the partnership
for water sustainability in bc

What the "Whole-System, Water Balance Approach" means for Lowland Drainage in British Columbia

Moving Towards "Sustainable Watershed Systems, through Asset Management"

Aerial view of Barrowtown Pump Station. *Photo Credit: City of Abbotsford*

Water Sustainability Action Plan for British Columbia
Published on the waterbucket.ca Website – May 2017

“More hard surfaces in the uplands means more surface runoff volume is discharging into the agricultural lowlands. This is the real issue,”

states Ted van der Gulik, former Senior Engineer, BC Ministry of Agriculture

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People learn from stories, and this e-newsletter article is the first in a series that the Partnership for Water Sustainability will publish over time. The series purpose is to reflect on the policy, program and regulatory framework for land and water stewardship in this province.

In our stories, we will pass on knowledge that otherwise might be lost. The series focus will be on the genesis of regulatory objectives and/or requirements in British Columbia.

This first article in the series is about lowland drainage, in particular the ***“ARDSA criteria”*** *that have defined standard practice since the 1960s. Ted van der Gulik, formerly the Senior Engineer in the BC Ministry of Agriculture, connects the dots between past, present and future.*

Chilliwack lowlands

Agricultural Development – Context

Ted van der Gulik

President, Partnership for Water Sustainability

*Formerly the Senior Engineer in the Ministry of Agriculture, Ted van der Gulik received the **2014 Legacy Award** when he retired from government.*

*He was also an inaugural inductee into the **BC Public Service Hall of Excellence**.*

Ted van der Gulik led the team that received the Premier's Award for the Agriculture Water Demand Model.

In British Columbia, agricultural development is often situated in the lowlands, and close to rivers. Historically, urban development has occurred in the uplands, with the rate of land development and re-development accelerating in recent decades.

This article serves two purposes. It provides historical context for the "ARDSA criteria" that have guided design and operation of drainage infrastructure in the agricultural lowlands. It also provides insight as to why it is necessary to restore watershed hydrology in the urban uplands.

The understanding provided by this article is part of the big picture for the *whole-system, water balance approach* that underpins "Sustainable Watershed Systems, through Asset Management"[1].

Historical Funding for Agriculture Development: The ARDA program (Agriculture Rural Development Agreement) of the 1960's and early 1970's was a Federal and Provincial capital projects program that funded rural agriculture development. This program was followed by ARDSA (Agriculture Rural Development Subsidiary Agreement) in the late 1970's and early 1980's.

Both programs encompassed rural irrigation water supply, rural drainage infrastructure as well as rural electrification. Funding was provided on a maximum formula of 75% from the program and 25% from the local partner.

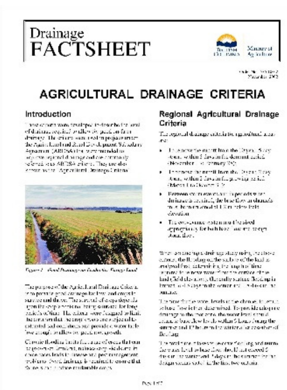
"When the ARDA and ARDSA funding programs were in their heyday, the rules were quite strict," reports Ted van der Gulik. "Projects were required to have a return on the investment greater than 1. In other words the value of the increase in agriculture production due to project implementation had to return more than the original cost of the project over a 20-year time frame, in net present value dollars at the time of project approval."

[1] http://waterbucket.ca/viw/files/2015/11/Beyond-Guidebook-2015_final_Nov.pdf

Genesis of Agricultural Drainage Criteria

"In the case of drainage, the province established a set of criteria which determined the level of drainage improvements that were deemed to be acceptable in terms of cost-benefit, and the ability to pay," explains Ted van der Gulik.

"The supporting analysis optimized the relationship between agricultural return on production and cost of drainage infrastructure investment. These have come to be known as ARDSA criteria[2]."



Drainage FACTSHEET

AGRICULTURAL DRAINAGE CRITERIA

Introduction

Regional Agricultural Drainage Criteria

The ARDSA criteria are also known as the ***"Agricultural Drainage Criteria".***

In November 2002, the Ministry of Agriculture released a 7-page explanatory document.

A copy is included as an appendix to this article.

