Evolution of Stormwater Management in Calgary

TRIECA 2013

2013 March 26

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Personal Background

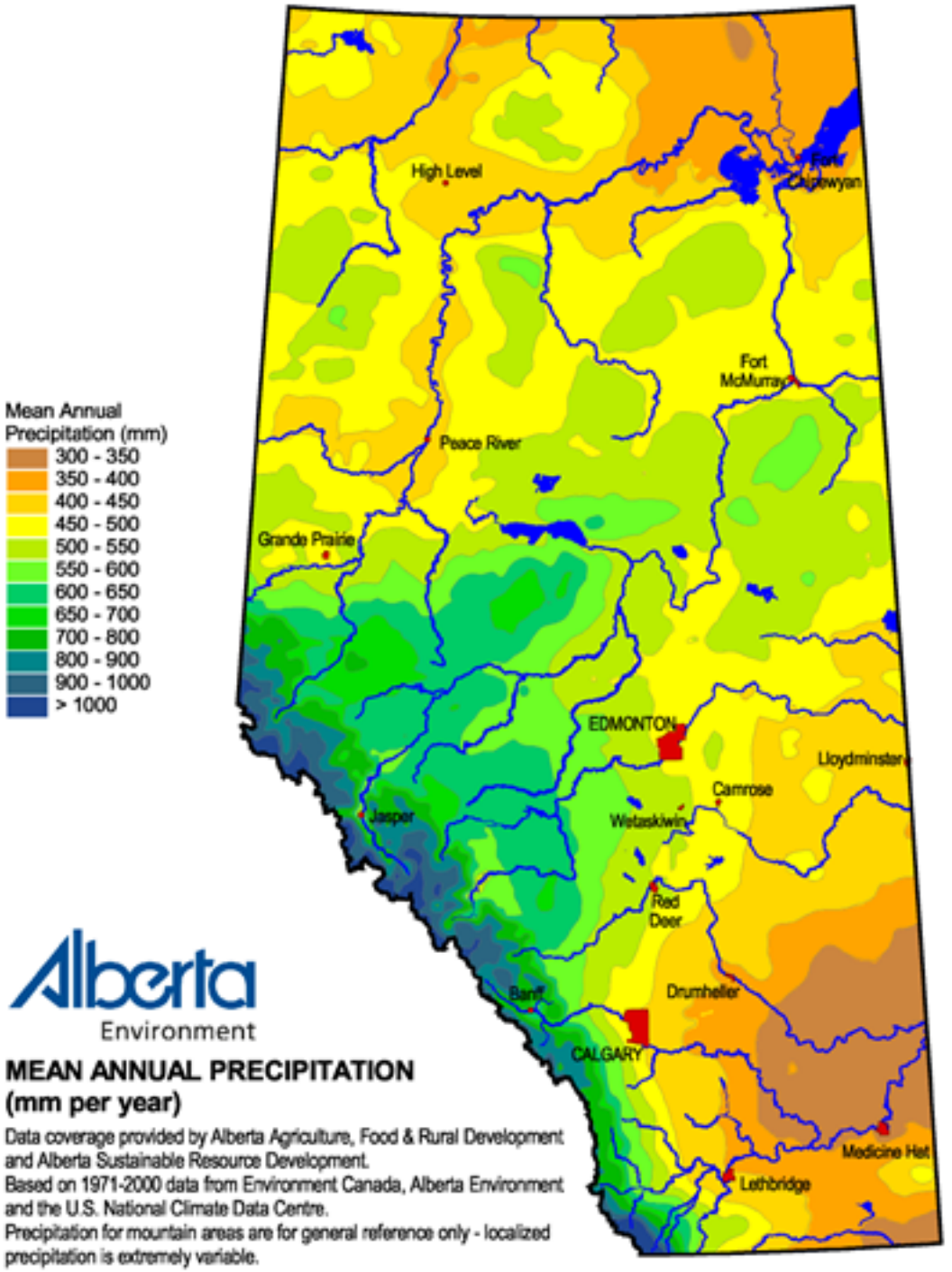
- Day-to-Day Responsibilities at City of Calgary:
  - Evolution of Calgary's Stormwater Management & Design Manual
  - Practical implementation of LID by development community
  - Support to LID initiative by Water Resources / Services
  - Training and mentoring of junior and intermediate staff
  - Internal and external training
- Founding member and Past-President of the Alberta Low Impact Development Partnership
- (used to be) "Adjunct Professor" at the University of Calgary, Schulich School of Engineering, Department of Civil Engineering

Differences between Ontario and Calgary

- Climate and topography differences
- Low drainage density
  - wetlands are our equivalent of your streams
- Organizational Structure
  - Provincial level
  - Conservation Authorities vs. WPACs
  - Role of non-profit organizations such as ALIDP

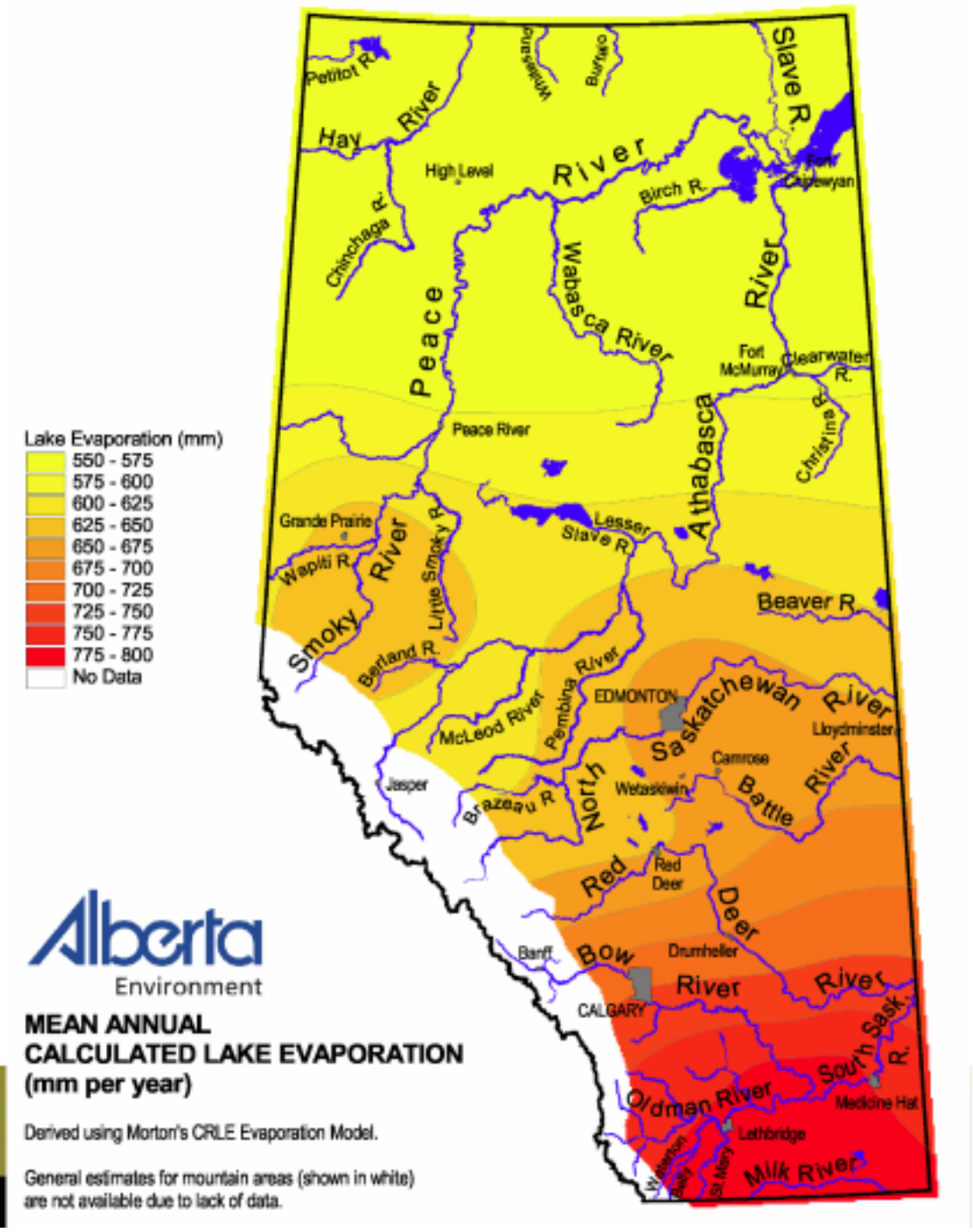
Annual Precipitation

- Calgary
  - 410 mm
- Edmonton
  - 450-500 mm
- Grande Prairie
  - 450-500 mm
- Semi-arid conditions with moisture in the Rockies
- For comparison purposes:
  - Toronto 793 mm
  - Ottawa 944 mm
  - London 987 mm



Annual Lake Evaporation

- Calgary
  - 700-750 mm
- Edmonton
  - 650-675 mm
- Grande Prairie
  - 625-650 mm
- For comparison purposes:
  - Toronto ???
  - Ottawa ???
  - London ???



