STATE OF MAINE
LAND USE REGULATION COMMISSION

PLUM CREEK
ZONING PETITION ZP 707

PREFILED DIRECT TESTIMONY OF
JONATHAN A. QUEBBEMAN, P.E., L.S.E.

SUBMITTED ON BEHALF OF MAINE AUDUBON AND NATURAL RESOURCES COUNCIL OF MAINE IN REGARDS TO PLUM CREEK'S APPLICATION FOR MOOSEHEAD LAKE REGION CONCEPT PLAN

I. Introduction

Maine Audubon and the Natural Resources Council of Maine (NRCM) have requested an assessment of potential water quality impacts to a series of receiving water bodies due to potential development as proposed by Plum Creek. I was tasked to complete an assessment of these water quality impacts using the best available information, and completing any required information where it may have been missing or unavailable. These assessments were developed to provide a *magnitude* of potential impacts, rather than absolute engineered values. There are still many unknowns with respect to development locations, sizes of development, site grading and water quantity/quality controls. Although there are many unknowns, this assessment is designed to provide a basis for comparison and discussion of potential water quality impacts, and to provide biologists a tool to evaluate possible impacts to ecological systems.

II. Biographical Information

My name is Jonathan Quebbeman and I am a Water Resources Engineer with Kleinschmidt Associates, and also a registered Professional Engineer with the State of Maine. My work at Kleinschmidt entails both hydraulic and hydrologic studies. I regularly work with Geographic Information Systems (GIS) and other Hydraulic and Hydrologic (H&H) software packages. I have performed watershed wide water quality and vulnerability studies, watershed management plans and water quality studies.

Throughout my career, I have held positions involved in site development, stormwater management and water quality. I graduated from the University of Iowa with a degree in Civil Engineering, and have graduate experience in the Water Resources program at the Iowa Institute of Hydraulic Research (IIHR). During this time, I obtained my Grade II Water Treatment certification for the operation of a Grade IV water treatment facility. This position involved continuous water treatment and testing operations, including suspended solids, turbidity, pH, nitrates, hardness and other water quality parameters.

I previously worked for Land Use Consultants, Inc. in Portland, Maine, as a Civil Engineer performing site development and analysis projects. This position involved working with Landscape Architects, State and local agencies and developers through the process of site development and permitting. I worked on site layouts, road layouts, open spaces, stormwater management plans, erosion and sedimentation plans, BMP design and water quality analyses. Many of these projects involved working through the permitting processes which required meeting with various agencies to determine how the project may comply with local and State regulations. During this time, I also obtained my State of Maine Site Evaluation license for the evaluation of soils to locate and design septic systems.

III. Executive Summary

Runoff from development contains pollution that can harm streams and ponds. Pollution in runoff can include temperature (thermal) pollution, phosphorus loadings and lowered dissolved oxygen (DO) from increased Biochemical Oxygen Demand (BOD).[1].

Kleinschmidt Associates (Kleinschmidt) estimated the water quality impacts to a number of streams and Burnham Pond due to Plum Creek's proposed large-scale resort developments in the Moose Mountain and Lily Bay areas . Kleinschmidt used Geographic Information Systems (GIS) and standard water quality computer models to predict water quality impacts. Terrence J. DeWan and Associates, Landscape Architects/Planners, developed sketches of the extensive buildouts that Plum Creek's proposed concept plan would allow around Moose Mountain and Lily Bay. Kleinschmidt assembled these sketches into GIS format and then quantitatively estimated the impacts from the development on water quality.

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[1] BOD is measure of organic matter that rots (is consumed by bacteria) when it enters water. As bacteria consume this organic matter, they use oxygen ion the water to metabolize it, just as we breathe oxygen from the air to metabolize food we eat.

1. Harmful Impacts of the proposed development on water quality in the Moose Mountain Area

- As estimated by Terrence J. DeWan and Associates, the proposed Plum Creek plan would allow 305 housing lots/units in the Burnham Pond watershed. Phosphorus runoff from these lots, units and roadways at this level of development would result in algae blooms in Burnham Pond, thus causing it to violate its water quality classification (Class GPA). **Development on this scale cannot fit in the Burnham Pond watershed.**
- Typical larger summertime storms in this area would likely cause dissolved oxygen levels to drop significantly in Burnham Pond because runoff from these storms would contain waste from the proposed development sites. As this polluted water drains from Burnham Pond into Burnham Brook, which is a Class A stream that runs between Burnham Pond and Indian Pond, it will likely cause a violation of Class A dissolved oxygen standards in the brook.
- The proposed Plum Creek plan would result in very large increases in temperature in Lower Burnham Brook (3.3 to 4.4 degrees Celsius, Figure 4). These increases could affects the brook's suitability as brook trout habitat (see testimony of Brandon Kulik, Fisheries Biologist, Kleinschmidt Associates).
- The area of impervious surfaces (surfaces that do not absorb water) would exceed 10% (Figure 3) in the Burnham Brook watershed. According to DEP water quality expert Jeff Dennis (personal Communication, August 27, 2007) the vast majority of streams with 10% impervious surfaces in their watersheds that have been studied do not even meet Class B water quality standards for aquatic life, which are significantly less strict than Class A standards.

2. Harmful impacts of the proposed development on water quality in the Lily Bay area.

- The Development in the Lily Bay Area would cause significant increases in water temperature in Burgess Brook (about 1.5 degrees Celsius) and in an unnamed Class A stream Labeled LB Moosehead 3 (Figure 2). Again, this could affect the ability of the stream to serve as habitat for trout (see testimony of Brandon Kulik, Fisheries Biologist, Kleinschmidt Associates)
- The development in the Lily Bay area will result in a major increase in impervious surface in the stream watersheds there (Figure 1). Again, pollution in runoff from impervious surfaces can include temperature (thermal) pollution, phosphorus loadings and lowered dissolved oxygen (DO) from increased Biochemical Oxygen Demand (BOD).

3. Conclusion

In summary, development on the scale that Plum Creek is proposing in the Moose Mountain and Lily Bay areas will likely cause detrimental impacts on water quality sufficient to cause violations of water quality standards through potentially low DO levels, increased thermal pollution above what may be considered natural, and excessive phosphorus loadings to ponds and streams.

IV. Overview of Analysis

The proposed Plum Creek development areas around Moose Mountain and Lily Bay contain Class A streams and Burnham Pond, which is Class GPA. The classification of streams is defined in Title 38, Chapter 3, Subsection 465 'Standards for classification of fresh surface waters'. Class A waters include the following two standards:

- *Class A waters shall be of such quality that they are suitable for the designated uses of drinking water after disinfection; fishing; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403; and navigation; and as habitat for fish and other aquatic life. The habitat shall be characterized as natural.*
- *The dissolved oxygen content of Class A waters shall be not less than 7 parts per million or 75% of saturation, whichever is higher. The aquatic life and bacteria content of Class A waters shall be as naturally occurs.*

Class GPA waters are defined in Title 38, Chapter 3, Subsection 465-A, which includes the following standards:

- *Class GPA waters shall be of such quality that they are suitable for the designated uses of drinking water after disinfection, recreation in and on the water, fishing, industrial process and cooling water supply, hydroelectric power* *generation and navigation and as habitat for fish and other aquatic life. The habitat shall be characterized as natural.*

- *Class GPA waters shall be described by their trophic state based on measures of the chlorophyll "a" content, Secchi disk transparency, total phosphorus content and other appropriate criteria. Class GPA waters shall have a stable or decreasing trophic state, subject only to natural fluctuations and shall be free of culturally induced algal blooms which impair their use and enjoyment.*
- *A change of land use in the watershed of a Class GPA water body may not, by itself or in combination with other activities, cause water quality degradation that impairs the characteristics and designated uses of downstream GPA waters or causes an increase in the trophic state of those GPA waters.*

This study is meant to evaluate any potential impacts that would cause a violation of either Class A or Class GPA standards.

This study has taken many different sources of data and combined them into one GIS for analysis of three major pollutants: Phosphorus, Temperature and Biochemical Oxygen Demand (BOD). Sketches of potential development, produced by Terrence J. DeWan Associates, were used as a basis for locating developments and impervious surfaces. Developments studied in this analysis are limited to Lily Bay and Moose Mountain developments, and include receiving water bodies such as North Brook, Burnham Pond, Burgess and Burnham Brooks.

Assessment of phosphorus has included an evaluation of the phosphorus report and calculations as prepared by DeLuca-Hoffman Associates[2]. They completed preliminary phosphorus loading calculations for lakes that Plum Creek is proposing to develop around as described in Appendix C of the plan.

Thermal impacts due to runoff were evaluated strictly from a percent impervious area standpoint. As pavement, rooftops and other impervious surfaces heat during the day, precipitation from a storm event will pass over these surfaces, and cool them by transferring their thermal energy to the run-off. Summaries of potential thermal impacts from the different subcatchments was completed.

