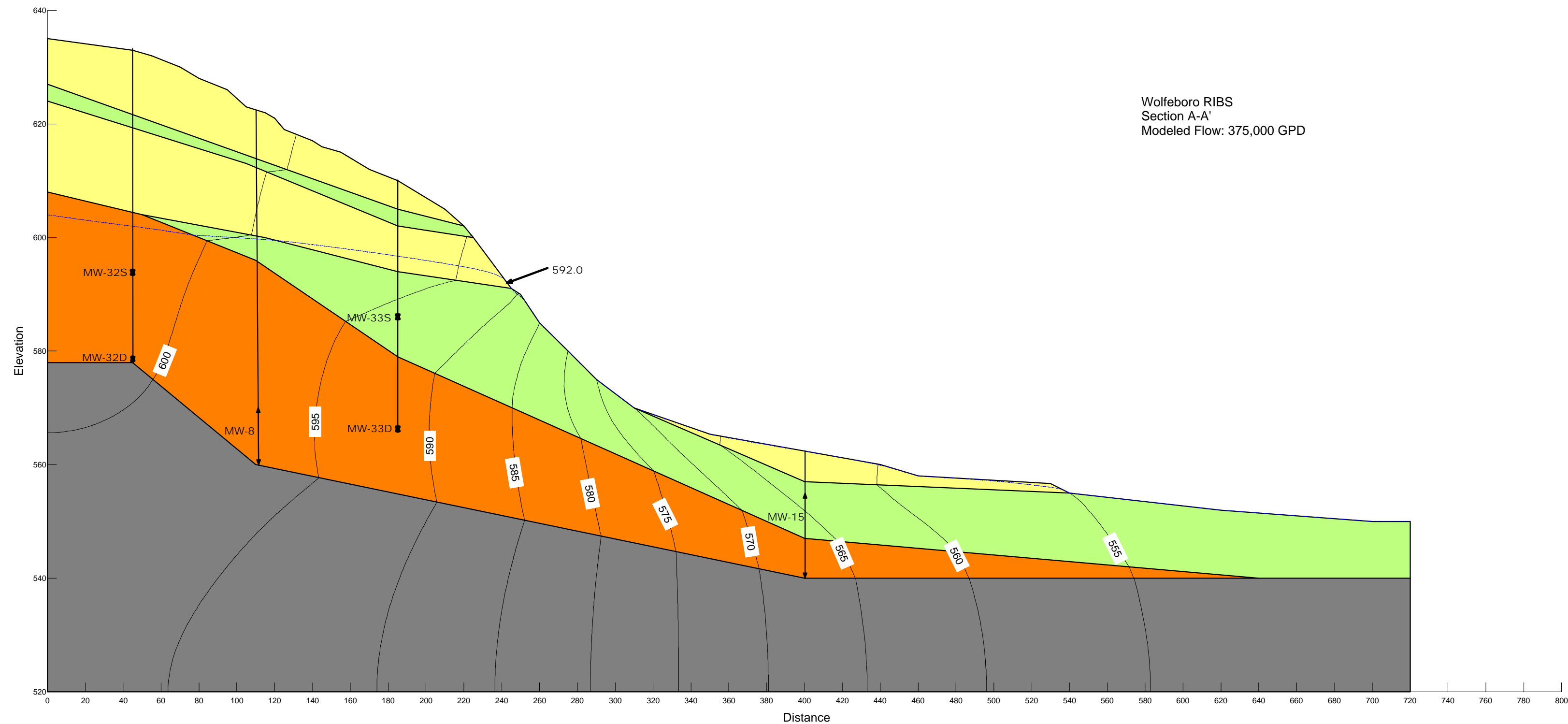
Wolfeboro RIBS  
Section A-A'  
Material Properties