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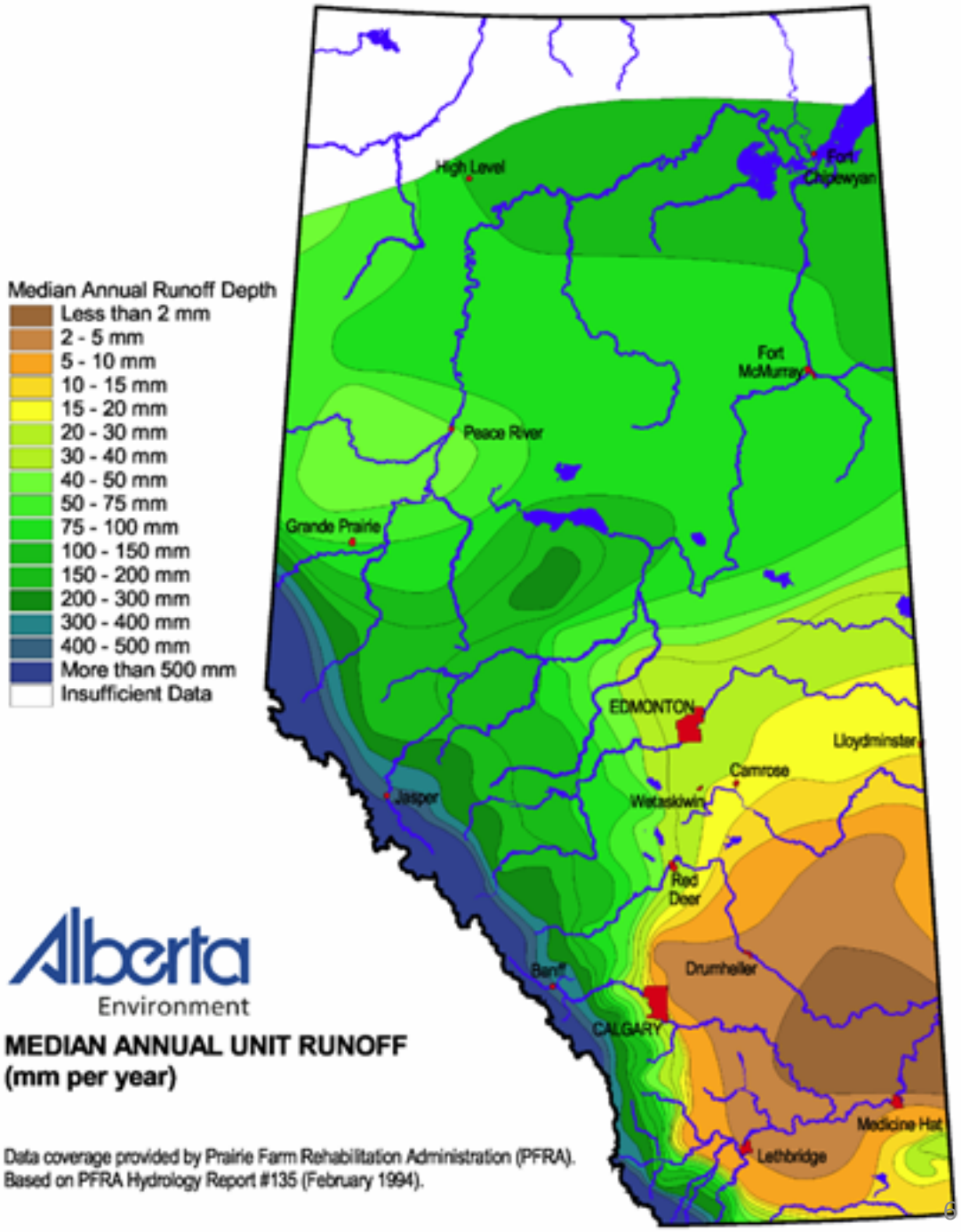
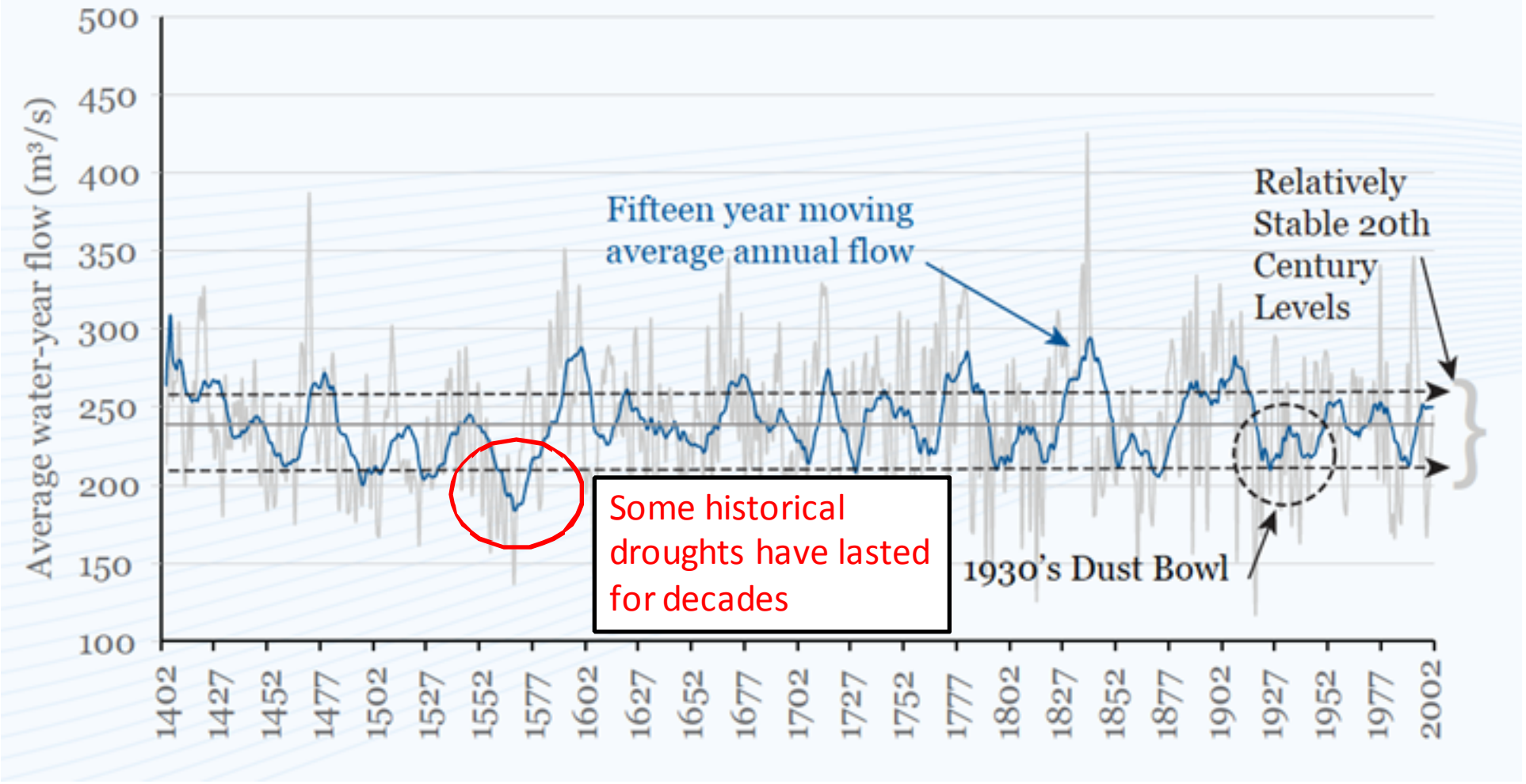
Annual Runoff Depth

- Calgary
  - 5 – 20 mm
  - (2 to 5%)
- Edmonton
  - 20 – 30 mm
  - (5 to 7%)
- Grande Prairie
  - 50 – 100 mm
  - (12 to 20%)
- For comparison purposes:
  - Toronto ???
  - Ottawa 330-420 mm
  - London ???



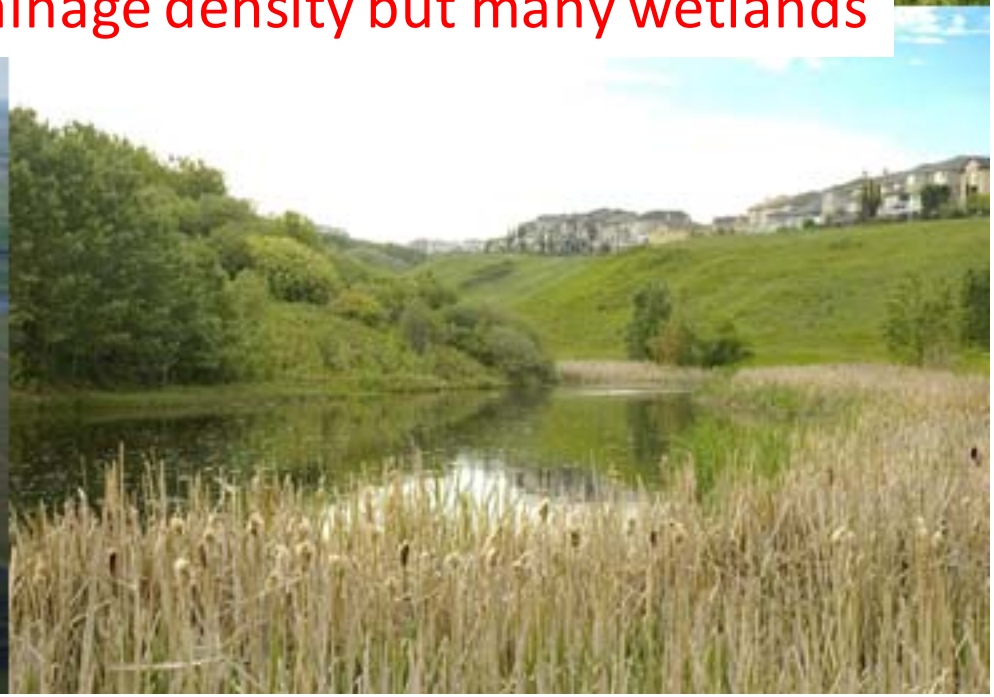
The Prairies are subject to extreme variability in water supply …