1. Tools & Methodology

The following tools and methods were used to complete this evaluation:

a. Geographical Information Systems (GIS) Analysis

A GIS was developed to complete summaries of available data for analysis. Information assembled in the GIS included:

- Development Locations (Buildings, Roads, Golf Courses, etc.)
- Subcatchments (NHDPlus)
- Soils
- Forest Cover
- Aerial Imagery

[2] DeLuca-Hoffman, April, 2007

b. TURM (Thermal Urban Runoff Model)[3]

This is a model developed by the University of Wisconsin for estimating increases in runoff temperatures from urban developments, and is based on percent of impervious area within the watershed.

c. Phosphorus Control in Lake Watersheds

Phosphorus methods developed by the Maine Department of Environmental Protection were followed in the assessment of phosphorus allocations and loadings.

2. Modeled Results and Findings

a. BOD (DO) Loadings from Development

Urban development will lead to changes in runoff characteristics and water quality. One major factor determining water quality is Dissolved Oxygen (DO), which is partly controlled through the Biochemical Oxygen Demand (BOD)[4] on the system. If there is insufficient retention time in the system, there may be a BOD loading, but there may be insufficient hydraulic retention time for this BOD to reduce the DO within the system. The following are results of an assessment of BOD and how it may effect DO for the Lily Bay and Moose Mountain Developments:

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[3] Thermal Urban Runoff Model available at: http://www.countyofdane.com/landconservation/thmodelpg.htm

[4] BOD is measure of organic matter that rots (is consumed by bacteria) when it enters water. As bacteria consume this organic matter, they use oxygen in the water to metabolize it, just as we breathe oxygen from the air to metabolize food we eat.

i. Lily Bay

- Development in Lily Bay will result in increased levels of BOD in runoff due to changes in landcover.
- Hydraulic retention times for most of the Lily Bay development are insufficient to reach lower DO levels due to BOD loading.
- If certain BMP's are used for onsite stormwater treatment, they may increase the retention time sufficiently to create periods of low DO stormwater runoff to be released to receiving streams.
- Further studies are needed with a more detailed site design to determine the potential effects of delayed runoff on DO from increased BOD loading.

ii. Moose Mountain

- Burnham Pond may receive runoff with high levels of BOD from large developed areas upstream
- Burnham Pond provides an area of significant hydraulic retention time; discharge from Burnham Pond may have reduced levels of DO from upstream BOD loading after larger storm events.

- Burnham Pond is susceptible to increased summertime temperatures due to its larger surface area and minimal depth. Higher temperatures have lower levels of DO saturation, leaving less DO available for BOD oxidation.
- BMP's may increase the hydraulic retention time of stormwater runoff, and allow for decreased levels of DO discharged to receiving streams.
- Significant BOD loadings to Burnham Pond have a potential to reduce the DO to less than 7.0 mg/l in Burnham Pond. This would result in a violation of Class A standards (less than 7 mg/l or 75% of DO saturation) in the water in Burnham Brook, which is the outlet brook for Burnham Pond.

Summertime DO levels were spot-measured on August 17, 2007 in Burnham Pond. Two measurements captured both the morning oxygen deficit, and an afternoon saturation level. DO increased from 8.7 (18.5 °C) to 9.4 mg/L (21.1 °C) throughout the day. The afternoon reading is above saturation levels at this temperature, and is likely an invalid reading, but nonetheless indicates that the water was likely near DO saturation levels of approximately 9.0 mg/l. During this period, if the pond were loaded with BOD at 10.0 mg/l, the outflow (i.e., the water in Burnham Brook) at critical deficit would have a DO level of approximately 6.5 mg/l, below the 7.0 mg/l and 75% saturation dissolved oxygen levels required by the class A standards. This would be a violation of Class 'A' water quality standards.

b. Phosphorus Loadings from Development

i. Lily Bay

We did not model phosphorus runoff levels for Lily Bay because DEP does not have a phosphorus allocation for Moosehead Lake. Although phosphorus loading to receiving streams was not calculated because DEP lacks numeric standards for phosphorus in streams, it should be considered. Due to changes in land cover from wooded to developed and urban, there will be an increase in the loading of phosphorus to receiving streams. Any increased phosphorus loadings may result in increased algae production, resulting in a degradation of stream water quality and potentially a violation of the streams' water quality classification.

ii. Moose Mountain

Phosphorus calculations for Moose Mountain have been divided into two separate receiving water bodies: Burnham Pond and Indian Pond. Calculations were completed according the 1992 phosphorus export guidelines, which sum the proposed road lengths, excess driveway lengths, and residential housing units.

A comparison of the calculations, as provided by Plum Creek in Appendix C of the proposed plan, to the scenarios developed by Terrence J. DeWan Associates was completed to determine a magnitude of scale check of the lot size and road length assumptions used in the calculations. The following table compares the assumptions in the phosphorus calculations to the summary tables developed from the proposed scenarios within the GIS:

Table 2 – Comparison of Provided and Calculated Phosphorus Loading Inputs

	Burnham Pond		**Indian Pond**	
	Provided P Calculations	**GIS Sampled Data**	**Provided P Calculations**	**GIS Sampled Data**
Number of Housing Units	26	305	20	487
Road Length (ft)	39,120	151,415	31,680	80,273

It can easily be seen that there is a significant discrepancy between what Plum Creek used in the preliminary calculations for phosphorus loading in Appendix C, and what may be considered a realistic design scenario as sampled using the GIS. The latest development plans developed by Plum Creek (May, 2007) showed that approximately 800 units were proposed in the area of Burnham Pond and Indian Pond. All of the developable areas in the proximity of these two ponds will drain towards one of these two ponds and need to be included in the phosphorus calculations.

Should the allowable phosphorus allocations be exceeded, this would result in algal blooms and a degradation of water quality, leading to a violation of Class GPA water quality standards. The proposed plan would allow a level of development around Burnham Pond that our modeling predicts would result in that water body violating GPA standards.

c. Thermal Impacts from Development

i. Lily Bay

The TURM model was used to determine impacts of thermal pollution from developed areas by evaluating the percent impervious cover. Appendix A has a figure that shows different subcatchments, and the approximate increase in runoff temperatures. Calculations of the various subcatchments is attached in Appendix B. The following results from the model were determined for the Lily Bay development:

- There is a significant increase in temperature along Burgess Brook with a change of approximately 1.5 degrees Celsius.

- Near the central resort area of Lily Bay, with a subcatchment labeled as LB Moosehead 3, there is a significant increase of approximately 2.0 degrees Celsius in the unnamed stream.
- Lower North Brook shows increases in temperature of approximately 0.3 degrees Celsius.
- It is likely that some BMPs could increase stream temperature further and may threaten the stream classification.

Moose Mountain

A similar process was used to evaluate temperature increases on the Moose Mountain development. This area is separated by subcatchments that drain either directly to Burnham Pond, or subcatchments that drain below the pond directly into Lower Burnham Brook, or Indian Pond. The following conclusions for thermal impacts around Moose Mountain were developed:

- Areas draining directly into Burnham Pond and Upper Burnham Brook show moderate increases in thermal pollution between 0.9 and 1.5 degrees Celsius.

- These increases in thermal pollution may have an adverse effect on water quality and stream habitat.
- Below Burnham Pond, around Lower Burnham Brook, there is significant development draining to the brook and Indian Pond. This development is showing a very significant increase in water temperature, which will likely lead to a degradation of water quality and a violation of the stream classification of Burnham Brook below Class 'A' standards. Runoff temperatures have been calculated to increase from between 3.3 to 4.4 degrees Celsius above background conditions. Calculations may be found in Appendix B.
- A similar indicator is the amount of impervious area located in this subcatchment, which exceeds 10%, a common threshold for determining watersheds of degraded water quality[5]. Plum Creek's plan would thus allow development around Lower Burnham Brook that poses a significant threat to water quality and would likely result in violation of water quality standards. A figure showing impervious areas is located in Appendix A.

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[5] According to DEP water quality expert Jeff Dennis, the vast majority of streams with 10% impervious area that have been studied in Maine do not meet Class A or even Class B aquatic life standards (personal Communication, August 27, 2007)

3. Conclusions

The development currently proposed by Plum Creek may impair the Class A waters in several streams draining the proposed development sites and in Burnham Pond. Based on available information, modeling results indicate that several key water quality parameters (dissolved oxygen, temperature and phosphorus) may adversely affect water quality and can potentially violate the Class A and Class GPA standards.

In summary, the following conclusions may be drawn from this assessment of preliminary development conditions for Lily Bay:

- Thermal pollution is a concern around Burgess Brook and a small unnamed stream towards the east. Increases of several degrees Celsius are possible and pose a potential violation of Class A standards.
- There is an opportunity for thermal pollution to North Brook, but it is less of an increase than determined around Burgess Brook. Increases to North Brook are estimated to be less than one degree Celsius; runoff is diluted from a larger undeveloped watershed upstream.
- Increased phosphorus loadings to streams pose a threat of increased algae production, which could cause a violation of stream water quality standards.
- BMPs may exacerbate thermal pollution and lower dissolved oxygen levels in stream waters if they discharge to streams.