Infrastructure Design and Operation: "The ARDSA criteria were used to determine the capacity of drainage ditches and pump stations for all ARDA and ARDSA projects that were approved for funding.

"The ARDSA criteria for operation of a regional lowland drainage system boil down to three numbers: 2, 5 and 10.

"Once the rain stops, the system must be able to remove runoff after **2 days** during the growing period (March through October); and after **5 days** during the dormant season (November through February).

"The number 10 refers to the 5-day, **10-year storm**. Between storms the depth to the water level in drainage ditches needs to be 1.2 m (4 feet) to allow subsurface drain tile systems to operate properly and promote proper root and plant growth."

The Test of Time: "These criteria were developed to provide an adequate level of drainage while keeping the cost of the infrastructure at a reasonable level to be able to achieve a cost-benefit ratio of greater than 1 for the entire project.

"It has been many years since these drainage criteria were developed by the Ministries of Agriculture and Environment in support of the ARDA and ARDSA programs. A key message is that the 2-5-10 criteria have stood the test of time," emphasizes Ted van der Gulik.

[2] http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/water/500-series/535100-2_agric_drainage_criteria.pdf

The survival of crops depends upon the crop's roots not being saturated for long periods of time. The criteria were designed to limit the duration that the crop's roots are subjected to saturated soil conditions and provide a water table low enough to allow for good root growth.

What does a 5-day, 10-year storm mean?

A 5-day storm, 10-year storm indicates the volume of water that is required to be removed by the drainage system. This volume of water is to be removed within 5 days from the time the root zone is saturated.

With the Passage of Time…..

"Although reference continues to be made in engineering reports to the ARDSA drainage criteria, there is an absence of recognition of the underlying cost-benefit rationale for the 2-5-10 criteria. I believe this reflects a loss of understanding that could have potentially serious implications for current and future decision-making," states Ted van der Gulik.

A Requirement is a Requirement: "We see this loss of understanding manifest itself in a number of ways. In recent years, for example, there have been instances of the criteria not being correctly presented in various engineering reports on lowland drainage, with misleading descriptor words such as 'should' creeping into reports.

"The ARDSA criteria were not developed to **maybe** provide the specified level of drainage relief. The project requirement was that they **must** provide the level of drainage for the 5-day, 10-year storm or the project would not have been approved and received ARDSA funding."

Impact of Uplands Development on the Water Balance: "One also hears or reads comments that ARDSA criteria are no longer valid and may therefore need to be increased because farmers are seeing more water on their land.

"And why is there more water? The explanation is two-fold. First, our climate is indeed changing. We are experiencing floods and droughts more frequently. In addition, the volume of rain falling during the 5 day 10-year storm is increasing.

"But overshadowing this hydrologic instability is the impact of the uplands development on the agricultural lowlands. Urbanization hardens the landscape. This changes the pre- and post-development annual water balance volume, and its time distribution.

"More hard surfaces in the uplands means more surface runoff volume is discharging into the agricultural lowlands. And the increased flows in streams are over longer durations. This is the real issue," states Ted van der Gulik in providing a capsule summary.

Jim Dumont

Engineering Applications Authority, Partnership for Water Sustainability in BC

Bring the 'State-of-the-Art' into 'Standard Practice':

"If communities are to truly benefit from use of nature's assets to provide vital community infrastructure services, then two issues must first be recognized as being impediment to changes in practice.

"Issue #1 is widespread lack of understanding of the relationship between flow-duration and stream (watershed) health.

"Issue #2 is widespread application of a standard of practice that has led to the current situation of degraded streams, and that has little connection to real-world hydrology."

Restore Watershed Hydrology in the Uplands: "The Ministry of Agriculture was an early adopter of the whole-system, water balance approach and the Water Balance Methodology that are at the heart of Stormwater Planning: A Guidebook for BC[3]," continues Ted van der Gulik. "This provincial direction resulted from a collaborative effort involving three Ministries: Environment, Municipal Affairs and Agriculture.

"The three Ministries shared this vision for the Guidebook: *foster a 'design with nature' ethic that, over time, would restore watershed hydrology in the urban regions*.