FIGURE 3. Historic Drought and Flood Record
{Source: David Sauchyn, University of Regina}



Streams and Wetlands

Southern Alberta has a low drainage density but many wetlands



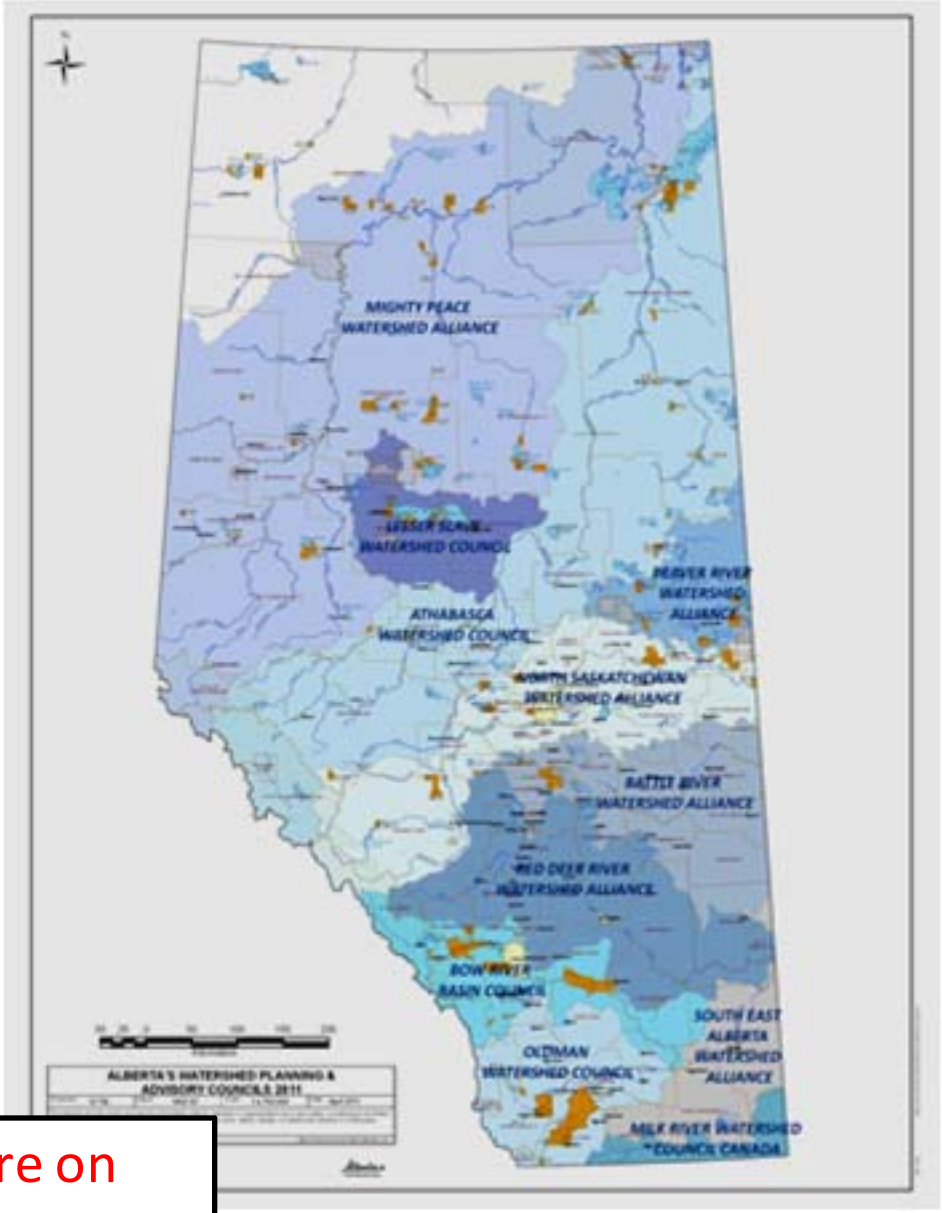
Streams and Wetlands

Southern Alberta has a low drainage density but many wetlands

Wetlands are largely owned by the crown, and one needs to (a) avoid, (b) minimize, or (c) compensate for impacts

Organizational Structure

- Alberta is serviced by 11 Watershed Planning and Advisory Councils (WPACs)
- They have no real power and are largely a watershed-based discussion forum with consensus-based decisions
- Main parties are the local jurisdictions and Alberta Environment and Sustainable Resource Development
- Watershed Stewardship Groups provide community-level action
- Numerous non-profit organizations including the "Alberta Water Council" and the "ALIDP"



In practice, this means that we are on our own with respect to stormwater management

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Who is the ALIDP?

- Non-profit society working in the province of Alberta
- Municipal, industry, academic, and non-profit members
- Focus is urban growth issues that have watershed implications
- Some of our members, for example:

Calgary has seen tremendous Urban Growth

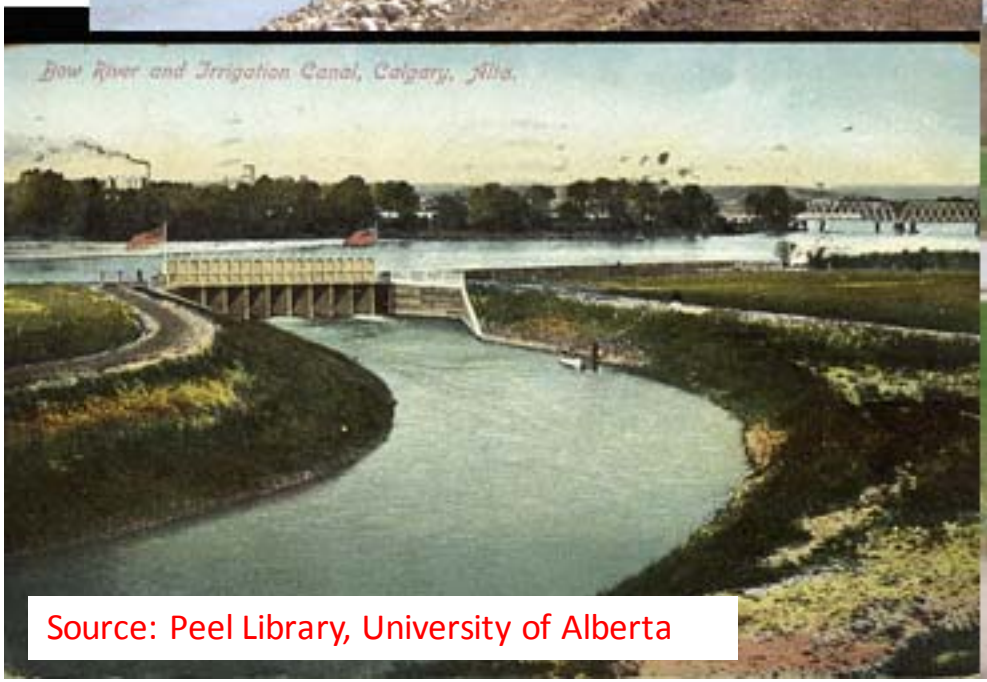
Evolution of Stormwater Management in Calgary

Traditional Stormwater Infrastructure

has been focused on extreme events

requiring irrigation infrastructure

Photos top: MPE Engineering Ltd.



Source: Peel Library, University of Alberta

and large pipes and large storm ponds

Source: ARMTEC

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But what did Calgary actually do?

In 1890, the first underground drainage pipes were constructed.

In the 1920s, Calgary started constructing separate storm and sanitary drainage systems

In the 1960s, the storm and sanitary waste-water systems were completely separated

And in the process, we got rid of sumps in catchbasins too

and the last couple of decades

1980s sees the implementation of the dual-drainage principle and ponds to detain peak flows

1990s and early 2000s focus moves to water quality

Now!