The following conclusions were determined for development around Moose Mountain:

- BOD loadings to Burnham Pond could result in lower DO levels in Burnham Brook potentially violating water quality standards.
- Implementation of BMP's poses a threat to DO levels by increasing the hydraulic retention time before stormwater is discharged to receiving streams. This may be compounded by lower receiving stream flows because of the delayed release of flows after a storm event.
- BMP's also may increase the temperature of released flows, thus lowering the DO saturation level.
- Preliminary phosphorus calculations completed by De-Luca Hoffman appear to not reflect the actual amount of development the plan would allow in the watersheds of Burnham Pond and Indian Pond. Our model predicts that phosphorus loadings from development on the scale allowed by Plum Creek's plan would result in Burnham Pond violating Class GPA standards that prohibit algae blooms.
- Thermal impacts to Burnham Brook may be considered significant at the proposed level of development. Lower Burnham Brook is expected to have a particularly large increase in runoff temperature.
- The use of BMP's may increase the thermal pollution to receiving water bodies.

Further analysis and design details are required for any of the proposed scenarios. In its current form, the plan would allow development that would lower water quality and likely cause water quality violations in sensitive streams and ponds in the proposed development area.

4. Literature Cited

Mathew Jones, EI and Bill Hunt, PhD, PE, *The Effect of Urban Stormwater BMPs on Runoff Temperature in Trout Sensitive Waters*, North Carolina University, Raleigh, North Carolina, 2007.

Phosphorus Control in Lake Watersheds: A Technical Guide to Evaluating New Development, Maine Department of Environmental Protection, September, 1992.

Concept Plan for Plum Creek's Lands in the Moosehead Lake Region, Appendix C, *Preliminary Phophorus Evaluation for Select Watershed of the Concept Plan for Plum Creek's Lands in the Moosehead Region,* DeLuca-Hoffman Associates, Inc., April, 2007.

Kyoung Joe Lim, Bernard A. Engel, Youngsug Kim, Budhendra Bhaduri, and Jon Harbor, *Development of the Long Term Hydrologic Impact Assessment (LTHIA) WWW Systems*, 2001.

Chandler Morse, Steve Kahl, *Measuring the Impact of Development on Maine Surface Waters*, Senator George J. Mitchell Center for Environmental and Watershed Research, January, 2003.

Appendix A - Figures

Appendix B – Calculations

VERIFICATION

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Signature of Witness: Jonathan A. Quebbeman

August 27, 2007

Before me appeared Jonathan A. Quebbeman, who, being duly sworn, did testify that the foregoing testimony was true and correct to the best of his knowledge and belief.

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NOTARY PUBLIC

JENNIFER Q. DOW
Notary Public
Maine
My Commission Expires March 12, 2009

Appendix A - Figures

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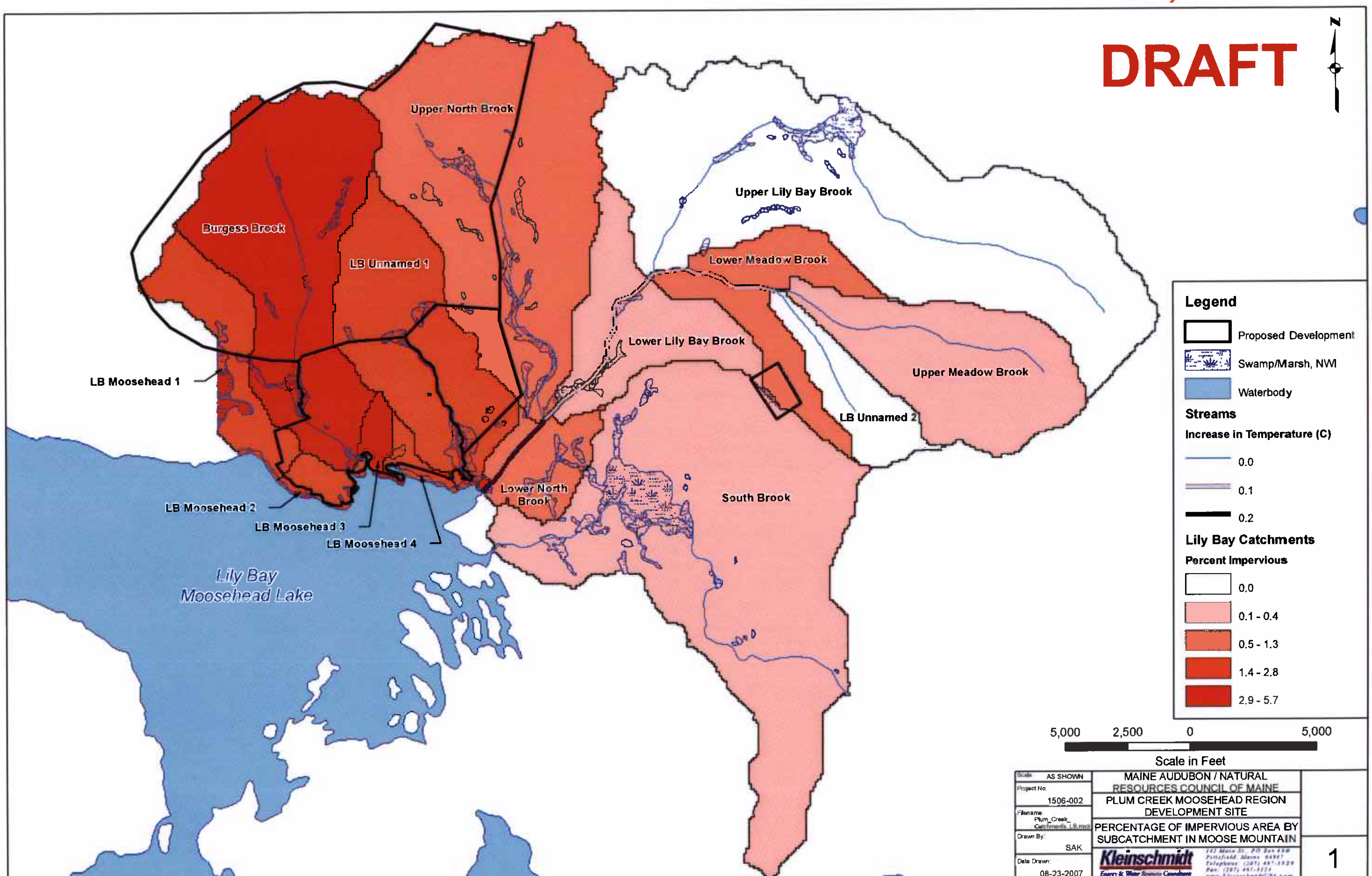
Attorney Work Product



Streams and Waterbodies - NHDPlus Region 1, USEPA and USGS (2005)
Development Areas - Plum Creek, Available At: ftp://ftp.state.me.us/outgoing/PlumCreek/
Swamp/Marsh, NWI - National Wetlands Inventory USFWS (1998)

Proposed Development Structures and Roads - Terry J. Dewan and Associates (2007)
Percentage of Impervious Area by Subcatchment - Kleinschmidt Associates (2007)