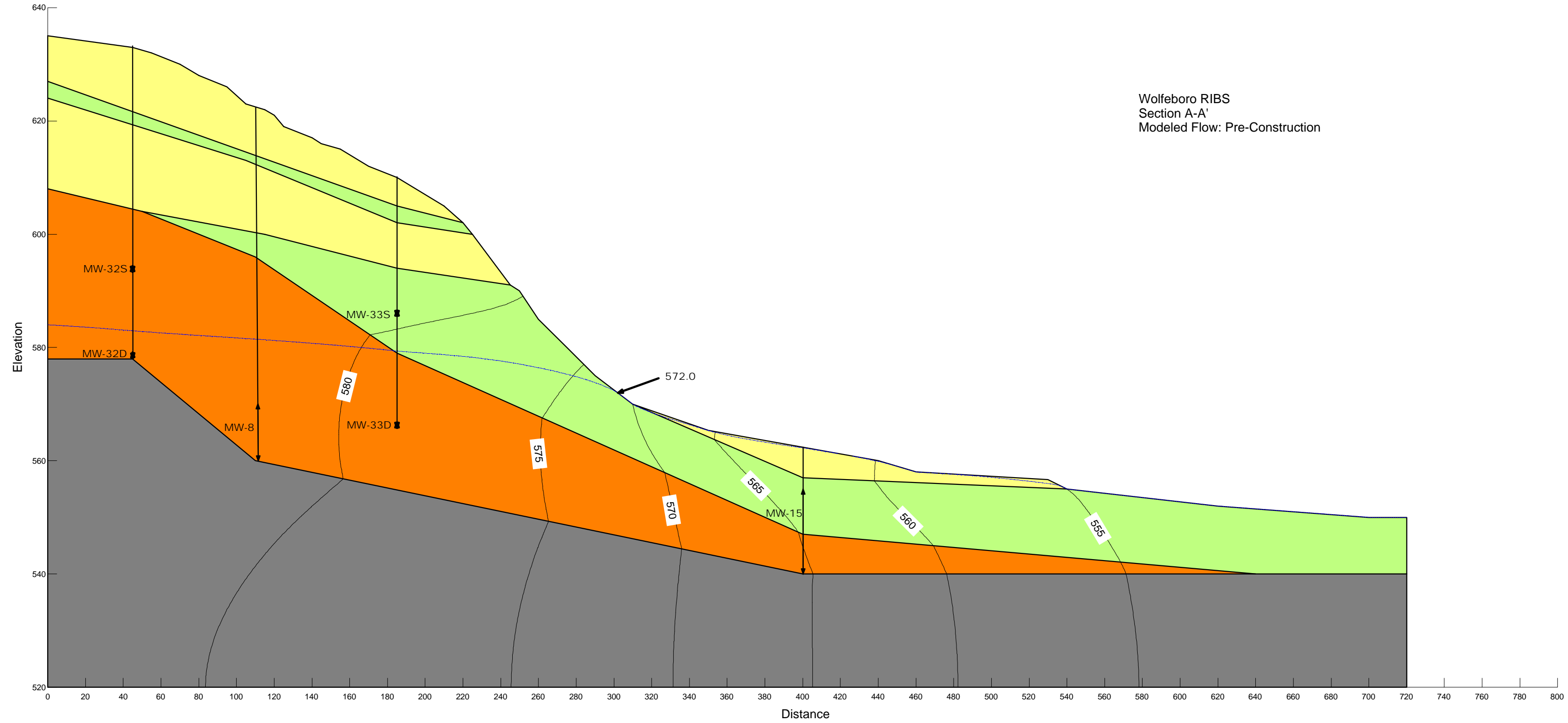


Wolfeboro RIBS  
Section A-A'  
Modeled Flow: 250,000 GPD

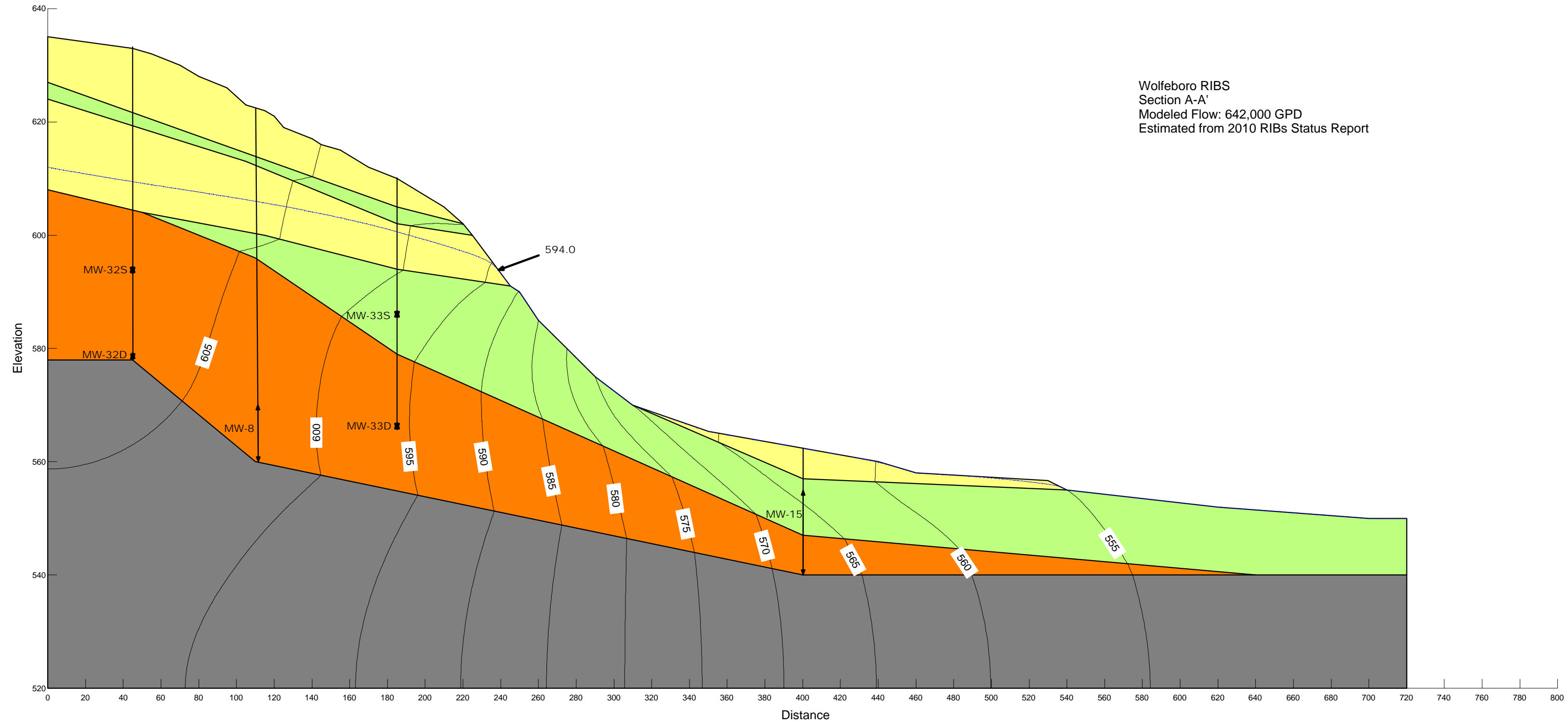
Wolfeboro RIBS  
Section A-A'  
Modeled Flow: 375,000 GPD



Wolfeboro RIBS  
Section A-A'  
Modeled Flow: Pre-Construction

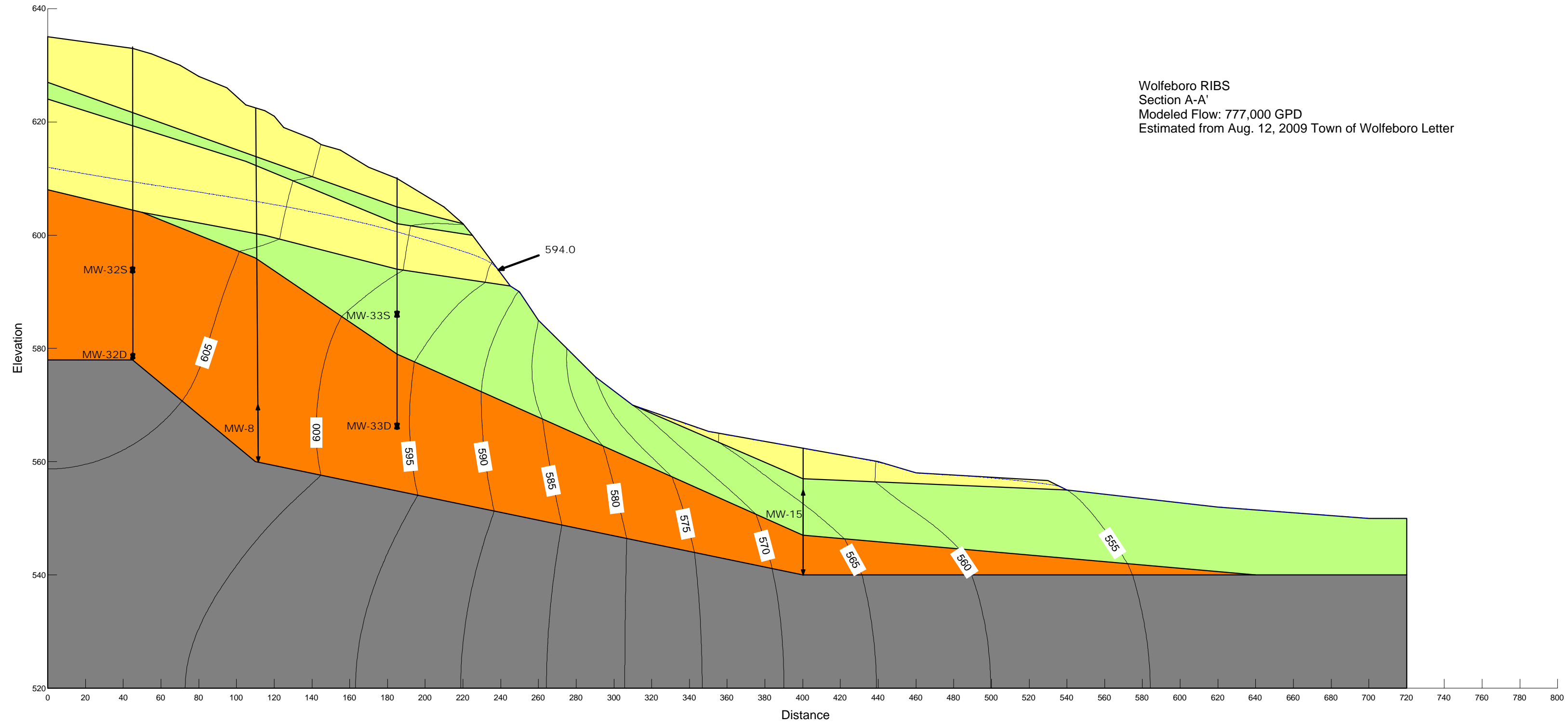


Wolfeboro RIBS  
Section A-A'  
Modeled Flow: 642,000 GPD  
Estimated from 2010 RIBs Status Report