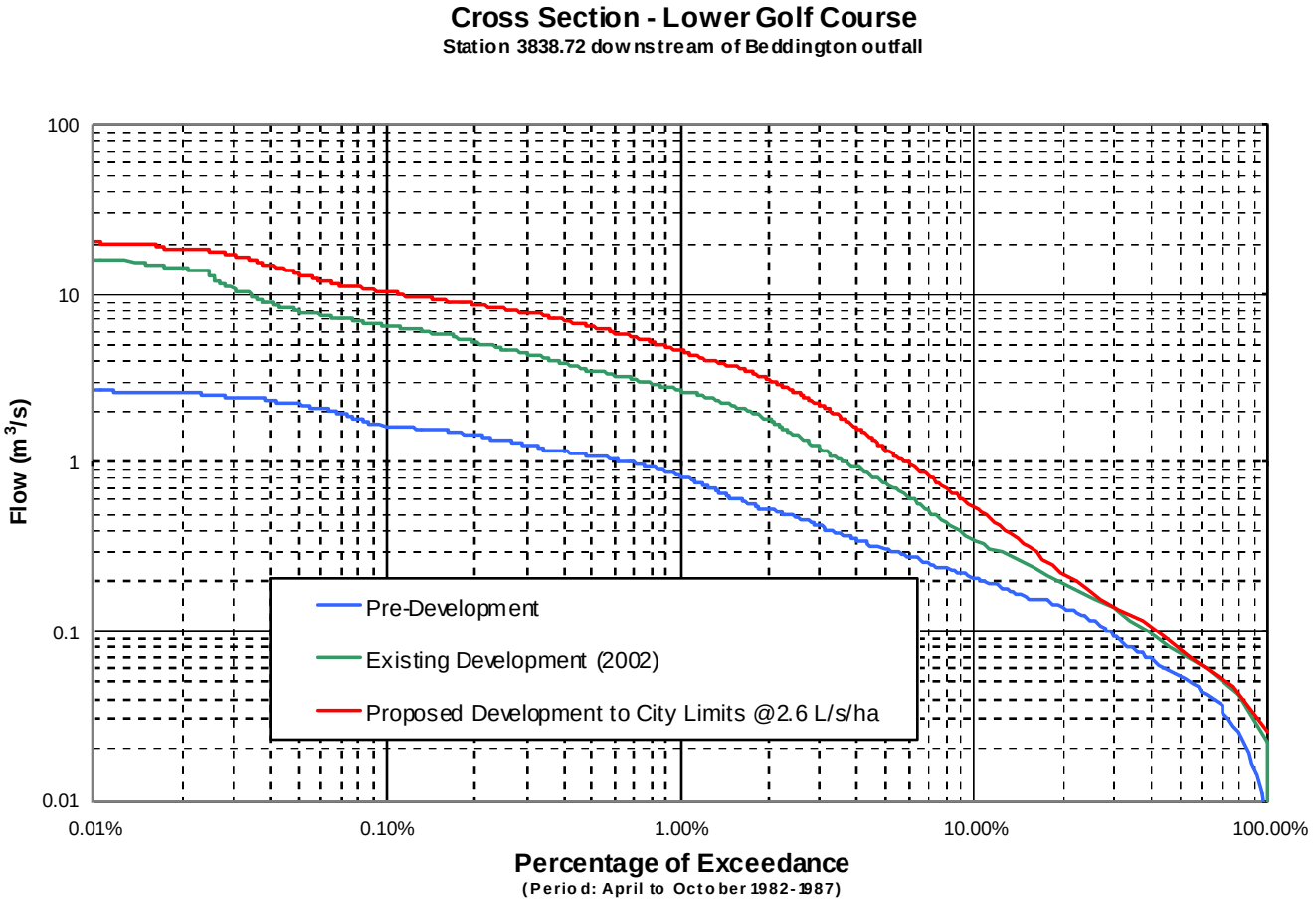
Low Impact Development

Current Design Targets: Regulatory Requirements

- 85% Total Suspended Solids removal on annual basis for particles that are 50 to 75 microns or greater
- AESRD (Operating Approval) Total Loadings objectives (kg/day)
  - TSS
  - Phosphorus
- Reduce sediment loading to the Bow River to or below the 2005 level by 2015 (through stormwater retrofits and LID in greenfield)
- Watershed plans
- Irrigation Districts in Southern Alberta

DISCONNECT

We have also learned that our smaller creeks are being impacted due to the increase in flows …



Credit: Westhoff Engineering Resources, Inc.

Nose Creek Targets

- To achieve intermediate and high flow instream objectives, the current Maximum Allowable Release Rate of 2.6 L/s/ha for the 1:100 year return period should be reduced to 0.99 L/s/ha on West Nose Creek and to 1.257 L/s/ha on Nose Creek for the period April through October, based on gross catchment area

Table 8.1. Implementation schedule for reduction in Runoff Volume Control Targets.

	Runoff Volume Control Targets			
Date of Implementation	2007	Jan 2010	Jan 2013	Jan 2017
Nose Creek main stem Target	90 mm (50 mm)*	30 mm	16 mm	11 mm
West Nose Creek Target	90 mm (50 mm)	50 mm	26 mm	17 mm
% Precipitation Volume Capture	75%-85%	85-90%	93-95%	95-97%
% Increase in Channel Width	~ 100-200 %	~100%	~50%	0-25%
Target Impacts on Creeks	High	High	Moderate	Low

* The 50 mm Runoff Volume Control Target should be applicable to country residential developments and low density industrial, commercial and institutional developments from 2007 to Jan 2010.

Nose Creek Watershed Water Management Plan (2008)

Bow Basin WMP

- Bow and Elbow River WMP plans approved by Council in September 2008.
- Key Recommendations from Phase 1
  - All new residential and commercial developments should incorporate elements of low impact development beneficial management practices into the overall design.
  - Municipalities need to ensure timely responses when dealing with approval requests from developers wishing to incorporate low impact development methodologies.
  - Develop effective impervious targets for all new developments based on the overall goal of trying to achieve pre-development rates and volumes entering the streams and rivers.

Interpretation as part of Calgary's Municipal Development Plan

- Figure 5.2 – Core Indicator #12 - Watershed Health Indicator:
  - Long term goal for entire City of Calgary is an imperviousness of 10% to 20%. Current imperviousness of the City of Calgary is approximately 32%.
- Interpreted as effective imperviousness
- May be interpreted as average annual runoff volume target of 40 – 90 mm

Some of the Irrigation Districts have even stricter targets

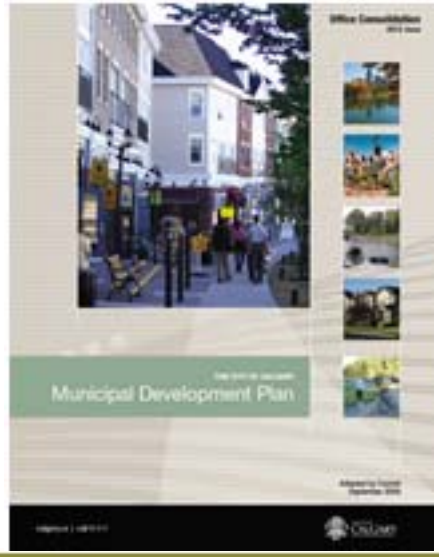
Parameter	Target	
	Short-Term Policy	Long-Term Goal
Runoff Rate	Limit to 2.0 L/s/ha from primary facility into WID facility	Limit to 2.0 L/s/ha or less, if required.
Runoff Volume	Aim for an achievable average annual runoff limit of 120 mm. Decrease in future as performance and design techniques improve	Limit to pre-development levels or 20 mm to 80 mm on annual basis
Total Phosphorus	Adopt a multi-train treatment approach to improve likelihood of reducing post-development TP loads to 0.1 mg/L or less. Secondary WID wet pond required to allow further treatment and storage to facilitate timed release, including off-season release. Compensation for Operation and Maintenance and a fee for any stormwater released with water quality not meeting WID guidelines.	0.03 mg/L
Total Suspended Solids	20 to 40 mg/L on annual basis.	10 mg/L
Bacteria	Continue monitoring	100 per 100 mL Fecal Coliforms
Salinity	Continue monitoring	0.6 mS/cm Electrical Conductivity

This should be seen within the context that our EMCs are considerably higher

Source: http://www.wid.net/library.html

Other drivers and initiatives

- Regulatory environment
  - Western Headworks Canal Direct Discharge Area (net-zero impact)
- Mandates, policies, and plans
  - Stormwater Strategy
  - Development & Building Approvals Sustainability Best Practices Project
  - Complete Streets initiative



Question: how do LEED targets fit within our watershed objectives?

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What LID is potentially attractive in Calgary?
Absorbent Landscaping

Just add some topsoil

Even in Calgary one can have attractive landscapes: give it decent topsoil and some water

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What LID is potentially attractive in Calgary?
Rainwater Harvesting

Alberta and Ontario have closely worked together in establishing rainwater harvesting guidelines. Here is an application in a high-end community in Calgary

What LID is potentially attractive in Calgary?
Stormwater Capture and Re-Use

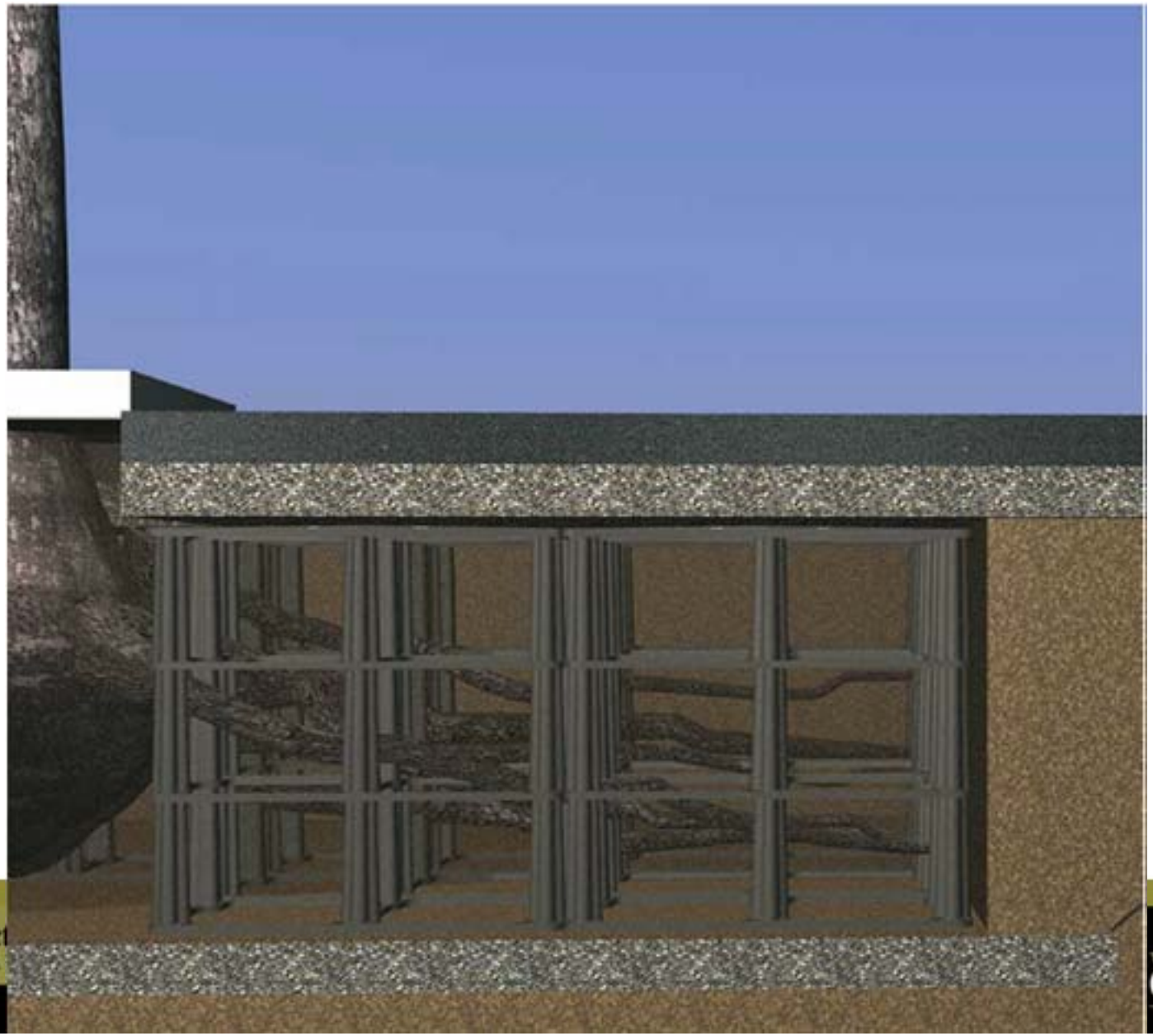
Our Parks department loves stormwater capture for irrigation purposes: a payback time of 3 – 5 years on investment