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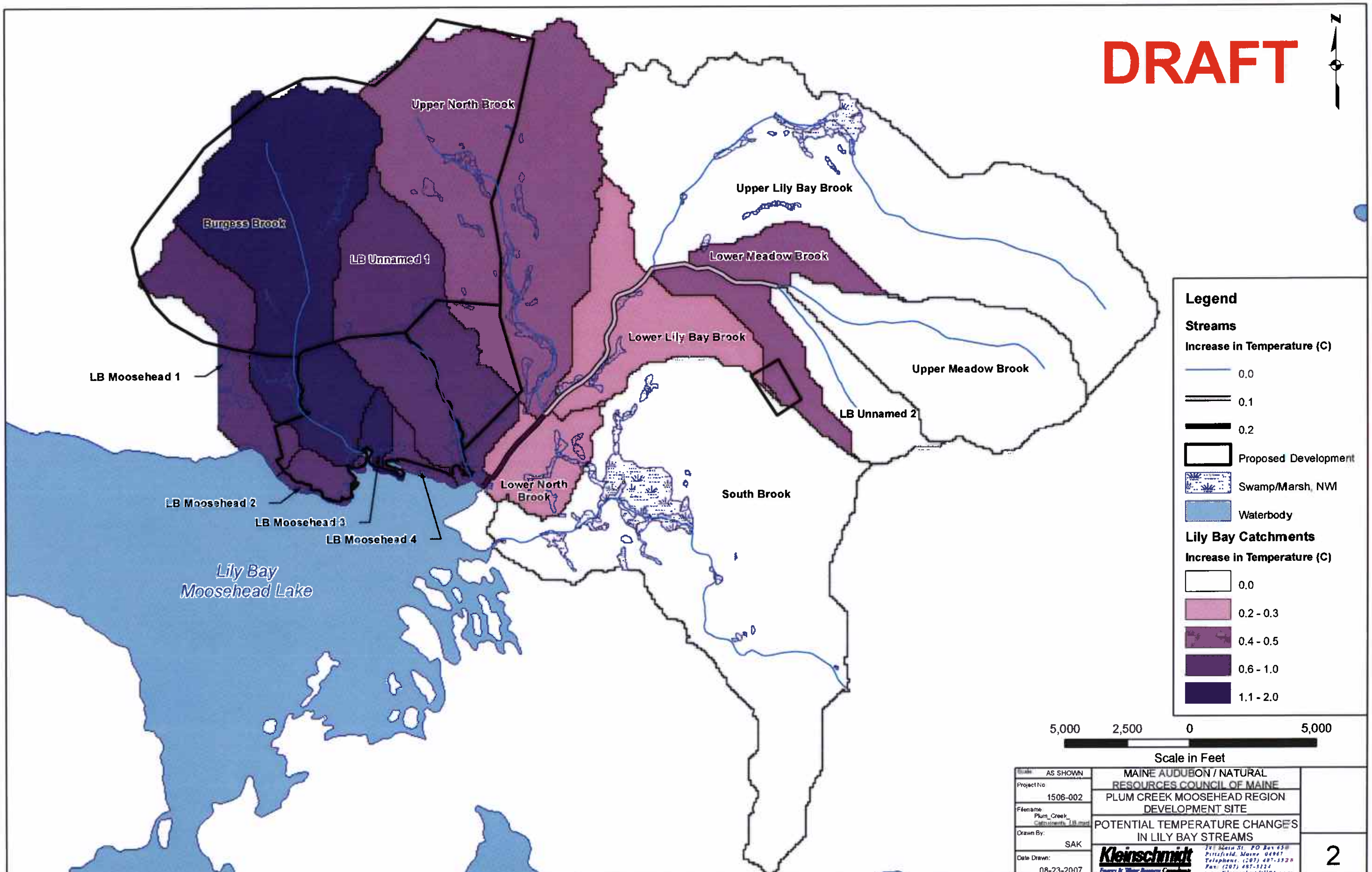

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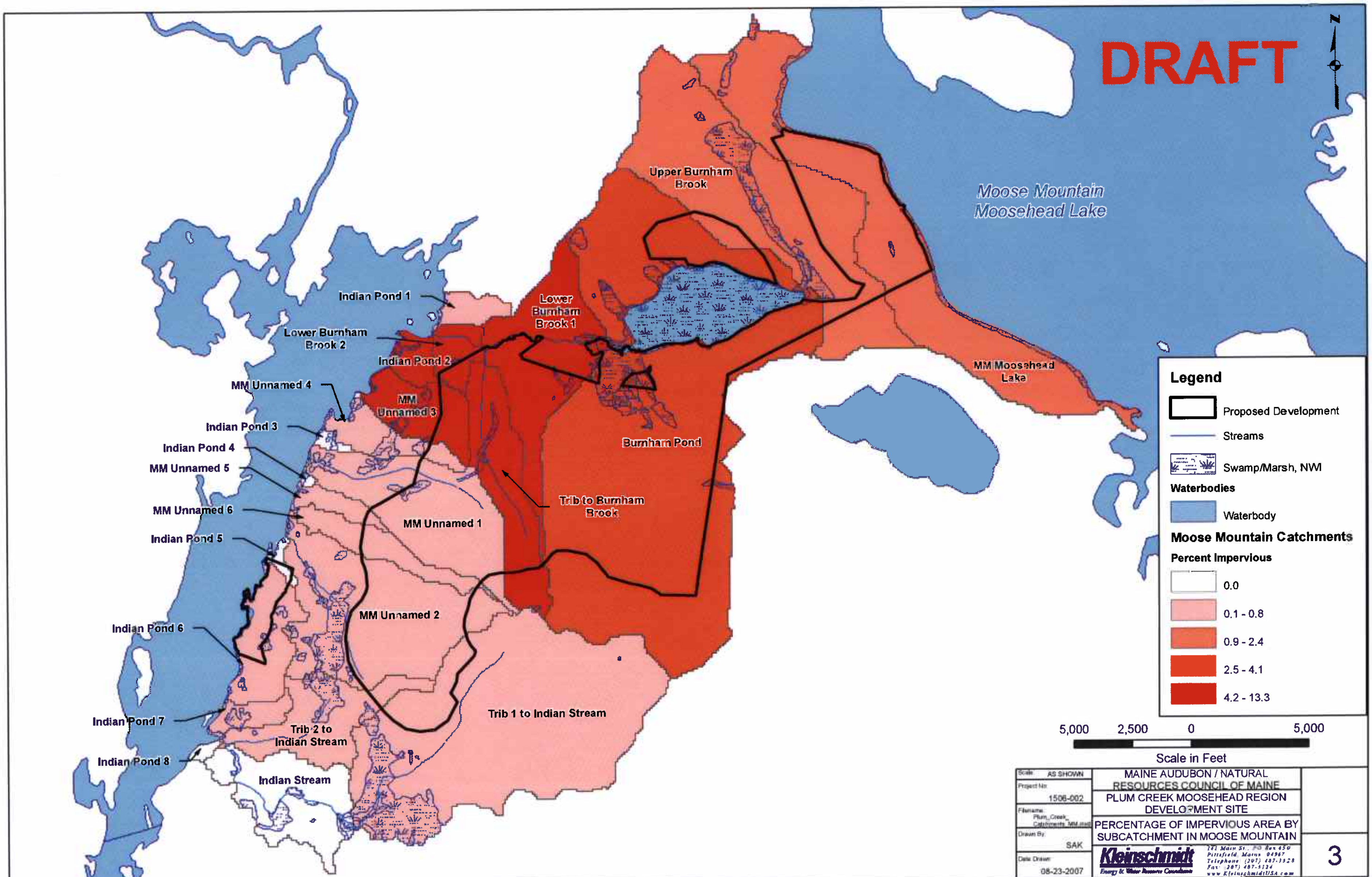

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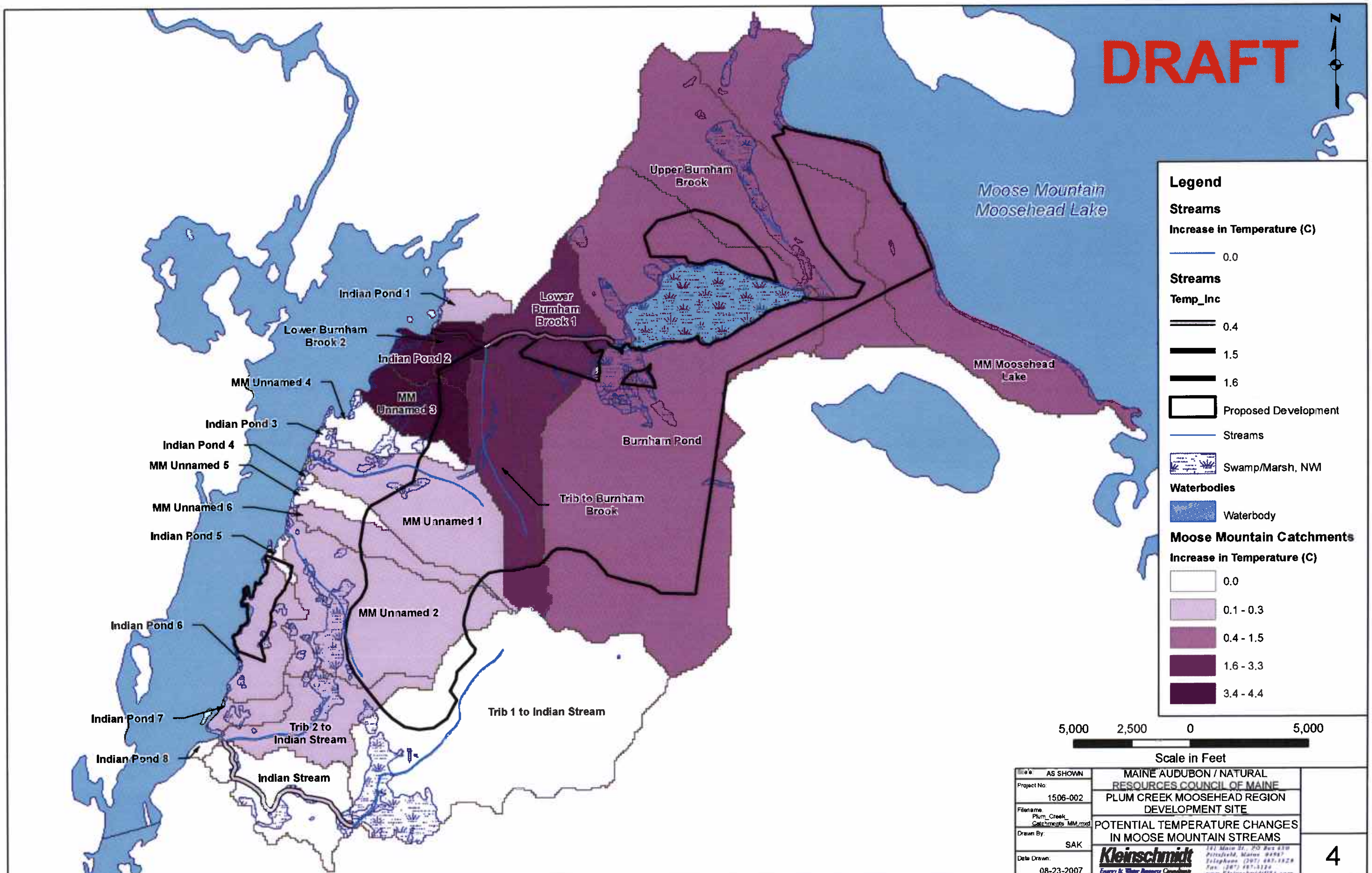