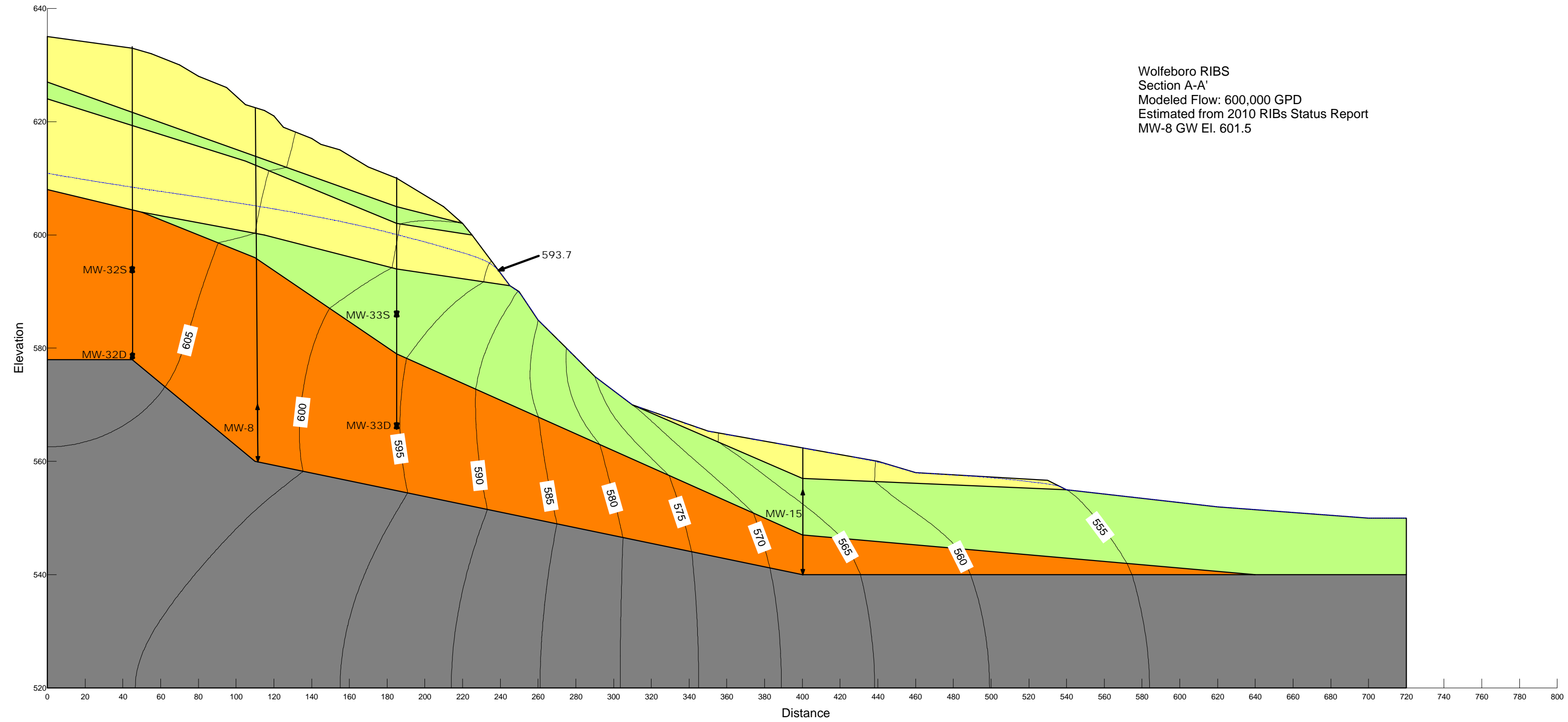




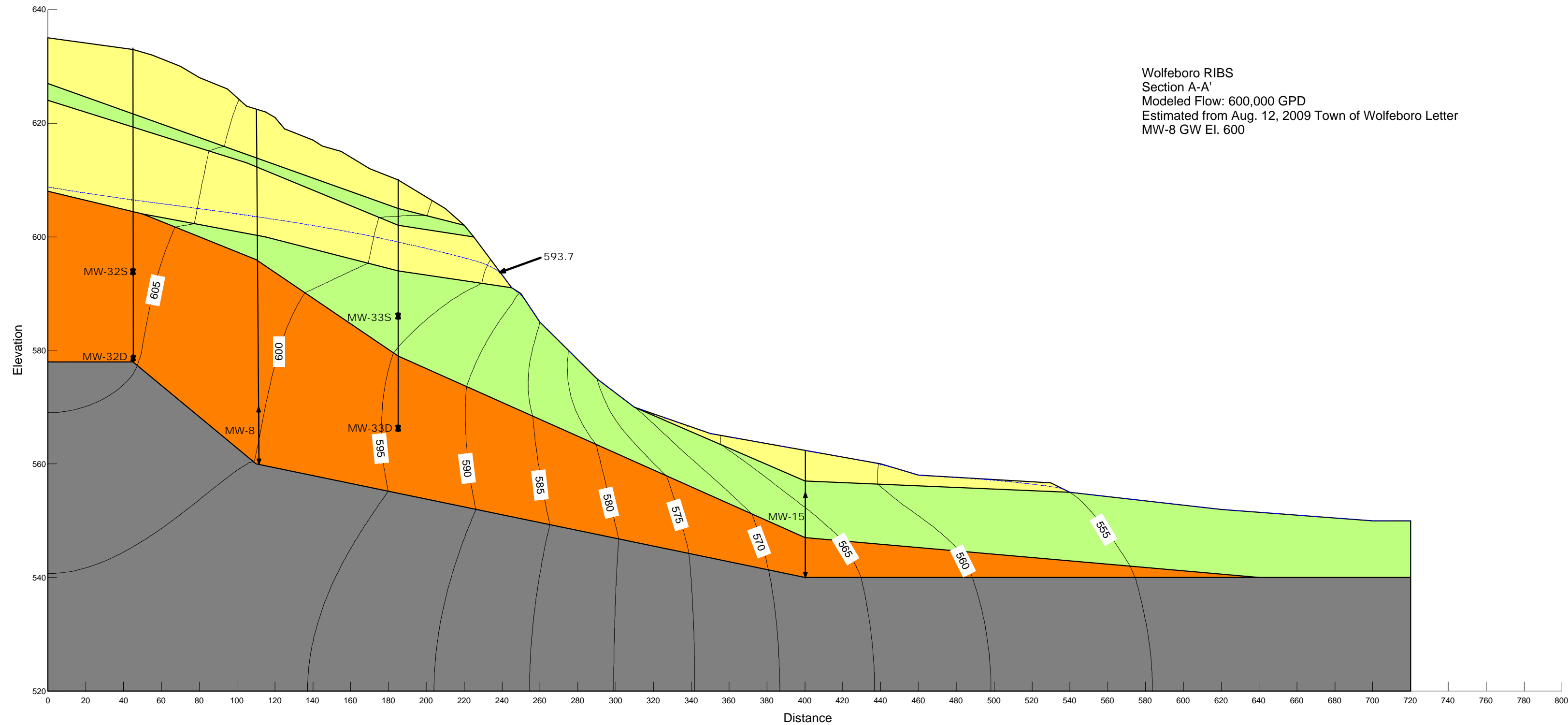
Wolfeboro RIBS  
Section A-A'  
Modeled Flow: 777,000 GPD  
Estimated from Aug. 12, 2009 Town of Wolfeboro Letter



Wolfeboro RIBS  
Section A-A'  
Modeled Flow: 600,000 GPD  
Estimated from 2010 RIBs Status Report  
MW-8 GW El. 601.5