"To help make this happen, the three Ministries made a long-term commitment (beginning in 2003) to invest in web-based tools and professional development. This program would be delivered through partnerships and under the umbrella of the **Water Sustainability Action Plan**.

"In the critical early years of Action Plan program development, the Ministry of Agriculture co-chaired and provided substantial funding for development of the online Water Balance Model for British Columbia[4]. The Ministry recognized that the agricultural lowlands benefit when watershed hydrology is restored in the urban uplands.

"The commitment to watershed restoration is long-term. It requires doing business differently. Use of the Water Balance Methodology and online Water Balance tools would help local governments bring state-of-the art hydrology into engineering standard practice."

Water Balance Tools - for use by different users at different scales and different purposes:

- **Water Balance Methodology** (existing) – independent of software platform or computer model
- **Water Balance Model for BC** (existing) – planners
- **Water Balance Express** (existing) – homeowners
- **Online Watershed Assessment Tool** (ready in 2017) – engineers

"Our objective is to make it easy for local governments to establish, require and implement Water Balance performance targets," states Ted van der Gulik.

[3] http://waterbucket.ca/rm/sites/wbcrm/documents/media/242.pdf
[4] http://waterbalance.ca/

A Path Forward

The New Paradigm: Watersheds as Infrastructure Assets

A watershed is an integrated system. Three pathways by which rainfall reaches streams are "infrastructure assets". The pathways provide "water balance services".

Whole-System, Water Balance Approach

Understand where the water goes naturally and reproduce those conditions.

*Restore sub-surface **interflow** to maintain hydrologic integrity.*

Maintain the proportion of rainwater entering a stream via each of 3 water balance pathways!

Replicate the streamflow-duration pattern to mimic the Water Balance.

"Clearly, there is a need to inform and educate a new generation of practitioners and decision-makers about the thinking and the analytical process that resulted in the ARDSA drainage criteria. This would help equip a new generation to make knowledge-based decisions," observes Ted van der Gulik.

"Without compliance with the drainage standards, the viability of agriculture and the local food supply is potentially at risk. The criteria are essential in protecting the crops (food on the table) from damage caused by excessive durations of flooding and saturation of the roots. If the crops are at risk, then so is the sustainability of the region," adds Jim Dumont.

In the Lowlands: "Understanding the context is also necessary," continues Ted van der Gulik. Keeping regional drainage systems operating to deliver the existing ARDSA criteria would be a challenge - because increased precipitation for the 10-year 5-day storm as well as increased upland runoff would increase the infrastructure costs."

In the Uplands: "To truly reduce impacts on agricultural lowlands, it would be necessary to restore the watershed hydrology in the uplands. Implement practices that slow, spread and sink rainwater runoff. This would have cumulative benefits, in particular avoided infrastructure costs in the lowlands," concludes Ted van der Gulik.

Uplands development in the City of Chilliwack

British Columbia’s Whole-System, Water Balance Approach

Kim A Stephens

Executive Director, Partnership for Water Sustainability in BC

“The vision for implementation of a whole-system, water balance approach is to protect and/or restore stream and watershed health in settled areas,” states Kim Stephens.

“In 2002, and with publication of *Stormwater Planning: A Guidebook for British Columbia*, a breakthrough resulted from application of science-based understanding to develop the **Water Balance Methodology**. This was a notable milestone in an ongoing process that one day would make possible Sustainable Watershed Systems.

“As of 2017, we can say that BC is progressing. Yet, persistent challenges for practitioners to adopt, change or evolve standards of practice means there is still a substantive disconnect between UNDERSTANDING and IMPLEMENTATION. This gap is a problem.”

Educate to Bridge the Gap: ““The whole-system, water balance approach hinges on an understanding of flow-duration. Yet the relationship is not well understood. Education is the way to overcome the impediments to changes in practice,” adds Jim Dumont.

“This will require education of the public, accountants, engineers and local government staff so that everyone appreciates the relationship between the flow-duration and the health of the stream.