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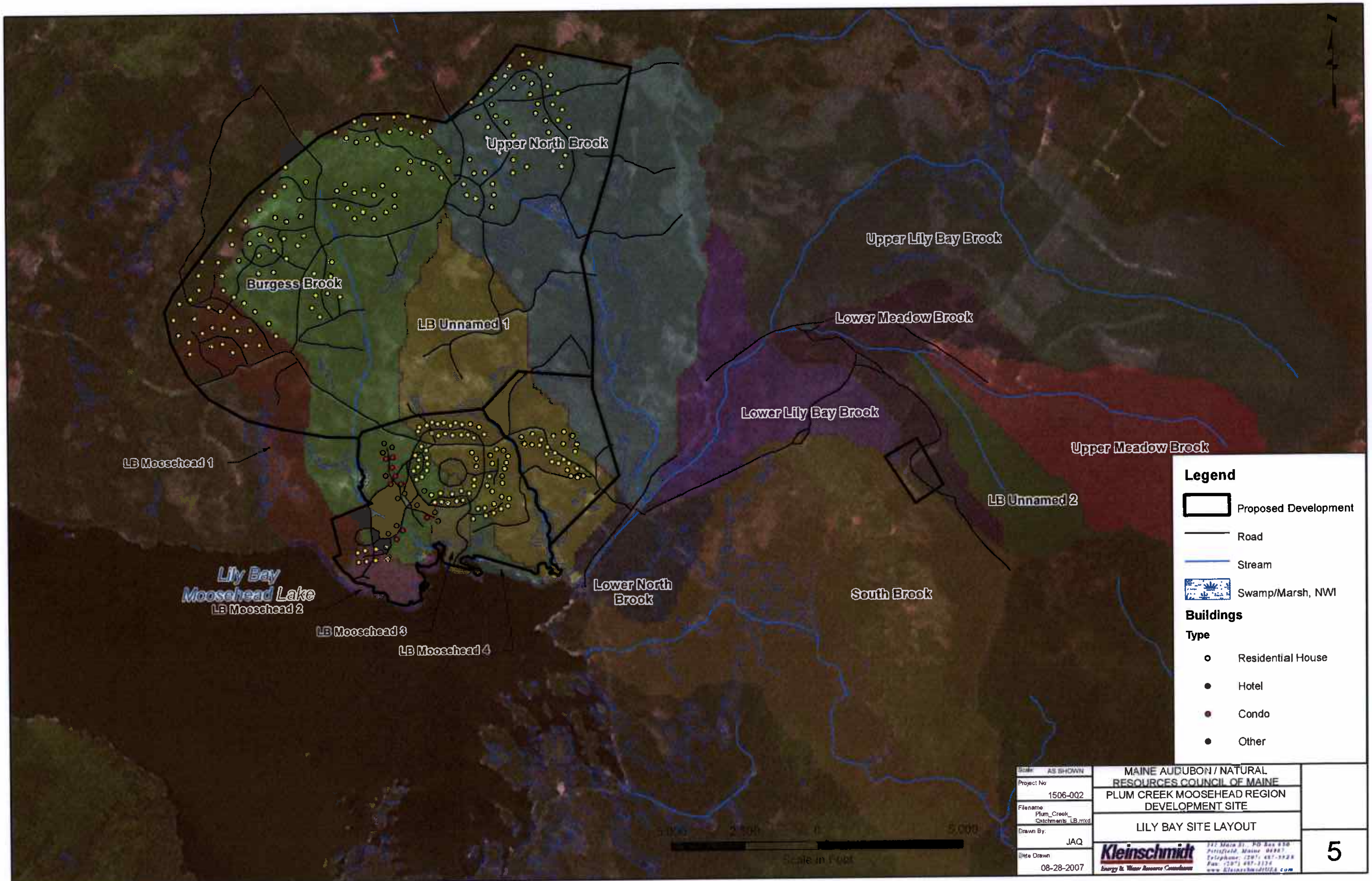

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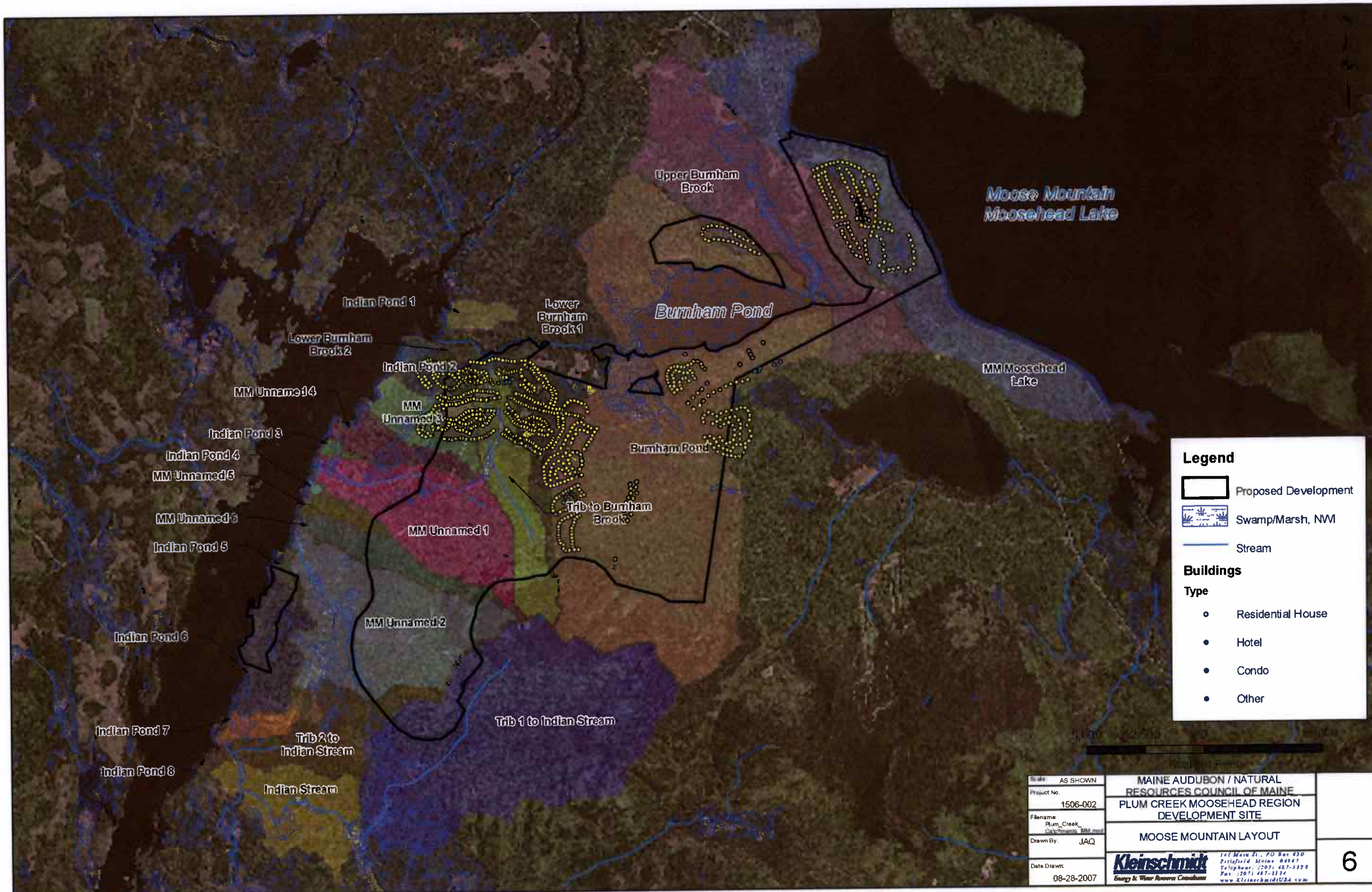