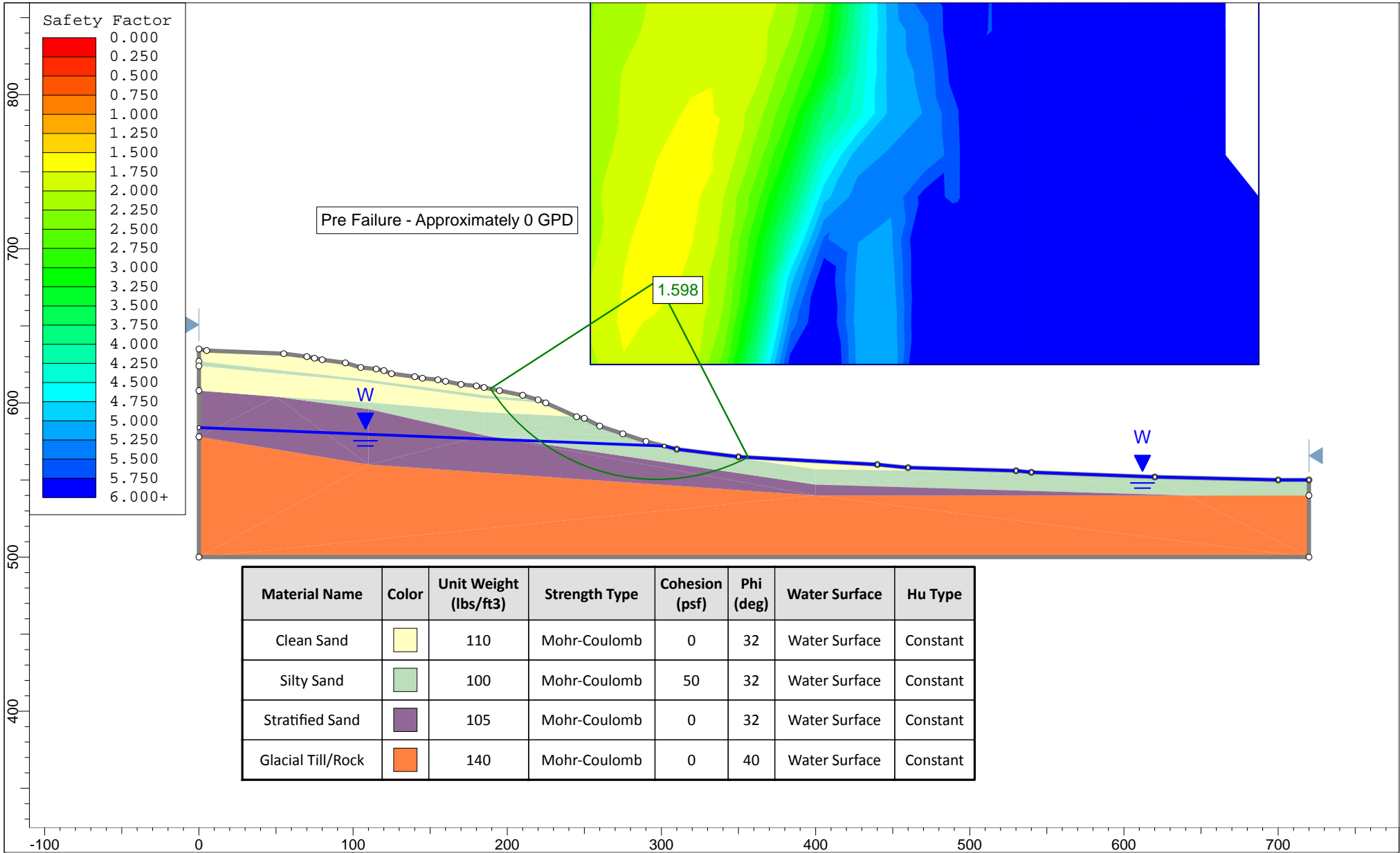






Wolfeboro RIBS  
Section A-A'  
Modeled Flow: 600,000 GPD  
Estimated from Aug. 12, 2009 Town of Wolfeboro Letter  
MW-8 GW El. 600



**APPENDIX B**

**Slide Model Outputs**

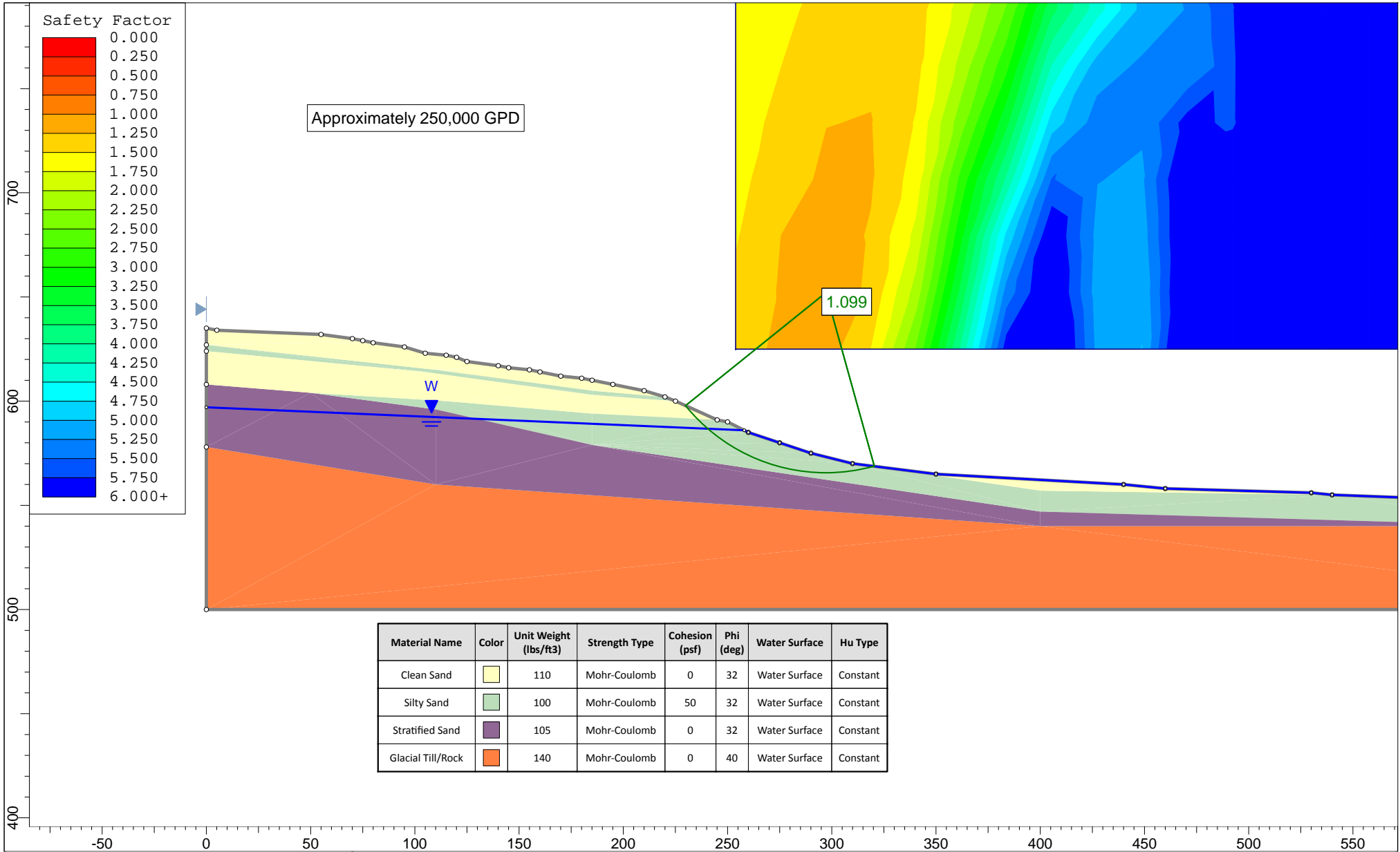



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type
Clean Sand		110	Mohr-Coulomb	0	32	Water Surface	Constant
Silty Sand		100	Mohr-Coulomb	50	32	Water Surface	Constant
Stratified Sand		105	Mohr-Coulomb	0	32	Water Surface	Constant
Glacial Till/Rock		140	Mohr-Coulomb	0	40	Water Surface	Constant