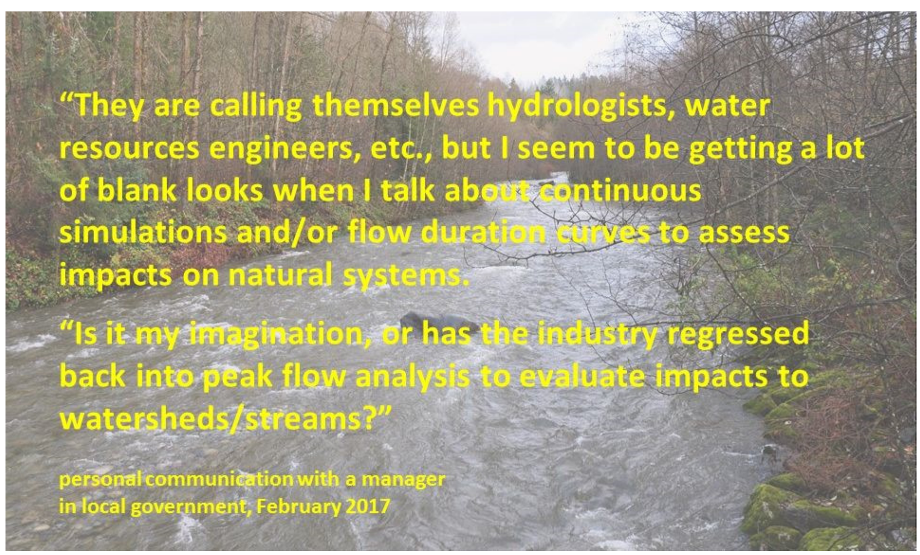
“A lynch-pin guiding principle for watershed planners and drainage designers must be to replicate the flow-duration pattern in order to limit stream erosion, prevent flooding and improve water quality.”

Benefits of Whole-System Approach

Less flooding, less stream erosion, more streamflow when needed most.

And the results will be:

- *Avoidance of an unfunded liability.*
- *Adaptation to a changing climate*



By 2017, an educational goal in British Columbia is that those involved in land use and drainage would be aware of the vision for…..

"Sustainable Watershed Systems, through Asset Management"

Applies to land uses that local government regulates, recognizes the importance of a stream in a natural state, and is founded on an understanding of the whole-system, water balance approach and how this led to the **Ecological Accounting Protocol** *as a tool to calculate the opportunity cost of drainage infrastructure*

Asset Management Continuum

Asset management for sustainable service delivery occurs alongside associated evolution in community thinking. It is a continuous quality-improvement process, and incremental.

A local government would experience the asset management process for sustainable service delivery as a continuum leading to a water-resilient future.

***Sustainable Watershed Systems** would be the outcome in Step Three*

Asset Management Continuum for Sustainable Service Delivery

GROUND ZERO: In the beginning, no **Asset Management Plan** exists. A consequence is 'unfunded infrastructure liability'.

STEP ONE: Local governments embrace the BC Framework, with an initial focus on core engineered assets (water supply, sewage, roads) and embark on an **Asset Management Strategy / Plan / Program** process.

STEP TWO: Local governments start thinking holistically and implement a life-cycle approach to infrastructure decision-making so that **Sustainable Service Delivery** for engineered assets becomes standard practice.

STEP THREE: For drainage function, local governments will integrate natural systems thinking and climate adaptation into asset management and account for the **Water Balance Services** provided by watershed systems.

As understanding grows, local governments will progress incrementally along the **Continuum**

THE OUTCOME:

A Sustainable Watershed System

What the "Whole-System, Water Balance Approach" means for Lowland Drainage in British Columbia

Moving Towards "Sustainable Watershed Systems, through Asset Management"

Appendix – Agricultural Drainage Criteria,
released in November 2002

Drainage FACTSHEET

BRITISH COLUMBIA | Ministry of Agriculture

Order No. 535.100-2
November 2002

AGRICULTURAL DRAINAGE CRITERIA

Introduction

These criteria were developed to describe the level of drainage required to allow for good on-farm drainage. The criteria were used in projects under the Agricultural and Rural Development Subsidiary Agreement (ARDSA) that were intended to improve regional drainage and are commonly referred to as ARDSA criteria. They are also known as the "Agricultural Drainage Criteria".

Figure 1 Good Drainage on Productive Forage Land

The purpose of the Agricultural Drainage Criteria is to provide good drainage for low land crops to survive and thrive. The survival of crops depends upon the crop's roots not being saturated for long periods of time. The criteria were designed to limit the duration that the crop's roots are subjected to saturated soil conditions and provide a water table low enough to allow for good root growth.