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Percentage of Impervious Area by Subcatchment - Kleinschmidt Associates (2007)

Appendix B - Calculations

Catchment Name	Area (sq. km)	Acreage	Houses	Condos	Hotels	Length of Existing Roads (ft)	Length of Proposed Roads (ft)	Length of Overlapping Roads	Watershed Area (Acres)
Burgess Brook	6.491	1603.90	81	18	1	15499	27516	21962	1604
LB Moosehead 1	1.871	462.40	16	0	0	3252	7787	4669	462
LB Moosehead 2	0.426	105.18	7	0	0	1897	1413	0	105
LB Moosehead 3	0.311	76.77	8	2	0	0	5007	0	77
LB Moosehead 4	0.289	71.37	3	0	0	797	1878	0	71
LB Unnamed 1	4.416	1091.11	44	0	0	18514	9096	8169	1091
LB Unnamed 2	1.468	362.73	0	0	0	0	0	0	363
Lower Lily Bay Brook	2.930	723.90	0	0	0	8939	739	0	5858
Lower Meadow Brook	2.440	602.87	0	0	0	18533	0	0	2028
Lower North Brook	1.328	328.27	0	0	0	1044	3407	631	8434
South Brook	12.455	3077.72	0	0	0	5147	0	0	3078
Upper Lily Bay Brook	12.570	3106.23	0	0	0	1185	0	0	3106
Upper Meadow Brook	4.297	1061.91	0	0	0	2477	0	0	1062
Upper North Brook	9.096	2247.70	52	0	0	7359	15636	13348	2248
Total:	60	14922	211	20	1	84643	72480	48779	N/A

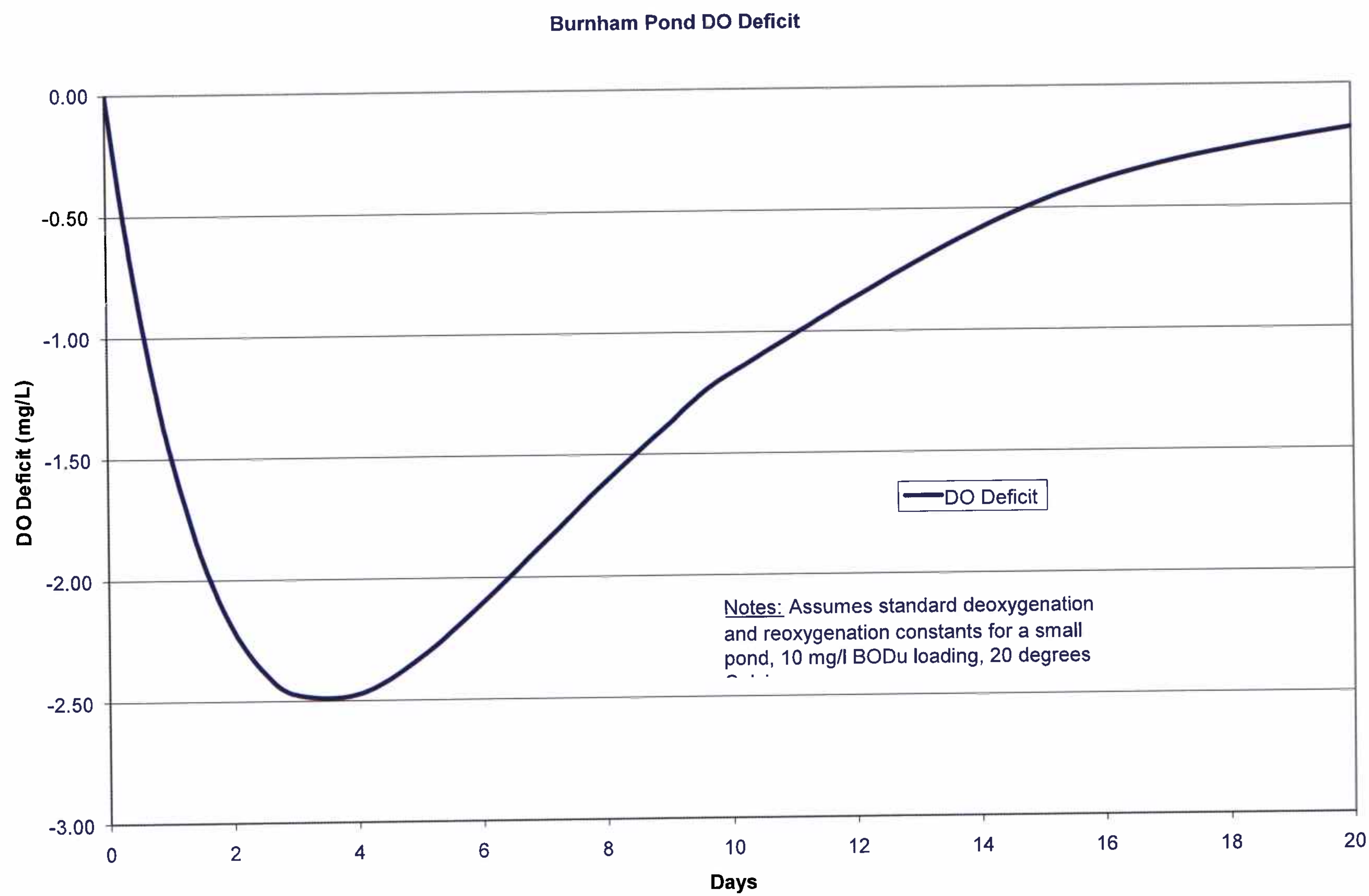
Watershed Name	Moose Mtn.	Moose Mtn.	Moose Mtn.	Moose Mtn.	Moose Mtn.	Moose Mtn.
Subcatchment	Burnham Pond	Indian Pond 1	Indian Pond 2	Indian Pond 3	Indian Pond 4	Indian Pond 5
Watershed Area (acres)	4916.94	79.81	84.31	19.27	8.41	25.73
Subcatchment Area (acres)	3532.3	79.8	84.3	19.3	8.4	25.7
Existing Roadways						
Length (ft)	33279.7	627.4	1444.5	0.0	0.0	0.0
Width (ft)	14	14	14	14	14	14
Shoulder (ft)	0	0	0	0	0	0
Proposed Roadways						
Length (ft)	65219.6	0.0	4840.7	0.0	0.0	0.0
Width (ft)	18	18	18	18	18	18
Shoulder (ft)	2	2	2	2	2	2
Re-Developed Roadways						
Length (ft)	22658.8	0.0	0.0	0.0	0.0	0.0
Width (ft)	18	18	18	18	18	18
Shoulder (ft)	2	2	2	2	2	2
Developments						
Housing Units	284	0	36	0	0	0
Impervious / Lot (ft2)	10,000	10,000	10,000	10,000	10,000	10,000
Lot Size (acres)	1.0	1.0	1.0	1.0	1.0	1.0
Impervious Area (acres)	65.2	0.0	8.3	0.0	0.0	0.0
Hotels	3	0	0	0	0	0
Building Area (ft2)	45,500	0	0	0	0	0
Parking Area (ft2)	160,000	0	0	0	0	0
Structures	16	0	0	0	0	0
Building Area (ft2)	15,000	15,000	15,000	15,000	15,000	15,000
Parking Area (ft2)	4,000	4,000	4,000	4,000	4,000	4,000
Condominium Developments	2	0	0	0	0	0
Impervious / Unit (ft2)	20,000	20,000	20,000	20,000	20,000	20,000
Impervious Area (ft2)	40,000	0	0	0	0	0
Total Impervious Area (ft2)	6,279,741	8,784	486,719	0	0	0
Total Impervious Area (acres)	144.2	0.2	11.2	0.0	0.0	0.0
% Subcatchment Impervious	4.1%	0.3%	13.3%	0.0%	0.0%	0.0%
Pre-Development Runoff Temp (F)	66.2	66.2	66.2	66.2	66.2	66.2
Post-Development Runoff Temp (F)	68.8	66.4	74.2	66.2	66.2	66.2
Subcatchment Increase Degrees (F)	2.6	0.2	8.0	0.0	0.0	0.0
Watershed Increase in Degrees (F)	**2.3**	**0.2**	**8.0**	**0.0**	**0.0**	**0.0**
Subcatchment Increase in Degrees (C)	**1.5**	**0.1**	**4.4**	**0.0**	**0.0**	**0.0**
Watershed Increase in Degrees (C)	**1.3**	**0.1**	**4.4**	**0.0**	**0.0**	**0.0**