What LID is potentially attractive in Calgary?
Rain Gardens on Private Lots

Trumpeter at Big Lake, Edmonton

What LID is potentially attractive in Calgary?
Bioretention Areas / Biofilters

What LID is potentially attractive in Calgary?
Suspended Pavement Structures



but what about green roofs?

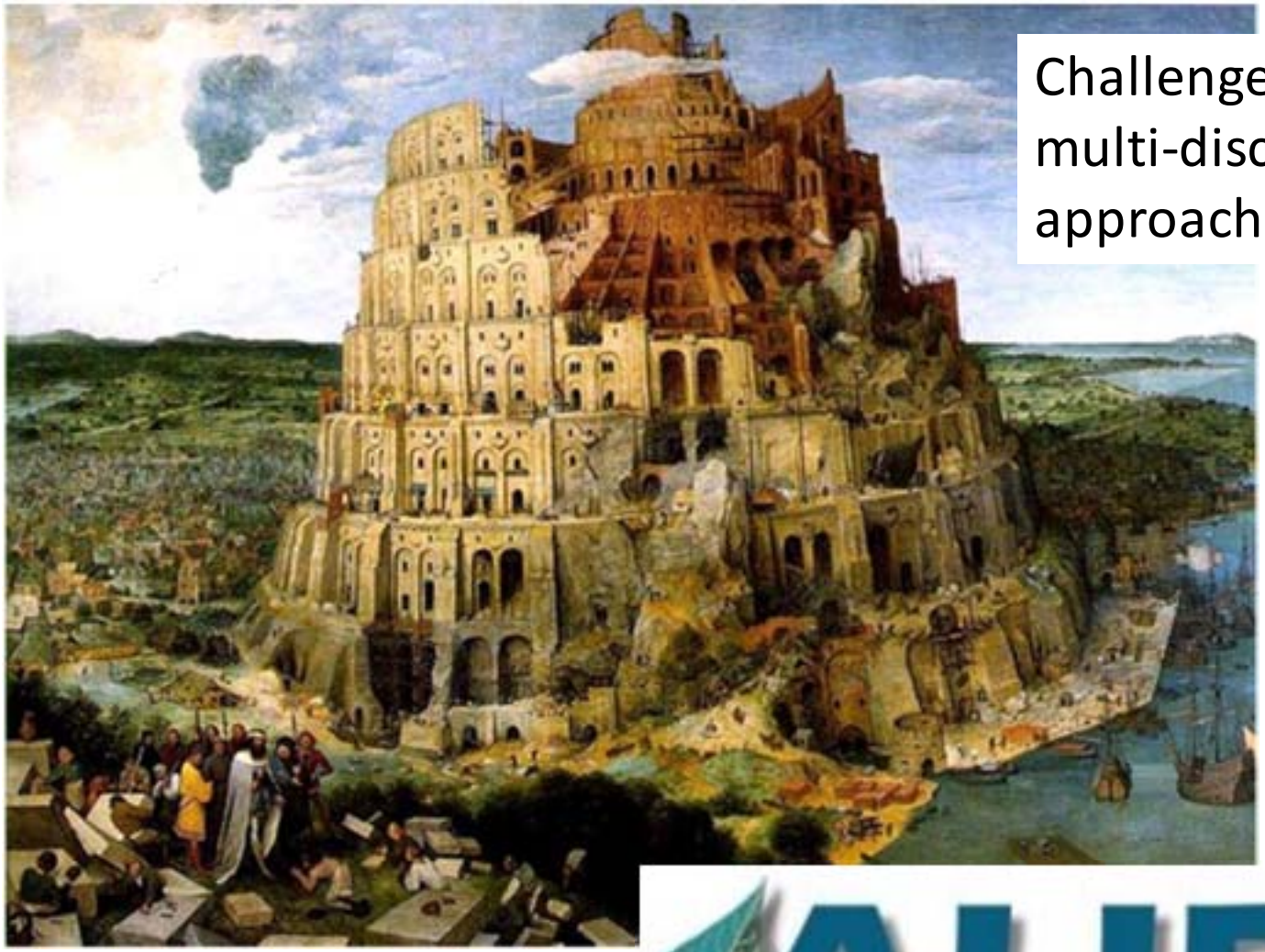
Green roof systems are possible with the proper selection of vegetation. The implementation may be limited; however, we want it done correctly so that there won't be nutrient leaching challenges

or permeable pavement?

Permeable pavement can be done in Calgary too. However, the conditions need to be right due to our extensive winter sanding practices

However, some are still very much on the learning track …

What have we learned?



Challenges with multi-disciplinary approaches

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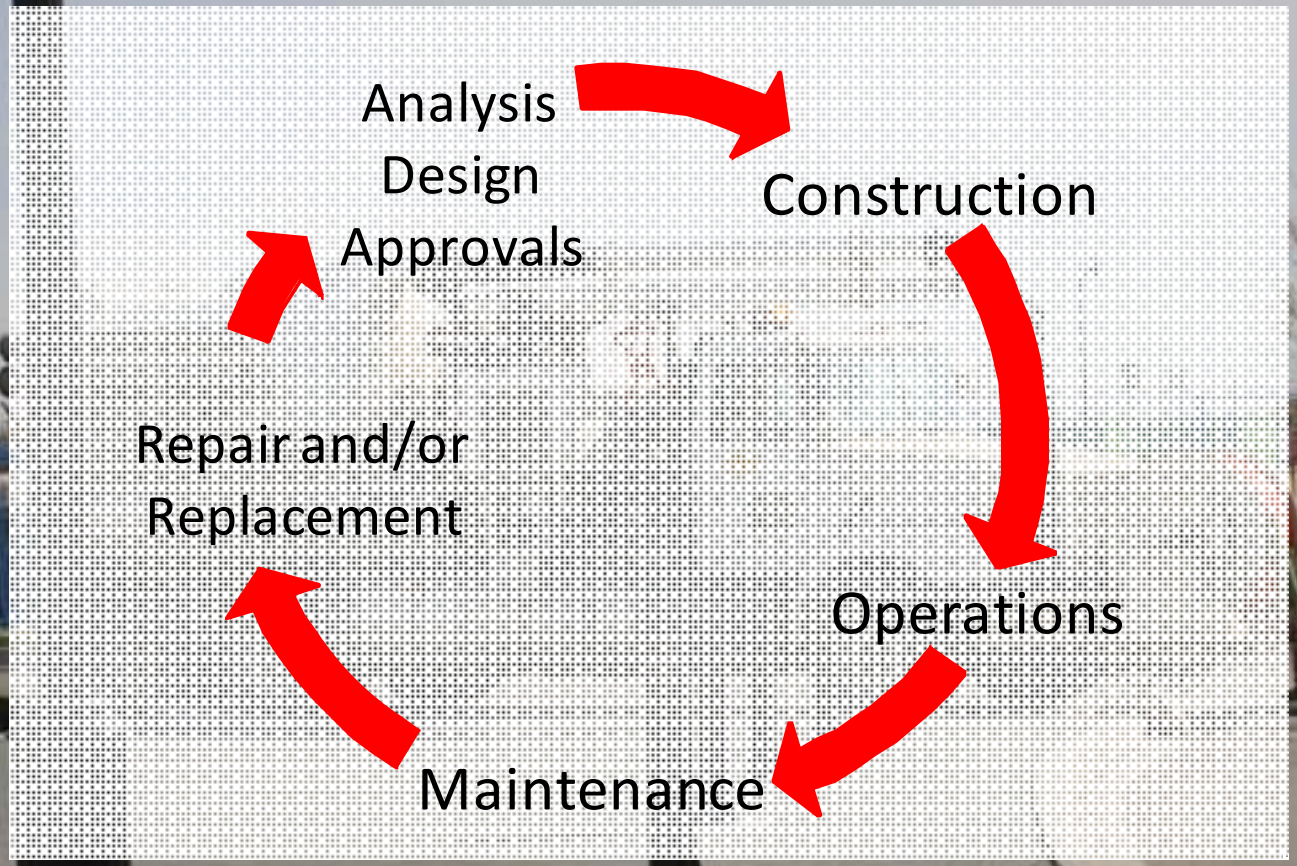
ALIDP
Alberta Low Impact Development Partnership

Interaction needed with Operation & Maintenance for asset life-cycle management



What else have we learned?