Chronic flooding limits the range of crops that can be grown on farmland, reduces crop yields and in some cases leads to disease and pest management problems. Good drainage is required to ensure that farmers can produce marketable crops.

Regional Agricultural Drainage Criteria

The regional drainage criteria for agricultural areas are:

- To remove the runoff from the 10 year, 5 day storm, within 5 days in the dormant period (November 1 to February 28);
- To remove the runoff from the 10 year, 2 day storm, within 2 days in the growing period (March 1 to October 31);
- Between storm events and in periods when drainage is required, the base flow in channels must be maintained at 1.2 m below field elevation.
- The conveyance system must be sized appropriately for both base flow and design storm flow.

When conducting a drainage study using the above criteria, the flooding on the surface of the land is analyzed first, determining the length of time required to remove water from the surface of the land (field elevation). Generally surface flooding is limited to 4.5 days in the winter and 1.8 days in the summer.

The time for the water levels in the channel to return to base flow is then determined. To provide adequate drainage to the root zone, the water level should return to base flow levels within 6 hours during the summer and 12 hours in the winter after cessation of flooding.

The total time it takes to remove flooding and return the water level to base flow should not exceed 5 days in the winter and 2 days in the summer for the design storms stated in the first two criteria.

Explanation of Terms

Flooding

Flooding is considered to occur when the water levels exceed the designated field elevation.

Runoff

Runoff is considered all water above base flow that is not infiltrated.

Base Flow

Base flow is the amount of water flowing in the channel when there is no runoff from storm events.

In order to determine the effect that any changes in the watershed will have on water flows, an estimate of the base flow for summer and winter are required.

The summer base flow condition is to be based on available stream flow and precipitation data.

The winter base flow is calculated for an extremely wet period defined as 20 to 22 days of rainfall during a wet month.

On some systems the outlet is controlled by a pump station during freshet. The cycling of the pump determines water levels. Where the pump station operation governs the water levels, base flow water levels will be determined by the arithmetic mean of the maximum and minimum channel water elevations at the location that is near the lowest land in the flood cell.

Storm Flow

Storm water runoff should be calculated for summer and winter conditions using a one in 10 year return period for 5-day winter and 2-day summer storms.

The Rational and SCS method for calculating peak flows should not be used when designing regional drainage systems. These methods over simplify a very complex process. Continuous simulation models are more realistic and take into account rainfall events that last for many days.

Freeboard

Freeboard is the elevation difference between base flow water levels in the channel and the field elevation.

For the purposed of determining freeboard the baseflow water level in the ditches is determined by analyzing base flow periods during the growing season.

Ideally the freeboard should be 1.2m, this provides a good outlet for tile drains. A freeboard of 0.9m <u>may</u> be acceptable in some areas.

Field Elevation

The field elevation can be designated where 95% of the land in the flood cell lies above the determined elevation. This is a general guideline.

5% of the land would be below the designated field elevation. This 5% may receive less drainage benefits than the surrounding land.

Calculation of the Duration of Poor or InadequateDrainage

Inadequate drainage is considered to occur when water levels rise above base flow conditions and crop roots are affected.

The duration of poor drainage should be calculated by summing the periods of inundation for the entire period of influence of the storm event.

During the dormant and growing seasons a certain amount of inadequate drainage may occur but the duration must be limited to the stated criteria to prevent damage to the crops

Explanation of Criteria

Remove the runoff from the 10 year, 5 day storm, within 5 days in the dormant period (winter).

What does a 5 day 10 year storm mean?

A 5-day storm, 10-year storm indicates the volume of water that is required to be removed by the drainage system. This volume of water is to be removed within 5 days from the time the root zone is saturated.

The amount of rain that can fall in a 5-day 10-year storm varies around the province.

To determine the local 5-day 10 year storm precipitation data from a near by climate station is statistically analyzed to determine what the average rainfall would be for a storm lasting 5 days that would occur once every 10 years. This would be more severe than a storm that occurs once a year, just as a 100-year storm would be even more severe than a 10-year storm.