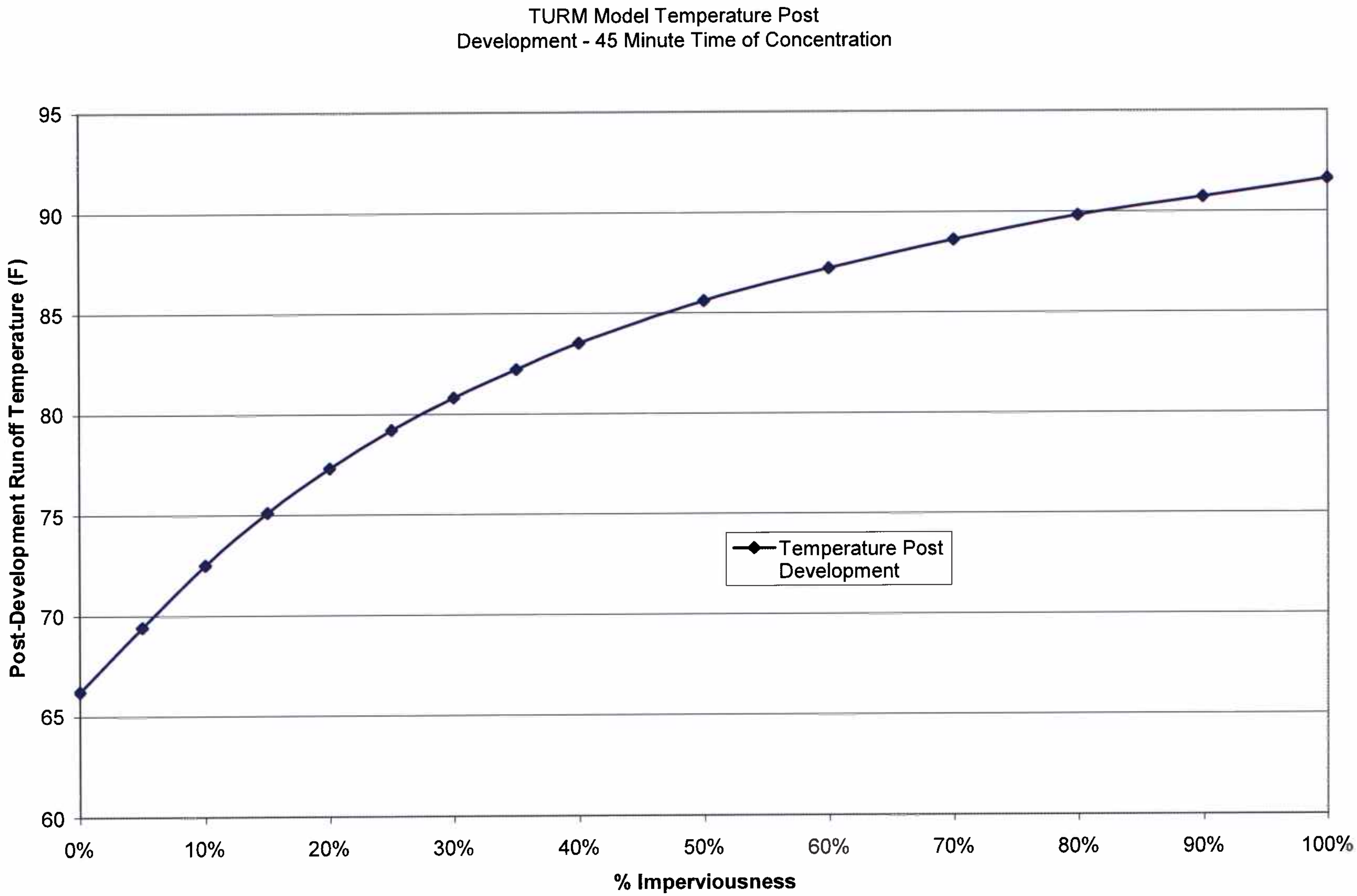
*Temperature Modeling based from Temperature Urban Runoff Model (TURM)

Moose Mtn. Indian Pond 6	Moose Mtn. Indian Pond 7	Moose Mtn. Indian Pond 8	Moose Mtn. Indian Stream	Moose Mtn. Lower Burnham Brook 1	Moose Mtn. Lower Burnham Brook 2	Moose Mtn. MM Moosehead Lake
272.94	83.62	16.16	2744.1	5540.98	5656.77	1238.95
272.9	83.6	16.2	432.8	624.0	115.8	1239.0
1223.9	1624.2	0.0	614.6	11842.2	1502.3	2775.9
14	14	14	14	14	14	14
0	0	0	0	0	0	0
0.0	0.0	0.0	0.0	15661.5	5354.2	13546.4
18	18	18	18	18	18	18
2	2	2	2	2	2	2
0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	18	18	18	18	18	18
2	2	2	2	2	2	2
0	0	0	0	179	45	71
10,000	10,000	10,000	10,000	10,000	10,000	10,000
1.0	1.0	1.0	1.0	1.0		
0.0	0.0	0.0	0.0	41.1		
0	0	0	0	1	0	0
0	0	0	0	45,500	0	0
0	0	0	0	160,000	0	0
0	0	0	0	2	0	0
15,000	15,000	15,000	15,000	15,000	15,000	15,000
4,000	4,000	4,000	4,000	4,000	4,000	4,000
0	0	0	0	0	0	0
20,000	20,000	20,000	20,000	20,000	20,000	20,000
0	0	0	0	0	0	0
17,134	22,739	0	8,605	2,543,844	588,823	1,046,883
0.4	0.5	0.0	0.2	58.4	13.5	24.0
0.1%	0.6%	0.0%	0.0%	9.4%	11.7%	1.9%
66.2	66.2	66.2	66.2	66.2	66.2	66.2
66.3	66.6	66.2	66.2	72.1	73.4	67.4
0.1	0.4	0.0	0.0	5.9	7.2	1.2
0.1	**0.4**	**0.0**	**0.1**	**2.7**	**2.8**	**1.2**
0.1	**0.2**	**0.0**	**0.0**	**3.3**	**4.0**	**0.7**
0.1	**0.2**	**0.0**	**0.4**	**1.5**	**1.6**	**0.7**

Moose Mtn. MM Unnamed 1	Moose Mtn. MM Unnamed 2	Moose Mtn. MM Unnamed 3	Moose Mtn. MM Unnamed 4	Moose Mtn. MM Unnamed 5	Moose Mtn. MM Unnamed 6	Moose Mtn. Trib 1 to Indian Stream
644.3	907.16	245.76	160.45	77.03	182.68	1928.13
644.3	907.2	245.8	160.5	77.0	182.7	1928.1
9565.2	21344.8	1871.6	538.1	174.6	2159.1	4126.5
14	14	14	14	14	14	14
0	0	0	0	0	0	0
0.0	0.0	10250.6	0.0	0.0	0.0	0.0
18	18	18	18	18	18	18
2	2	2	2	2	2	2
0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	18	18	18	18	18	18
2	2	2	2	2	2	2
0	0	107	0	0	0	0
10,000	10,000	10,000	10,000	10,000	10,000	10,000
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
15,000	15,000	15,000	15,000	15,000	15,000	15,000
4,000	4,000	4,000	4,000	4,000	4,000	4,000
0	0	0	0	0	0	0
20,000	20,000	20,000	20,000	20,000	20,000	20,000
0	0	0	0	0	0	0
133,913	298,827	1,321,716	7,534	2,444	30,228	57,771
3.1	6.9	30.3	0.2	0.1	0.7	1.3
0.5%	0.8%	12.3%	0.1%	0.1%	0.4%	0.1%
66.2	66.2	66.2	66.2	66.2	66.2	66.2
66.5	66.7	73.7	66.3	66.2	66.4	66.2
0.3	0.5	7.5	0.1	0.0	0.2	0.0
0.3	**0.5**	**7.5**	**0.1**	**0.0**	**0.2**	**0.0**
0.2	**0.3**	**4.2**	**0.0**	**0.0**	**0.1**	**0.0**
0.2	**0.3**	**4.2**	**0.0**	**0.0**	**0.1**	**0.0**

Moose Mtn. Trib 2 to Indian Stream	Moose Mtn. Trib to Burnham Brook	Moose Mtn. Upper Burnham Brook
383.19	427.43	1384.63
383.2	427.4	1384.6
7211.9	15400.4	11952.2
14	14	14
0	0	0
0.0	12104.7	15754.5
18	18	18
2	2	2
0.0	0.0	2550.2
18	18	18
2	2	2
0	115	89
10,000	10,000	10,000
0	0	0
0	0	0
0	0	0
0	2	0
15,000	15,000	15,000
4,000	4,000	4,000
0	0	0
20,000	20,000	20,000
0	0	0
100,966	1,669,909	1,460,033
2.3	38.3	33.5
0.6%	9.0%	2.4%
66.2	66.2	66.2
66.6	71.9	67.7
0.4	5.7	1.5
0.4	**5.7**	**1.5**
0.2	**3.1**	**0.9**
0.2	**3.1**	**0.9**


Burnham Pond DO Deficit
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
DO Deficit (mg/L)
0
2
4
6
8
10
12
14
16
18
20
Days
DO Deficit
Notes: Assumes standard deoxygenation and reoxygenation constants for a small pond, 10 mg/l BODu loading, 20 degrees