We need to do a much better job on Erosion and Sediment Control

As challenges such as above are the direct result of practices such as to the right

Research Activities

- Stormwater reuse study
- Permeable pavement
- Bioretention / biofiltration
- Green Roof systems

- Potential association with Olds College and the ALIDP

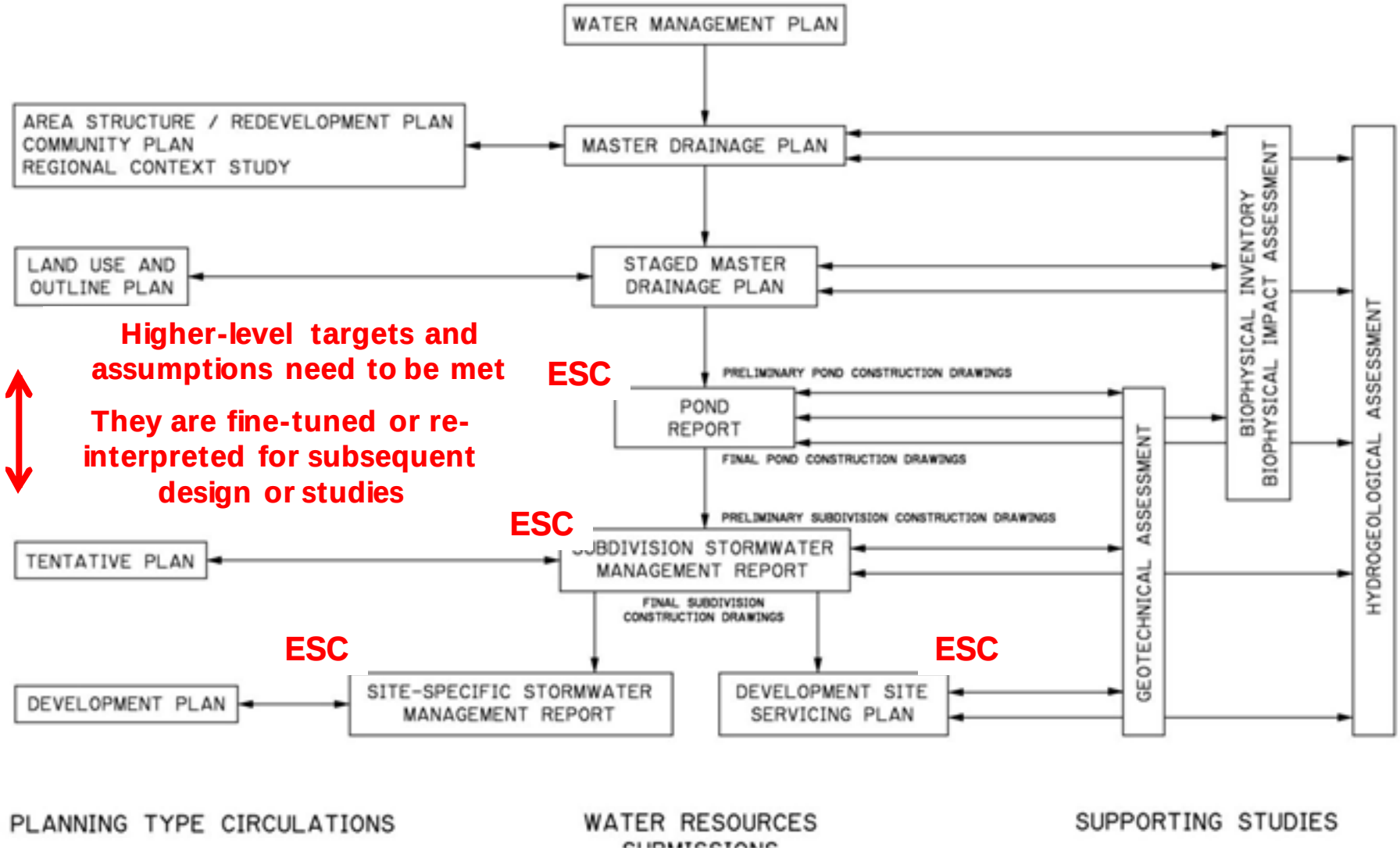
Research Activities

- Research consists of combination of installations in the field as well as laboratory set-ups
- The latter are used to get a better appreciation of potential long-term performance as function of I/P ratio

Structure for Drainage Management in Calgary

- Water Resources: planning, analysis and design; and customer relations and billing services
- Water Services: construction services; and Operations and Maintenance
- Submissions by consultants are made to Urban Development Business Unit, which circulates drawings to various Business Units
  - E-construction drawing submission implemented as of January 1, 2013 for all new submissions
- Stormwater Reports are directly submitted to Water Resources. Automated submission and review process (partially) active as of February 1, 2013

Interaction between submissions



At the higher-level planning levels, one needs to give adequate thought to “if” and “how” a system can be built, operated and maintained. If we cannot construct it properly, or protect it during the construction process, something else needs to be done!

Potential Comments

438B Master Drainage Plan (LID Developments)

Department Responsible: Urban Development

Stage of Development (File Type): Outline Plan

Type of Condition or Comment: Prior to Council

Wording:

A hydrogeology report is required for Low Impact Developments prior to land use. The hydrogeology report is to be prepared by a qualified hydrogeologist. Percolation rates and regional groundwater analysis is required to demonstrate the underlying soil can accommodate stormwater infiltration. Contamination of groundwater is prohibited. All report(s) will be reviewed to the satisfaction of The City of Calgary (Environmental & Safety Management).

Commentary:

This condition is intended to supplement the Source Control Practices Handbook (2007).

Potential Comments

409A Stormwater Easement Registration (LID)

Department Responsible:	Urban Development
Stage of Development (File Type):	Tentative Plan
Type of Condition or Comment:	Condition of Approval (Concurrent with Registration)

Wording:

Stormwater Easements (Low Impact Development) – Stormwater Easements are required to protect Low Impact Development features such as Bioswales, Rain Gardens, Rainwater Cisterns, etc. Any required easements and caveats shall be registered on the affected titles concurrent with the final instrument.

Commentary:

The intent of this comment is so LID measures remain on private property in perpetuity.

However, all of this should be seen within the context of the following Water Resources Commitments:

- Water Resources will review and approve, as appropriate, the incorporation of LID facilities in new or redeveloped areas
- Extended guarantees for performance will not be sought beyond the FAC period nor will the FAC period be extended for LID facilities
- Internal City issues with LID facilities from other City business units should be reviewed jointly with Water Resources and the developers

Letter from Directors of Water Resources and Water Services to other Business Unit Directors and cc'd to UDI (Feb 2008)

Water Resources Commitments

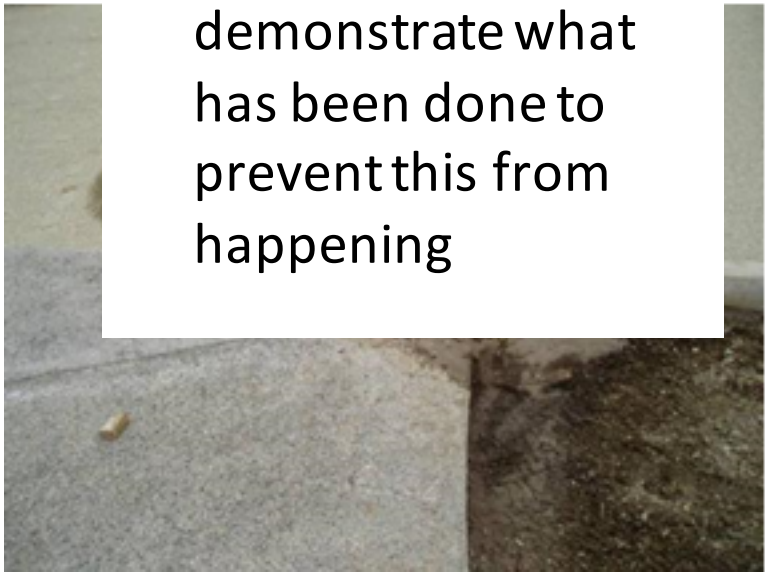
- The incorporation of LID facilities in developments should not unduly delay the approval process as this would discourage their use;
- Approved LID facilities on public land will be maintained by Water Resources / Water Services on handover to The City; and
- LID features on private land will be the responsibility of the landowner

On-Line Materials

- Available at the Urban Development website, see http://www.calgary.ca/PDA/DBA/Pages/Urban-Development/Publications.aspx:
  - 2011 Stormwater Management & Design Manual
  - Erosion & Sediment Control Guidelines
- Available at the Water Resources, Development Approvals webpage, see http://www.calgary.ca/UEP/Water/Pages/Specifications/Submission-for-approval-/Development-Approvals-Submissions.aspx:
  - Various checklists
  - Various report templates
  - Climate database
  - Water Balance Spreadsheet

Checklists

- These checklists are preliminary and subject to change as detailed guidelines, etc. are prepared
- We want the designer to also think of what may go wrong, and demonstrate what has been done to prevent this from happening