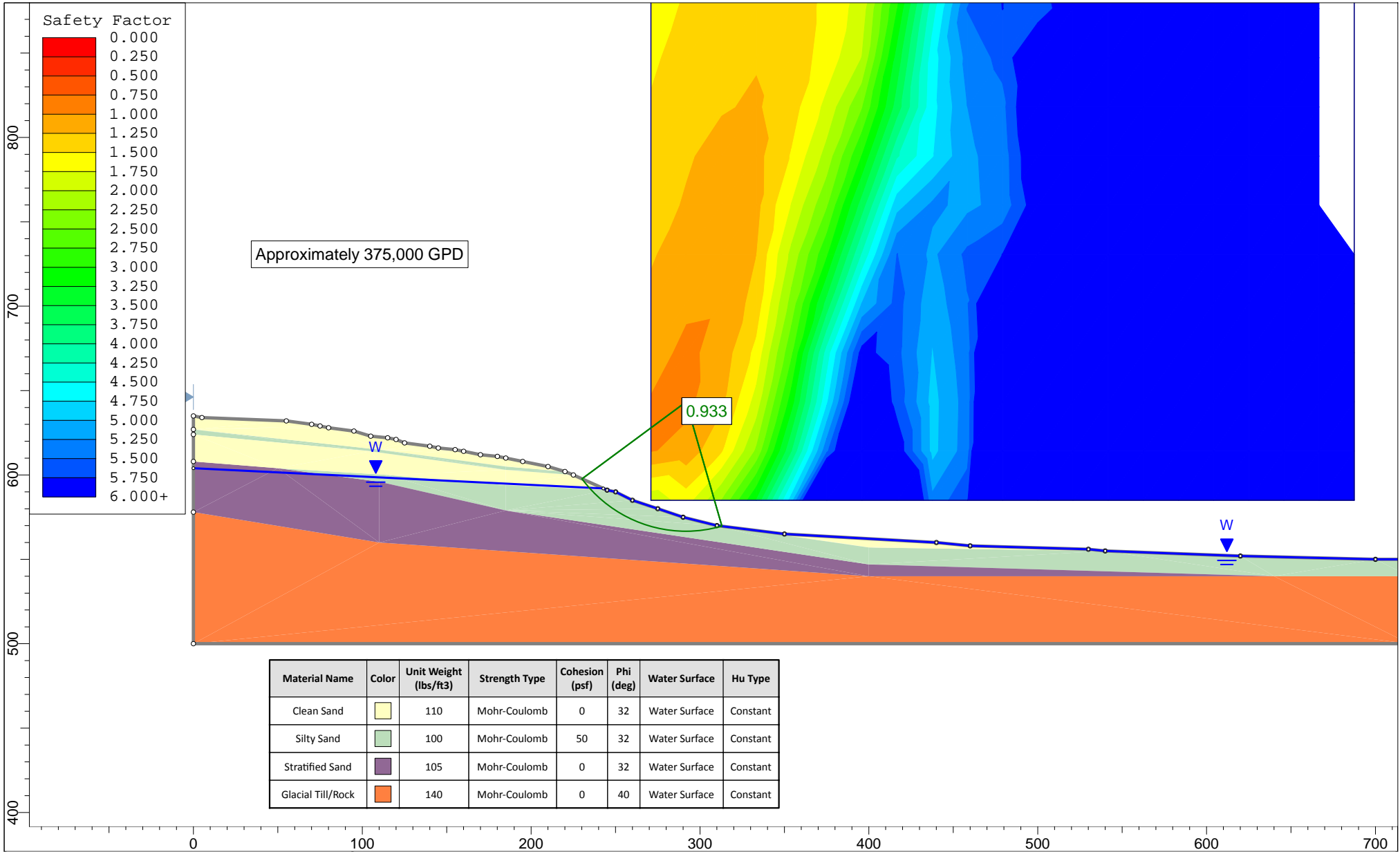
SLIDEINTERPRET 6.020

Project		Pre Failure Approximately 0 GPD	
Analysis Description		Geotechnical Slope Stability Review - Rapid Infiltration Basins - Wolfeboro, NH	
Drawn By	MMH	Scale	1:1034
Date	8/7/2013, 7:45:45 AM	Company	Haley & Aldrich, Inc.
		File Name 2013-0808-HAI-Wolfeboro Geotechnical Slope Stability Pre-Failure-Approx_0k Loading slim	

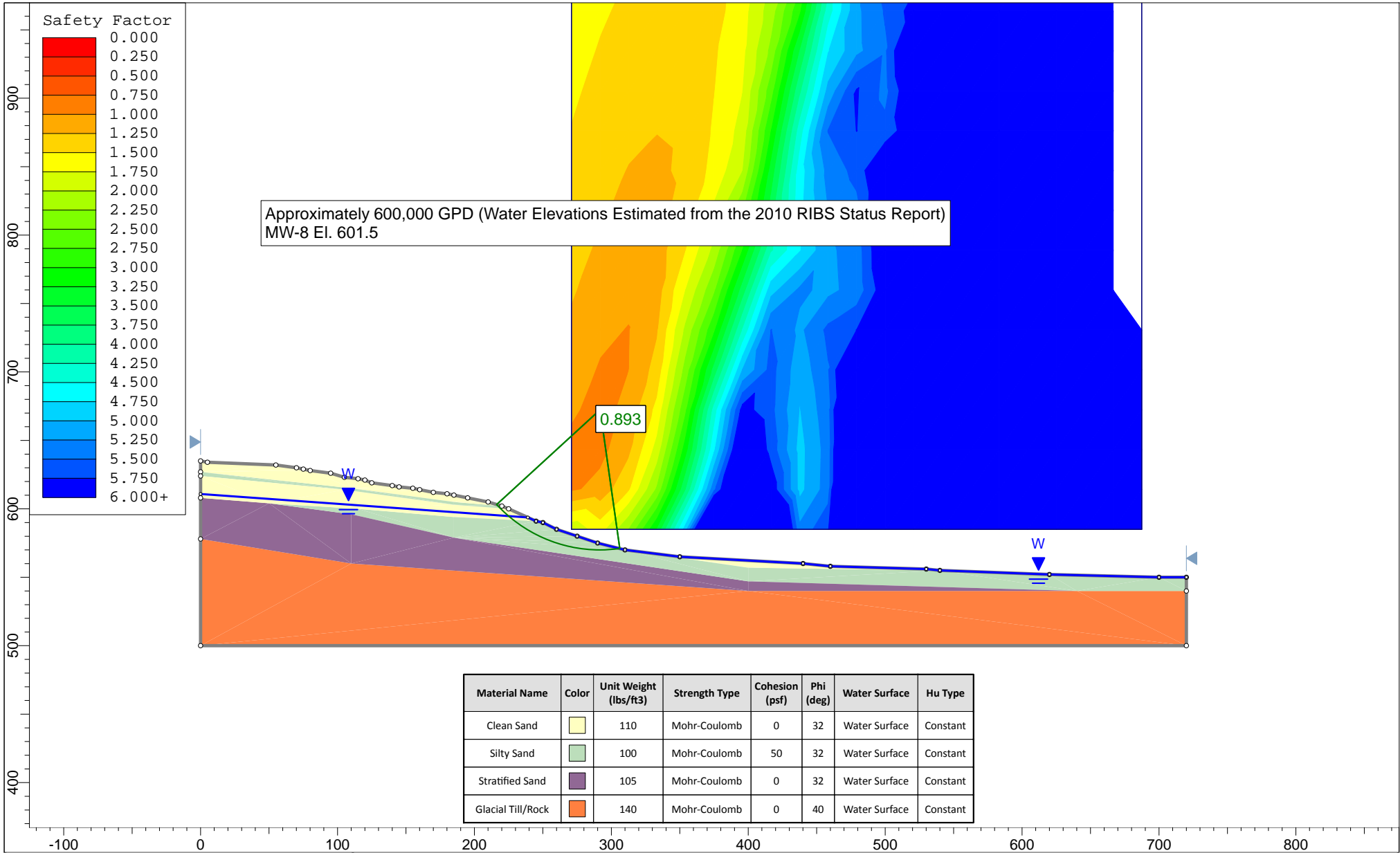



	Project			Approximately 250,000 GPD										
	Analysis Description						Geotechnical Slope Stability Review - Rapid Infiltration Basins - Wolfeboro, NH							
	Drawn By		MMH		Scale		1:764		Company		Haley & Aldrich, Inc.			
	Date						8/7/2013, 7:45:45 AM			File Name			2013-0808-HAI-Wolfeboro Geotechnical Slope Stability Post-Failure-Approx 250k Loading slim	