TURM Model Temperature Post
Development - 45 Minute Time of Concentration
95
90
85
80
75
70
65
60
Post-Development Runoff Temperature (F)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Imperviousness
Temperature Post Development

Phosphorus Export Evaluation Worksheet A-7
Total Phosphorus Export From Project
Standard Review Method

Constants

Correction Factor 0.5

Watershed Burnham Pond

		Prelim. Value	KA Value
Total Export from Roads - Single Family Res.	Sheet A-2	22.17	151.26
Total Export from Lots - Single Family Res.	Sheet A-3	4.00	46.97
Total Export from Driveways > 150 FT	Sheet A-4	3.74	0.00
Total Export from Multi-Unit, Comm, Industrial	Sheet A-5	0.00	0.00
Credits	Sheet A-6	0.00	0.00
Total Export From Project (TE) (lb/yr):		**29.92**	**198.23**
Phosphorus Availability, TPA = Correction Factor x TE		**14.96**	**99.11**
PPE (lb/yr) - from Step 1 *		**15.97**	

***If PPE > TPA, then phosphorus control is adequate**
If PPE < TPA, then additional phosphorus control is needed

Watershed Name	Lily Bay	Lily Bay	Lily Bay	Lily Bay	Lily Bay
Subcatchment	Burgess Brook	LB Moosehead 1	LB Moosehead 2	LB Moosehead 3	LB Moosehead 4
Watershed Area (acres)	1603.90	462.40	105.18	76.77	71.37
Subcatchment Area (acres)	1603.90	462.40	105.18	76.77	71.37
Existing Roadways					
Length (ft)	15499	3252	1897	0	797
Width (ft)	14	14	14	14	14
Shoulder (ft)	0	0	0	0	0
Proposed Roadways					
Length (ft)	27516	7787	1413	5007	1878
Width (ft)	18	18	18	18	18
Shoulder (ft)	2	2	2	2	2
Re-Developed Roadways					
Length (ft)	21962	4669	0	0	0
Width (ft)	18	18	18	18	18
Shoulder (ft)	2	2	2	2	2
Developments					
Housing Units	81	16	7	8	3
Impervious / Lot (ft2)	10,000	10,000	10,000	10,000	10,000
Lot Size (acres)	1.0	1.0	1.0		
Impervious Area (acres)	18.6	3.7	1.6	1.8	0.7
Hotels & Structures	1	0	0	0	0
Building Area (ft2)	60,000	0	0	0	0
Parking Area (ft2)	240,000	0	0	0	0
Condominium Developments	18	0	0	2	0
Impervious / Unit (ft2)	25,000	25,000	25,000	25,000	25,000
Impervious Area (ft2)	450,000	0	0	50,000	0
Total Impervious Area (ft2)	2,865,512	479,557	127,649	190,159	82,485
Total Impervious Area (acres)	65.8	11.0	2.9	4.4	1.9
% Subcatchment Impervious	4.1%	2.4%	2.8%	5.7%	2.7%
Pre-Development Runoff Temp (F)	66.2	66.2	66.2	66.2	66.2
Post-Development Runoff Temp (F)	68.8	67.7	68.0	69.8	67.9
Subcatchment Increase Degrees (F)	2.6	1.5	1.8	3.6	1.7
Watershed Increase in Degrees (F)	**2.6**	**1.5**	**1.8**	**3.6**	**1.7**
Subcatchment Increase in Degrees (C)	**1.5**	**0.8**	**1.0**	**2.0**	**0.9**
Watershed Increase in Degrees (C)	**1.5**	**0.8**	**1.0**	**2.0**	**0.9**

*Temperature Modeling based from Temperature Urban Runoff Model (TURM)

Lily Bay LB Unnamed 1	Lily Bay LB Unnamed 2	Lily Bay Lower Lily Bay Brook	Lily Bay Lower Meadow Brook	Lily Bay Lower North Brook	Lily Bay South Brook	Lily Bay Upper Lily Bay Brook
1091.11	362.73	5857.64	2027.51	8433.61	3077.72	3106.23
1091.11	362.73	723.90	602.87	328.27	3077.72	3106.23
18514	0	8939	18533	1044	5147	1185
14	14	14	14	14	14	14
0	0	0	0	0	0	0
9096	0	739	0	3407	0	0
18	18	18	18	18	18	18
2	2	2	2	2	2	2
8169	0	0	0	631	0	0
18	18	18	18	18	18	18
2	2	2	2	2	2	2
44	0	0	0	0	0	0
10,000	10,000	10,000	10,000	10,000	10,000	10,000
10.1	0.0	0.0	0.0	0.0	0.0	0.0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
25,000	25,000	25,000	25,000	25,000	25,000	25,000
0	0	0	0	0	0	0
1,079,049	0	141,399	259,457	103,442	72,062	16,592
24.8	0.0	3.2	6.0	2.4	1.7	0.4
2.3%	0.0%	0.4%	1.0%	0.7%	0.1%	0.0%
66.2	66.2	66.2	66.2	66.2	66.2	66.2
67.7	66.2	66.5	66.8	66.7	66.2	66.2
1.5	0.0	0.3	0.6	0.5	0.0	0.0
1.5	**0.0**	**0.1**	**0.2**	**0.3**	**0.0**	**0.0**
0.8	**0.0**	**0.2**	**0.4**	**0.3**	**0.0**	**0.0**
0.8	**0.0**	**0.1**	**0.1**	**0.2**	**0.0**	**0.0**

Lily Bay Upper Meadow Brook	Lily Bay Upper North Brook
1061.91	2247.70
1061.91	2247.70
2477	7359
14	14
0	0
0	15636
18	18
2	2
0	13348
18	18
2	2
0	52
10,000	10,000
0.0	11.9
0	0
0	0
0	0
0	0
25,000	25,000
0	0
34,676	1,260,672
0.8	28.9
0.1%	1.3%
66.2	66.2
66.2	67.0
0.0	0.8
0.0	**0.8**
0.0	**0.5**
0.0	**0.5**

Section	BOD Loading to DO Critical Deficit	
Critical Time Calculations	Ultimate BODu (mg/L)	10.0
	Temperature T (F)	68.0
	Temperature T (C)	20.0
	K'r(20C)	0.4
	K'r(T)	0.4
	K'd(20C)	0.20
	K'd(T)	0.20
	Do	0.0
	DO Saturation (mg/L)	9.0
	tc (days)	**3.47**
	Dc (mg/L)	2.50
	Lowest DO (mg/L)	**6.50**
Time T Calculations	Time (hours)	200
	Time (days)	8.33
	BOD Use at T (mg/L)	8.11
	DO Deficit (mg/L)	**1.53**

*Aeration Constants use Base e

Catchment Name	Acreage	Houses	Condos	Hotels	Other	Length of Existing Roads (ft)	Length of Proposed Roads (ft)	Length of Overlapping Roads (ft)	Watershed Area (Acres)
Burnham Pond	3532.31	284	2	3	16	33280	65220	22659	4917
Indian Pond 1	79.81	0	0	0	0	627	0	0	80
Indian Pond 2	84.31	36	0	0	0	1445	4841	0	84
Indian Pond 3	19.27	0	0	0	0	0	0	0	19
Indian Pond 4	8.41	0	0	0	0	0	0	0	8
Indian Pond 5	25.73	0	0	0	0	0	0	0	26
Indian Pond 6	272.94	0	0	0	0	1224	0	0	273
Indian Pond 7	83.62	0	0	0	0	1624	0	0	84
Indian Pond 8	16.16	0	0	0	0	0	0	0	16
Indian Stream	432.78	0	0	0	0	615	0	0	2744
Lower Burnham Brook 1	624.04	179	0	1	2	11842	15661	0	5541
Lower Burnham Brook 2	115.79	45	0	0	0	1502	5354	0	5657
MM Moosehead Lake	1238.95	71	0	0	0	2776	13546	0	1239
MM Unnamed 1	644.30	0	0	0	0	9565	0	0	644
MM Unnamed 2	907.16	0	0	0	0	21345	0	0	907
MM Unnamed 3	245.76	107	0	0	0	1872	10251	0	246
MM Unnamed 4	160.45	0	0	0	0	538	0	0	160
MM Unnamed 5	77.03	0	0	0	0	175	0	0	77
MM Unnamed 6	182.68	0	0	0	0	2159	0	0	183
Trib 1 to Indian Stream	1928.13	0	0	0	0	4127	0	0	1928
Trib 2 to Indian Stream	383.19	0	0	0	0	7212	0	0	383
Trib to Burnham Brook	427.43	115	0	0	2	15400	12105	0	427
Upper Burnham Brook	1384.63	89	0	0	0	11952	15754	2550	1385
Total:	12874.88	926	2	4	20	129279.2	142732.1	25209.0	N/A