The City of Calgary
Development Approvals, Water Resources

Checklist for • STORMWATER SOURCE CONTROL PRACTICES
BIORETENTION AREAS

Project:

Developer:

YES	NO	N/A	
☐	☐	☐	1. For each bioretention area, provide a table summarizing • Location • Size of bioretention area (i.e., surface area of media) plus pre-treatment system, if any; • Size and type of hard areas, if any, draining into bioretention area; • Corresponding I / P ratio for bioretention area; • Size and type of total area draining into bioretention area; • Design saturated hydraulic conductivity of media; • Design safety factor for long-term performance • Design emptying time of bioretention area for 1 hour water quality event and 24 hour, 1:100 year "major" storm event; • Permissible and actual discharge rate into subdrain / storm sewer system for 1:100 year event and type of flow control, if any; • Target and anticipated water quality enhancement provided (with supporting information); • Thickness and composition of media, including type of vegetation and rooting depth of vegetation when vegetation is mature; • Anticipated life expectancy of the bioretention area based upon design assumptions, normal use and normal environmental conditions – provide supporting information or professional certification, as required); • Median annual runoff volume conveyed to subdrain / storm sewer system and/or median annual spillover volume.
☐	☐	☐	2. Supporting hydrologic / hydraulic computations of the operation of the bioretention area, including annual runoff volumes, peak inflow and spillover flows, and annual spillover volumes, are provided. The values for the saturated hydraulic conductivity of the media, and the infiltration rate into the subsoils, if any and supported by field tests, and assumed evapotranspiration rates are provided as well.
☐	☐	☐	3. Confirmation that the entire runoff volume generated by the 1 hour, water quality design event is treated by the bioretention area without surface overflow, if no secondary treatment (in e.g. a storm pond) is provided.
☐	☐	☐	4. Description of failure mechanism and consequences of failure with respect to level of service is provided.
☐	☐	☐	5. For each bioretention area plan view and cross-section details included on construction drawings c/w: ☐ Flat bottom with minimum 600 mm width (3000 mm preferred),

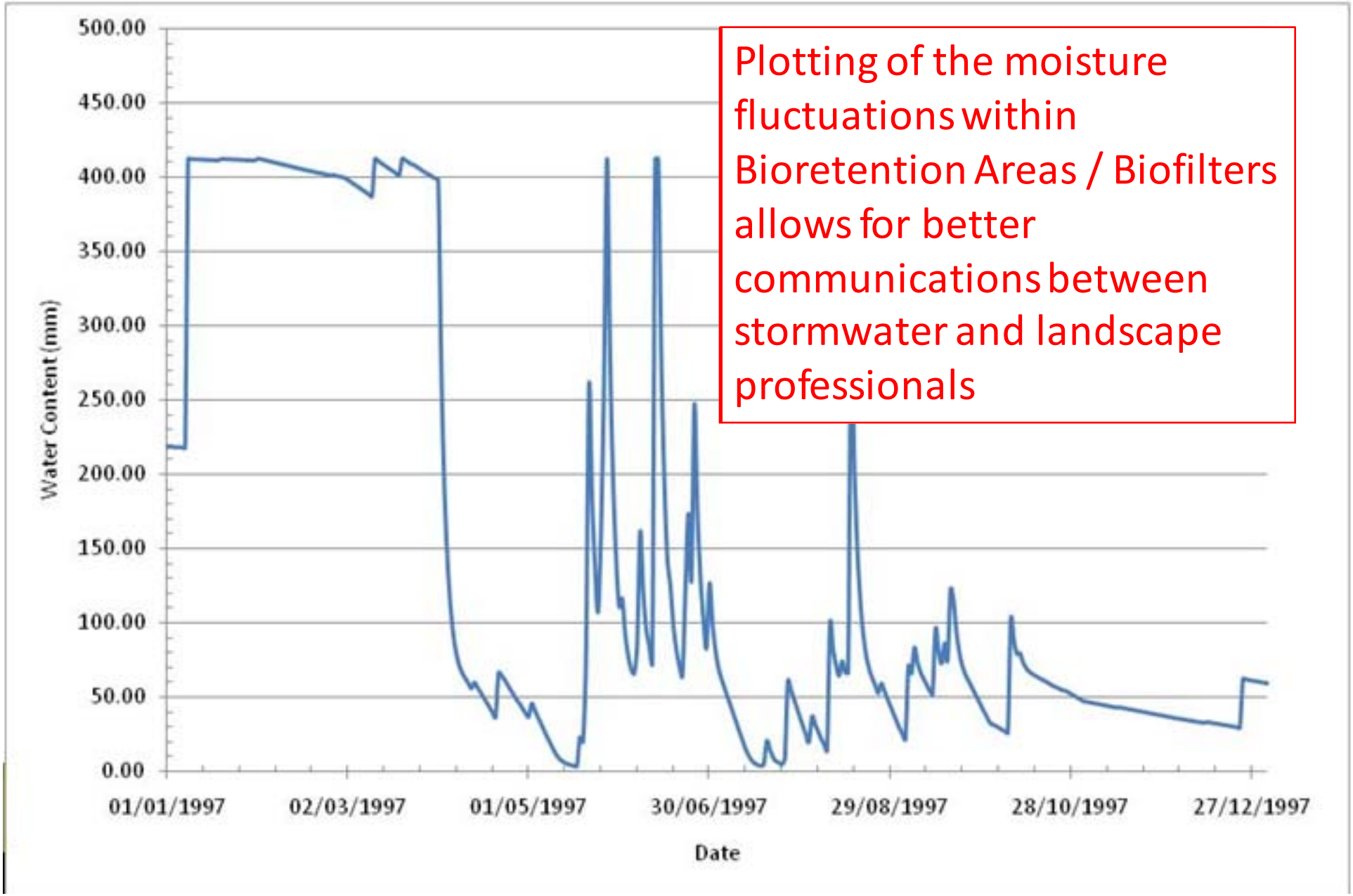
Climate Database

- Hourly temperature and precipitation datafiles for period 1960-2009, adapted from Environment Canada's information:
  - Consultants had been found to use different databases, some even excluding snow fall
  - Numerous errors found in the official "hourly" precipitation database when compared to "daily totals"
  - Official database was adjusted based on "daily totals" and recorded "weather conditions"
  - Snow fall was incorporated for the winter months

Computational Procedures

- Typically, HYMO or SWMM families of models are utilized, using guidance provided in the 2011 Stormwater Management & Design Manual
- Water Balance spreadsheet available for LID features and evaporation facilities. Features of this spreadsheet include:
  - Flexibility of re-direction of flows from one type of surface to the other, or to water reuse tanks, or to storm ponds
  - Rainwater harvesting and re-use of accumulated stormwater for irrigation and other uses
  - Replenishment of soil moisture due to irrigation. Tracking of soil moisture fluctuation over time.
  - Improved representation of reduced infiltration during winter months
  - Reduction of infiltration capability as a function of clogging over time
  - Enhanced statistics and graphical representation of source control practices and stormwater management

Sample Moisture Levels in a Bioretention area



Opportunities to downsize infrastructure

- One can downsize the minor system if it can be demonstrated that the runoff volume for a 1:5 year event is reduced:

$$UARR_{LID} = UARR_{Conventional} \; x \left\{ \frac{RV_{LID}}{RV_{Conventional}} \right\}$$

  - Truncated to 45 L/s/ha
  - Similar number of catchbasins
- The Water Balance Spreadsheet is to be used to analyze the impact of runoff volume reduction on stormwater management facilities
- However, if a pond or conveyance system is downsized with the introduction of LID features, these features MUST be built as intended!

Future on-line Materials

- Updates to and expansions of the 2011 Stormwater Management & Design Manual, checklists and templates
- Sample rainfall-runoff model datafiles
- Frequency Analysis Procedures manual
- LID guidelines, specifications and standards including sample Operation & Maintenance guidelines
  - Geotechnical and Hydrogeological Considerations
  - Vegetative and Absorptive Practices: (a) Bioretention/Biofiltration areas, Bioswales; (b) Absorbent Landscaping; (c) Suspended Pavement Structures
  - Green Roof Systems
  - Stormwater Capture and Re-use
  - Rainwater Harvesting
  - Permeable Pavement Structures

Training Activities

- Stormwater management is still an evolving field. Therefore, level of training offered by colleges and universities, and professional organizations has been found to be insufficient
- Erosion & Sediment Control courses have been offered since 2001
- Program has been expanded over time with stormwater management and LID courses
- ALIDP started to offer LID courses in 2010, and has now taken over the organization of the annual week of courses, hosting close to 700 participants last week
- Some level of certification desired in time