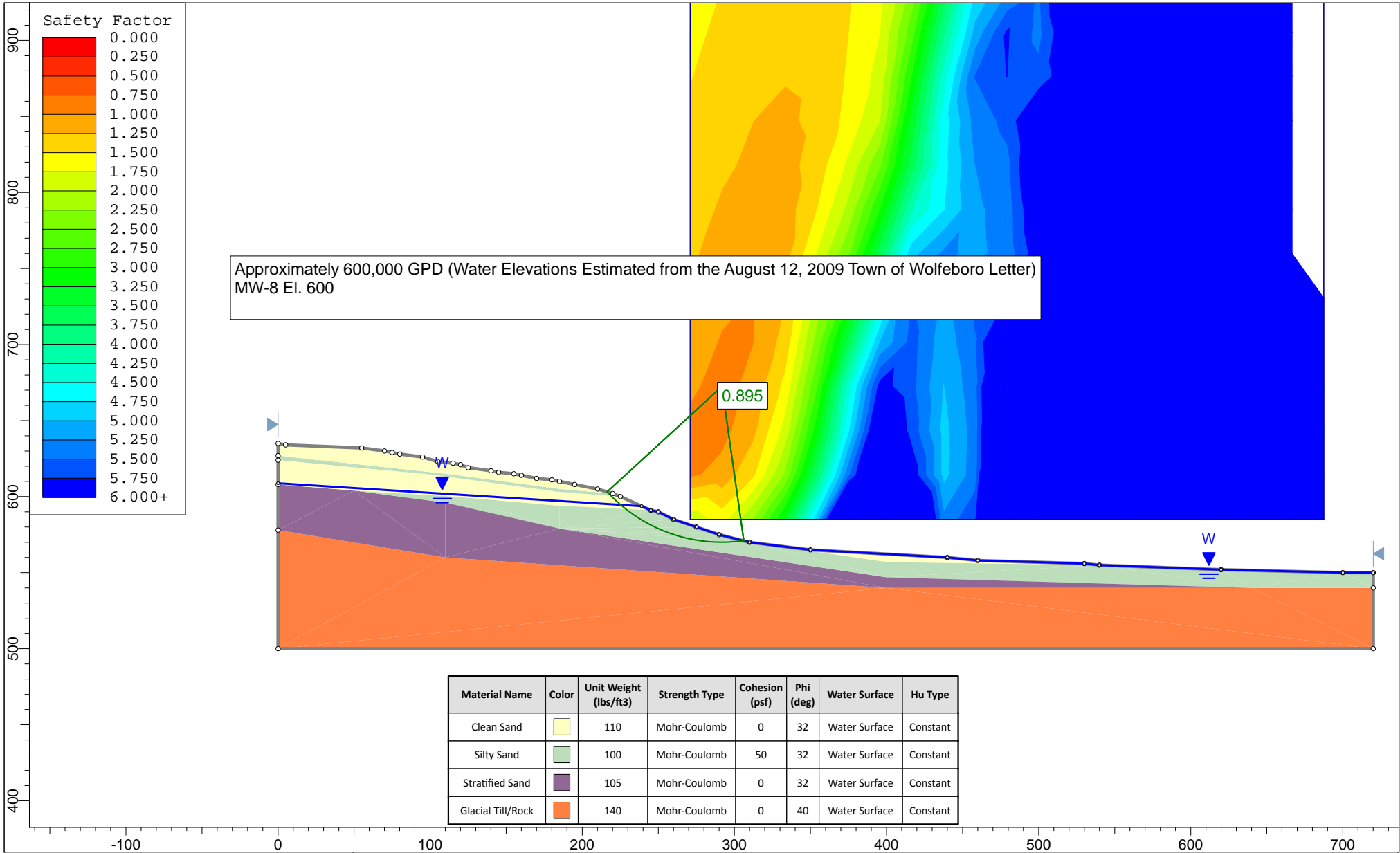




	Project			Approximately 375,000 GPD					
	Analysis Description						Geotechnical Slope Stability Review - Rapid Infiltration Basins - Wolfeboro, NH		
	Drawn By			Scale		Company			
	Date			File Name					
			1:943		Haley & Aldrich, Inc.				
8/7/2013, 7:45:45 AM			2013-0808-HAI-Wolfeboro Geotechnical Slope Stability			Post-Failure-Approx 375k Loading slim			



	Project			Approximately 600,000 GPD (Water Elevations Estimated from the 2010 RIBS Status Report)		
	Analysis Description			Geotechnical Slope Stability Review - Rapid Infiltration Basins - Wolfeboro, NH		
	Drawn By	MMH	Scale	1:1165	Company	Haley & Aldrich, Inc.
	Date	8/7/2013, 7:45:45 AM		File Name: 0815-HAI-Wolfeboro Geotechnical Slope Stability Near Failure-Approx. 600k Loading-Estimated from 2010 RIBS Report.slm		