Choosing this storm event to be used for the design or assessment a drainage system means that there is a level of acceptable risk that is assumed. The risk is that every 10 years a storm may occur that is larger than the drainage system is designed to convey.

There is a chance that a 5-day 10-year storm will occur more than once in a single year. The probability of this occurring is very small.

Remove the runoff within 5 days.

The on-farm drainage system is an integral part of removing the water from the root zone. Most subsurface drainage systems are installed with the pipe outlet at 1.0-1.1m below the field surface. To allow for the drains to flow freely the *base flow* in the channel should remain 1.2m below the field elevation between storm events.

Because regional drainage systems service on-farm drainage systems of farms with a variety of crops, a water level indicated by the 1.2m freeboard between storm events is the level used to determine if this criteria is met. By providing a 1.2m freeboard where it currently does not exist the agriculture community has the opportunity to convert to higher value crops.

However, in some situations where the crops grown are uniform and do not have deep roots determining when inadequate drainage begins can vary depending on the crop type.

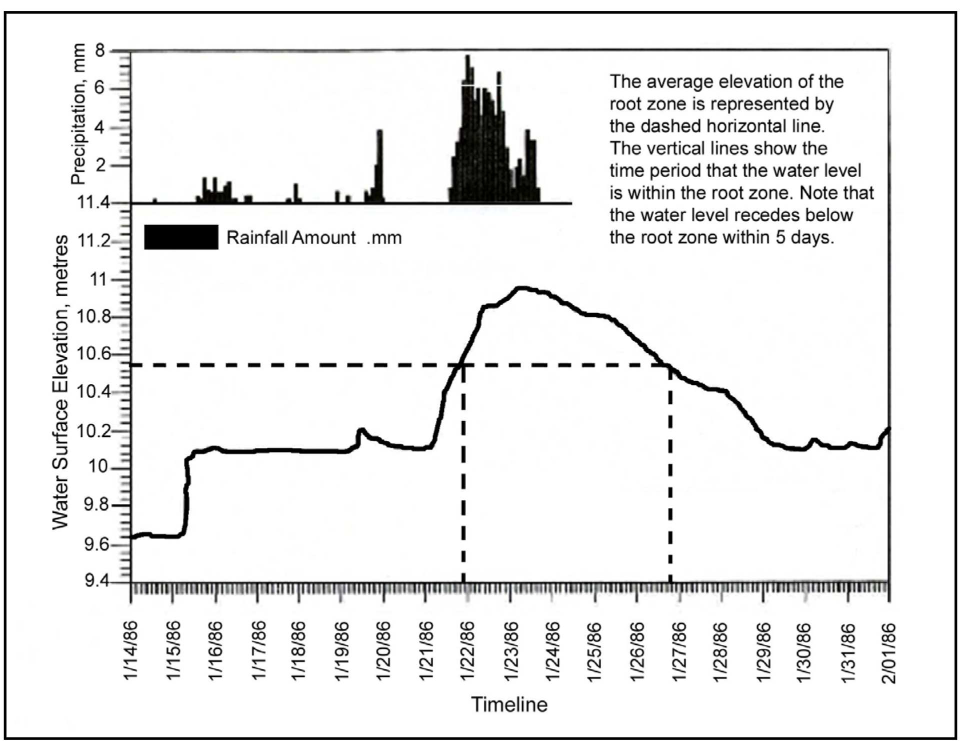


Figure 2 Sample Hydrograph

For perennial crops that have a deep established root system the roots of the crop should not be saturated for more than five days. The water level may rise higher but it must be below the root zone by the end of five days.

For **shallow rooted crops and grasses** the crop roots may not be affected until the water level has risen within 0.9m of the land surface. In these cases the inadequate drainage is considered to begin when it rises above this level and end when it falls below this level.

For **some vegetable crops** flooding during the winter is acceptable and even desirable. For drainage areas that only service areas where these crops exists inadequate drainage would be considered to begin the water reached the field elevation.

Figure 2 shows a hydrograph produced for a 5-day storm. Many factors affect the shape of the hydrograph including the land use in the area and the pattern of the storm. Notice the precipitation bars at the top of Fig. 2 indicates high rainfall the last day of the event and less the previous days. This may be a typical pattern for the area producing a certain volume of rain. This same amount of rainfall could fall in equal amounts each day and this would produce a different hydrograph.