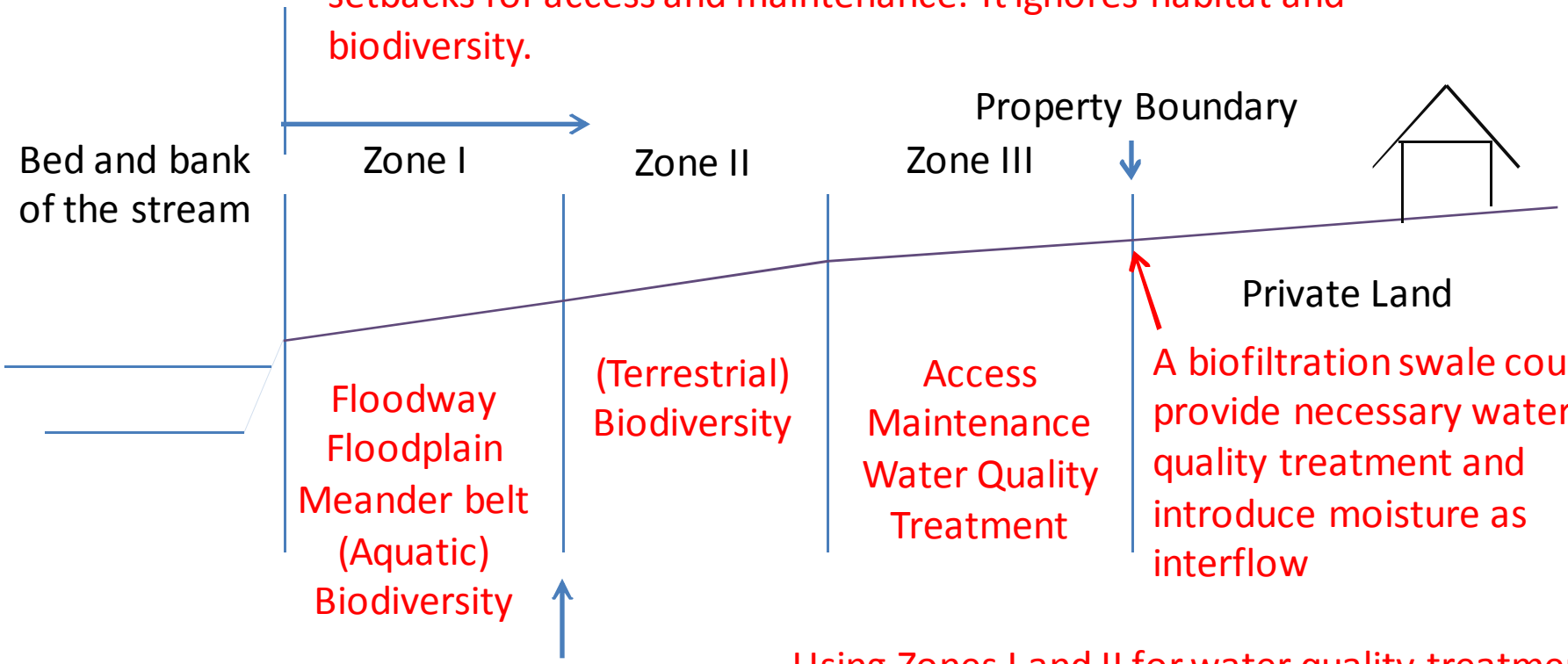
Ongoing challenges and direction

- Interpretation of setback zones
- Ponds and pipes
  - Excessive sedimentation in our conveyance system and ponds
  - Poor access to ponds and lack of emergency overland escape routes
  - What does functionality mean from a wetland preservation perspective?
- Decisions to be made
  - What is the appropriate split between private and public drainage infrastructure investment?
  - Do we want to implement a variable rate drainage fee structure?
  - How much and what kind of LID should be done where?

We are working on a Drainage Financial Plan

Setbacks: Example of Three-Zone System

Challenge: the Municipal Government Act in Alberta only allows setbacks for access and maintenance. It ignores habitat and biodiversity.



This is how far the stream could come at some point in the future

Using Zones I and II for water quality treatment has drawbacks

- Zones are inherently compromised
- No one ever talks about fate of contaminants
- Treatment concepts are based on sheet flow conditions which do not exist in reality

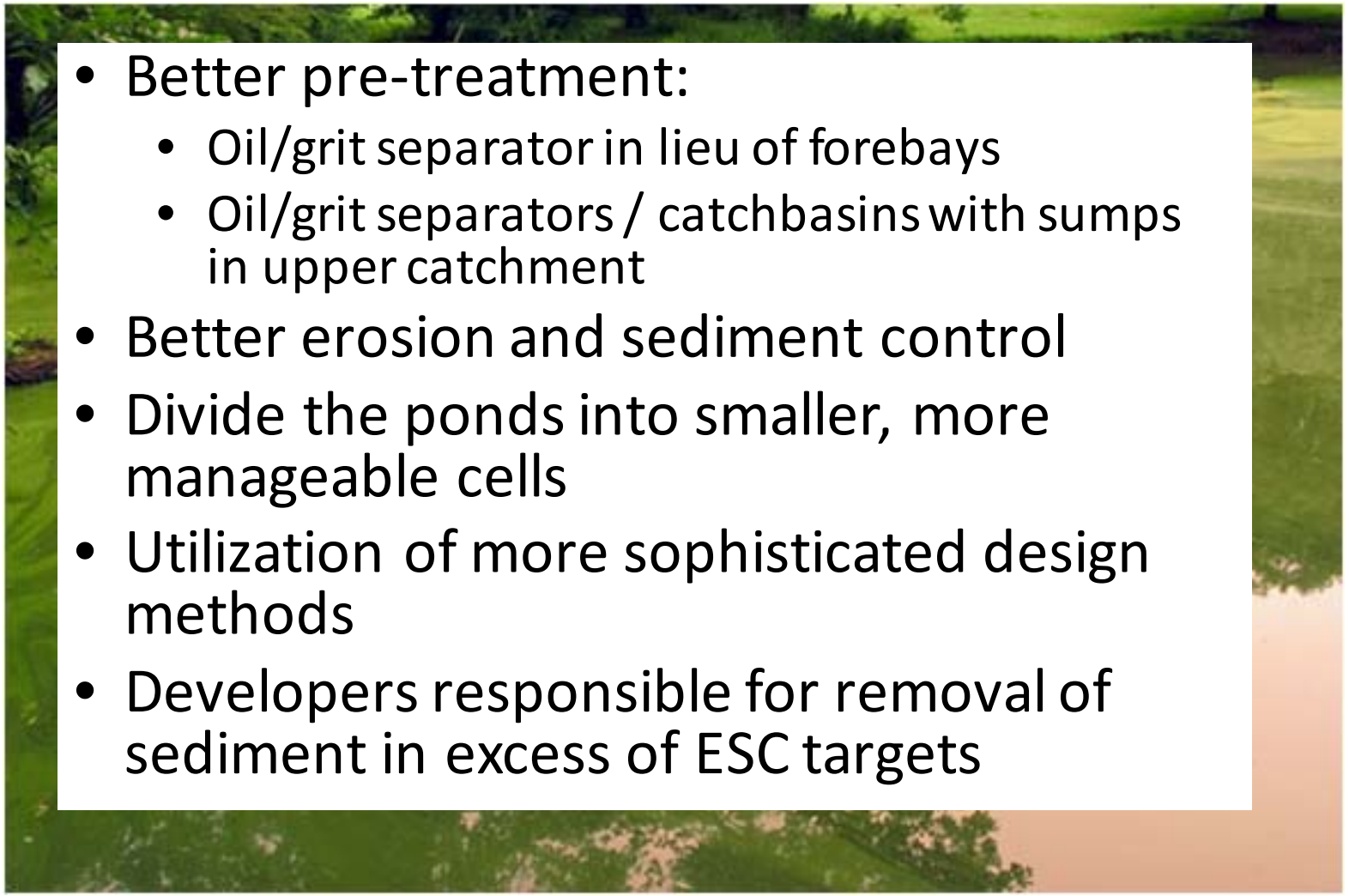
Elliston Park (68th Street SE) Pond
Even though "sediment traps" demonstrated presence of sediments, very little was ultimately found in the pond

Credit: Stephen Goudey, LIMNOS

While this may have a certain artistic “beauty”, we don’t want to go there …

We are now also running into issues with algae and odour complaints

Considerations for improvement:



- Better pre-treatment:
  - Oil/grit separator in lieu of forebays
  - Oil/grit separators / catchbasins with sumps in upper catchment
- Better erosion and sediment control
- Divide the ponds into smaller, more manageable cells
- Utilization of more sophisticated design methods
- Developers responsible for removal of sediment in excess of ESC targets

Interaction Parks & Water

- Open Space & Green Space Planning for stream corridor and wetland protection
- Considerations:
  - Retention of drainage courses is important as they also act as emergency overland escape routes
  - It is IMPOSSIBLE TO AVOID wetland impacts when land is developed because the watershed and the hydrology of wetland get altered! However, we can minimize impacts by:
    1. Create a storm pond beside the wetland that feeds the wetland
    2. Implement LID in the upstream catchment to control the runoff rate, volume and water quality into the wetland

Interaction Parks & Water

- Stormwater Capture (or rainwater harvesting) with re-use for irrigation of
  - Playfields and sport fields
    - to save on potable water demand
  - Trees along roadways boulevards
    - maintain the urban forest
  - Environmental Reserve
    - to make up for moisture lost due to catchment changes
    - as fire protection
- and, of course, it has benefits in reducing the runoff rate and volumes, thus reducing impacts on the downstream receiving water bodies

Interaction Parks & Water

- Rain Gardens on private property
- Bioretention / biofiltration within roadway boulevards, MR & ER lands
  - Options for runoff rate and water quality control
  - Increased biodiversity
- Water people need assistance from Parks people in selecting appropriate media and vegetation, as well as doing maintenance activities
  - Hot potato being the functionality, ownership of and credit mechanism for especially the MR and ER lands
  - There needs to be clear agreement where, when and how these features can be implemented and how Parks is reimbursed for its efforts

- Last message: our consultants are still looking for fresh blood! The “Go West, Young Man” adagium still applies in their mind.
- Bert van Duin, M.Sc., P.Eng.
  - Senior Development Engineer
  - Water Resources, Infrastructure Planning, Development Approvals
  - (403) 268-6449
  - bert.vanduin@calgary.ca