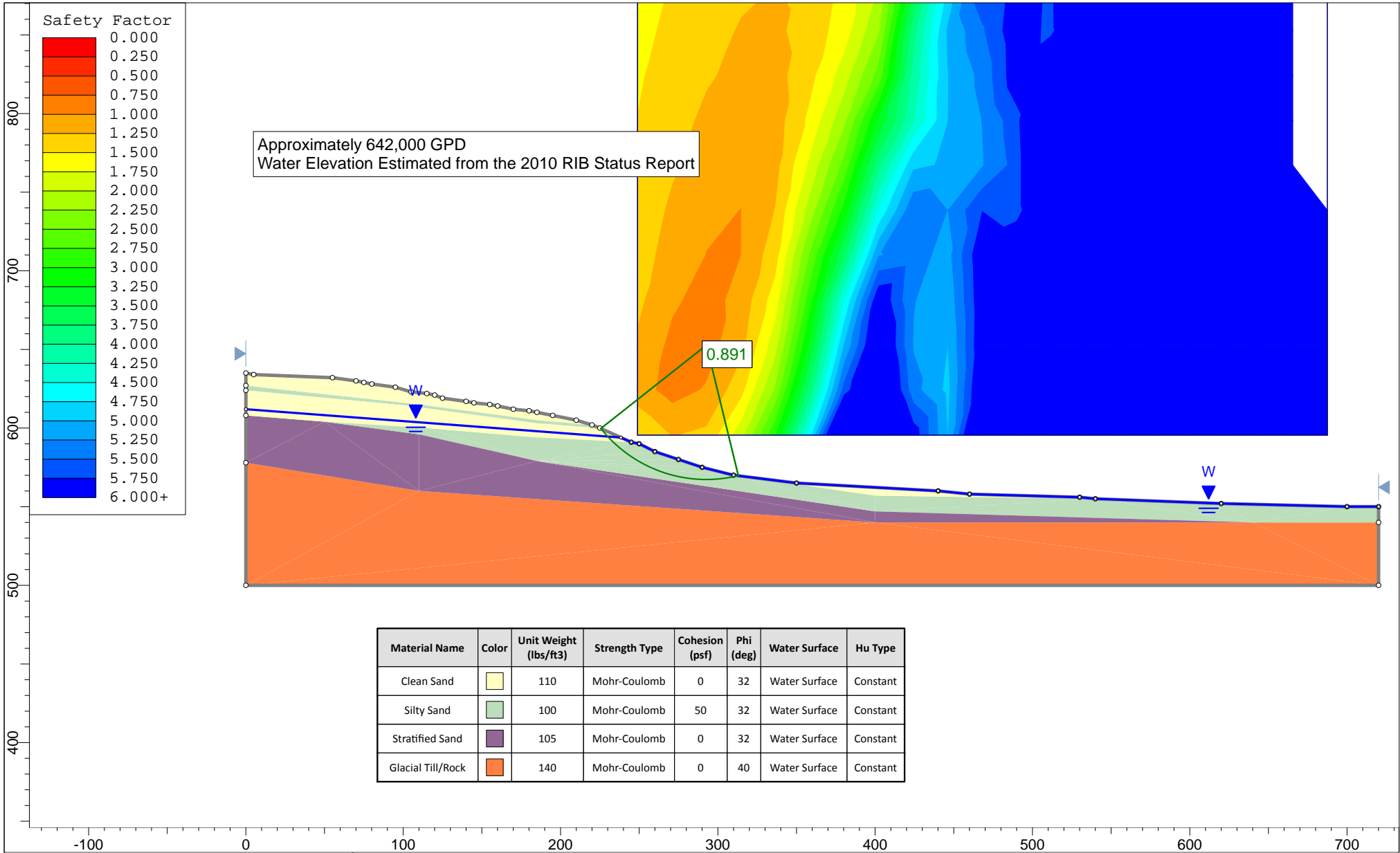


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type
Clean Sand	Yellow	110	Mohr-Coulomb	0	32	Water Surface	Constant
Silty Sand	Light Green	100	Mohr-Coulomb	50	32	Water Surface	Constant
Stratified Sand	Purple	105	Mohr-Coulomb	0	32	Water Surface	Constant
Glacial Till/Rock	Orange	140	Mohr-Coulomb	0	40	Water Surface	Constant



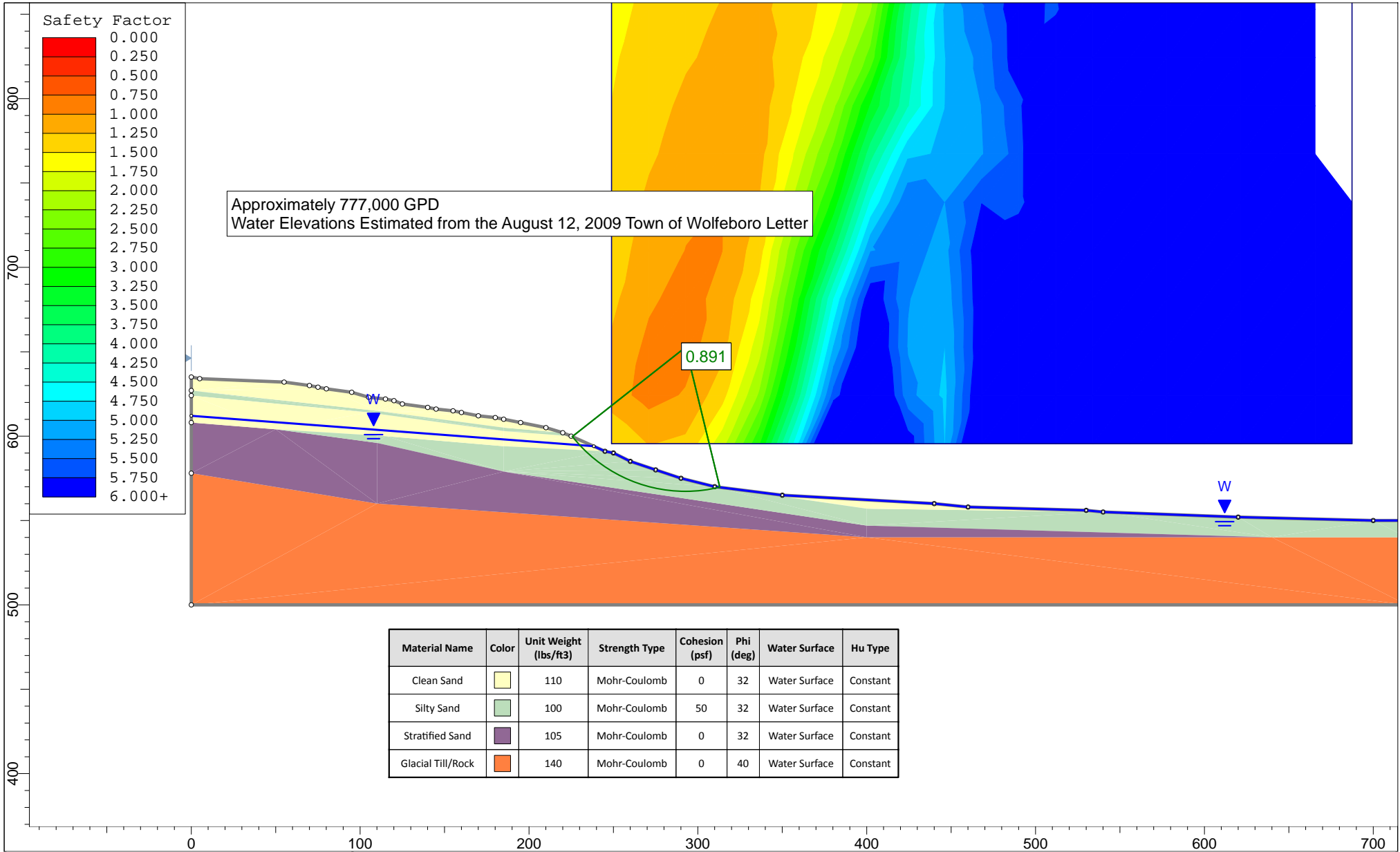
SLIDEINTERPRET 6.020

Project		Approximately 600,000 GPD (Water Elevations Estimated from the August 12, 2009 Town of Wolfeboro Letter)	
Analysis Description		Geotechnical Slope Stability Review - Rapid Infiltration Basins - Wolfeboro, NH	
Drawn By	MMH	Scale	1:1048
Date	8/7/2013, 7:45:45 AM	Company	Haley & Aldrich, Inc.
		File Name: 2013-0815-HAI-Wolfeboro Geotechnical Slope Stability Near Failure-Approx. 600k Loading-Estimated from Wolfeboro Letter slim	



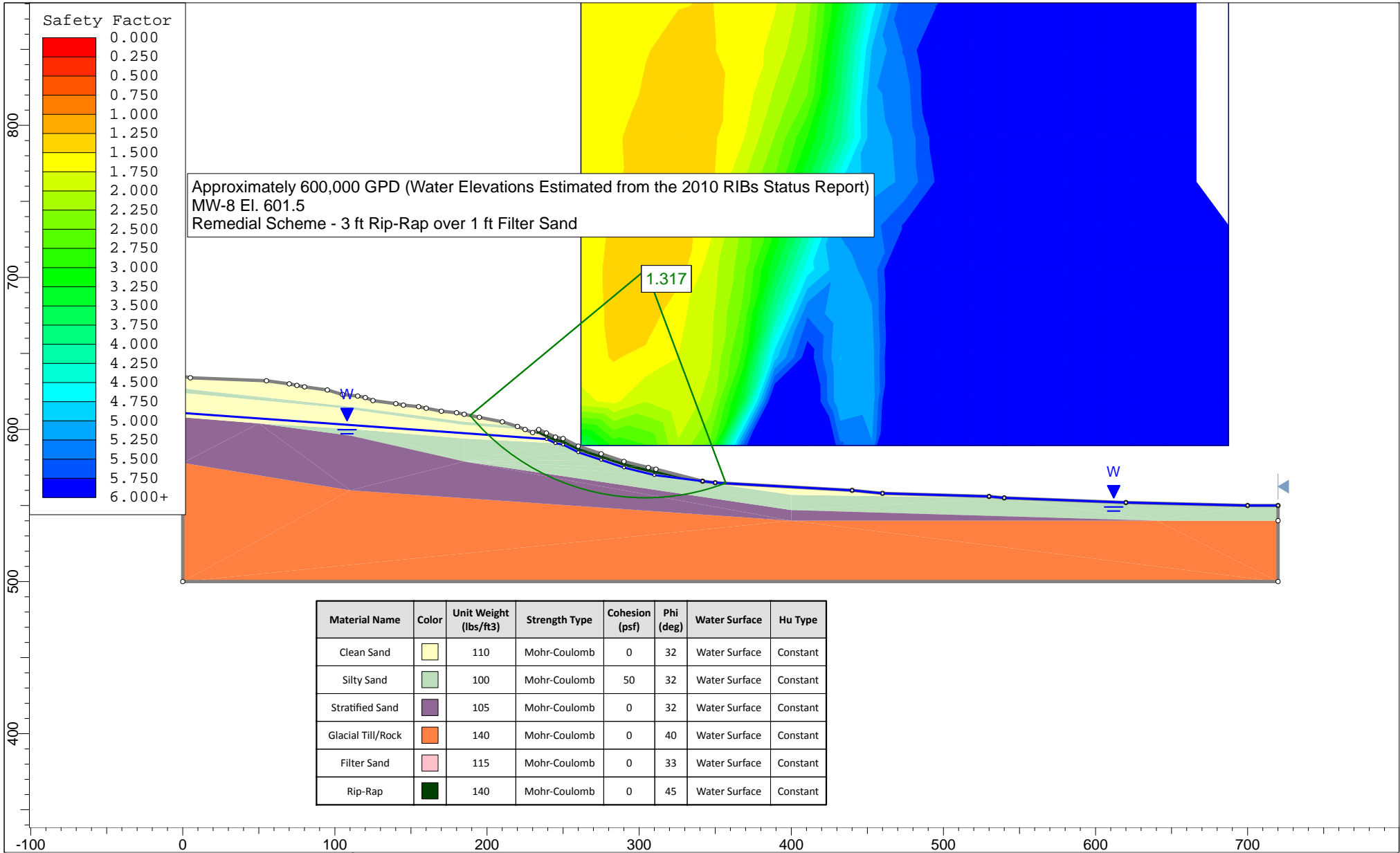
SLIDEINTERPRET 6.020

Project		Approximately 642,000 GPD (Water Elevations Estimated from the 2010 RIBS Status Report)	
Analysis Description		Geotechnical Slope Stability Review - Rapid Infiltration Basins - Wolfeboro, NH	
Drawn By	MMH	Scale	1:1014
		Company	Haley & Aldrich, Inc.
Date	8/7/2013, 7:45:45 AM		File Name
		2013-0815-HAI-Wolfeboro Geotechnical Slope Stability Near-Failure-Approx_642k Loading slim	



SLIDEINTERPRET 6.020

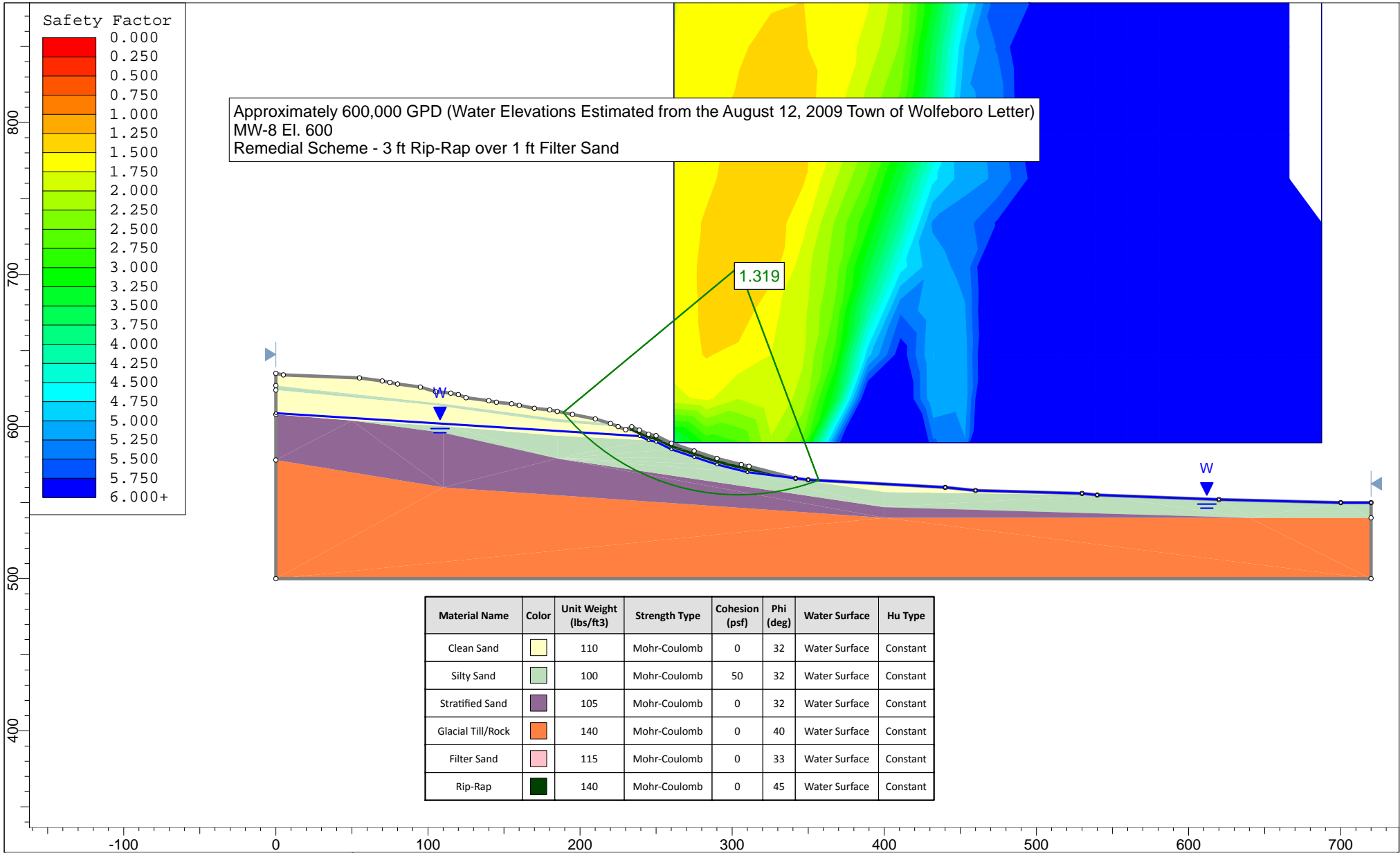
<i>Project</i>			
Approximately 777,000 GPD (Water Elevations Estimated from the August 12, 2009 Town of Wolfeboro Letter)			
<i>Analysis Description</i>			
Geotechnical Slope Stability Review - Rapid Infiltration Basins - Wolfeboro, NH			
<i>Drawn By</i>		<i>Scale</i>	<i>Company</i>
MMH		1:943	Haley & Aldrich, Inc.
<i>Date</i>		<i>File Name</i>	
8/7/2013, 7:45:45 AM		2013-0815-HAI-Wolfeboro Geotechnical Slope Stability Near-Failure-Approx_777k Loading slim	



SLIDEINTERPRET 6.020

Project			
Approximately 600,000 GPD -- Remedial Scheme 3 ft Rip-Rap -- Water Elevations Estimated from the 2010 RIBs Status Report			
Analysis Description			
Geotechnical Slope Stability Review - Rapid Infiltration Basins - Wolfeboro, NH			
Drawn By		Scale	Company
MMH		1:1048	Haley & Aldrich, Inc.
Date		File Name	
8/7/2013, 7:45:45 AM		Approx. 600k Loading-Remedial Scheme-3 ft Rip-Rap-From RIBs	





SLIDEINTERPRET 6.020

Project Approximately 600,000 GPD -- Remedial Scheme 3 ft Rip-Rap -- Water Elevations Estimated from the August 12, 2009 Town of Wolfeboro Letter			
Analysis Description Geotechnical Slope Stability Review - Rapid Infiltration Basins - Wolfeboro, NH			
Drawn By MMH	Scale 1:1048	Company Haley & Aldrich, Inc.	
Date 8/7/2013, 7:45:45 AM		File Name Approx. 600k Loading-Remedial Scheme-3 ft Rip-Rap-From Wolfeboro	