The example hydrograph shows the rise and fall of the water table due to the storm. For this situation the water level recedes below the root zone within 5 days.

To remove the runoff from the 10 year, 2 day storm, within 2 days in the growing period (summer).

The analysis for this criterion is similar to the analysis described for the 5-day 10-year storm to be removed in 5 days in the dormant season.

For this criteria the 2-day 10-year storm in the growing season is analyzed to determine the amount of water to be removed by the drainage system.

During the growing season the water has to be removed quickly, within 2 days, to prevent damage to the crop's development. Since plants breath through their roots it is important that there is air in the soils and the soil is not saturated for long periods of time.

Between storm events and in periods when drainage is required, the base flow in channels must be maintained at a 1.2 m below field elevation.

In many situations the banks of the watercourse may have been built up over the years. This creates a berm along the watercourse, see fig. 3. Although the bank may be at an elevation of 1.2 m above the water the actual low point in the field may be 0.5 m below the bank (berm) level. This would leave only a 0.7 m free board. It is important to have a topographical survey of the area showing all low spots, ditch bottoms and water levels in the channel.

The freeboard is critical in the spring and fall when equipment needs to access the fields. The water level may be maintained higher in the summer if field and crop conditions are conducive to subirrigation.

Subirrigation is an option that should be left up to the individual farmer.

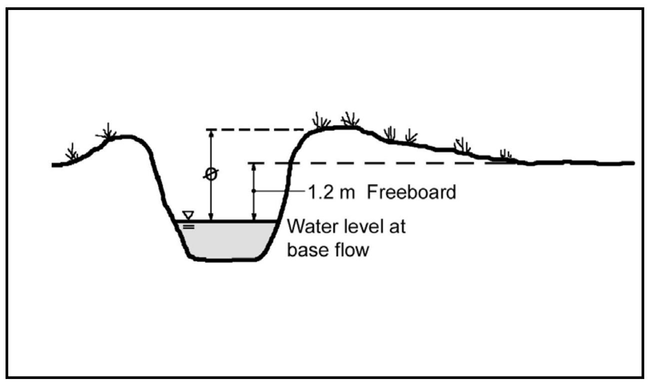


Figure 3 Determining Freeboard

The conveyance system must be sized appropriately for both base and design storm flows.

This criterion is to assure that all ditches and culverts are sized appropriately. In a number of regional drainage areas where the drainage is inadequate the problem is usually a culvert or channel that is too small to pass storm flows efficiently or a culvert installed too high.

Drainage Improvement Assessment for Agriculture

To conduct a proper drainage improvement assessment the following information should be provided for areas that do not meet the Agricultural Drainage Criteria.

- Delineate on a map the field areas that are capable of achieving 1.2m freeboard during non-storm situations.
- Delineate on a map the field areas that are capable of achieving only 0.9m freeboard during non-storm situations.
- If the 1.2m freeboard cannot be met within the time period stated after a storm, what water level in the ditches is achievable within the stated time period?
- If the 1.2m freeboard cannot be met within the time period stated after a storm, how long will it take to meet the 1.2m freeboard?
- If the 1.2 m freeboard cannot be met within a maximum of 12 hours in the summer or 24 hours in the winter after the cessation of flooding, create a map delineating the areas that meet 1.2m and 0.9 m of freeboard within the time period stated in the criteria. See fig. 4.

By providing this information in a report it is possible to assess the impact that the poorly drained areas will have on agriculture.

This information can help answer some of the most commonly asked questions and provides farmers with a clear picture of the drainage situation in their area.

The information indicates the severity of the impact.

> *Can the poorly drained areas support crops that are less sensitive to drainage conditions?*
>
> *Is the land unfarmable?*

The maps show the areas that are affected and how these areas relate to parcels of land that are farmed.

> *Does the poorly drained area negatively affect the entire parcel?*
>
> *Does it make the parcel of land unproductive or too difficult to farm?*

When planning drainage improvements this information gives an indication of which areas may benefit from drainage improvements and which areas may be too difficult to drain.

> *What is the cost / benefit ratio of improving drainage?*

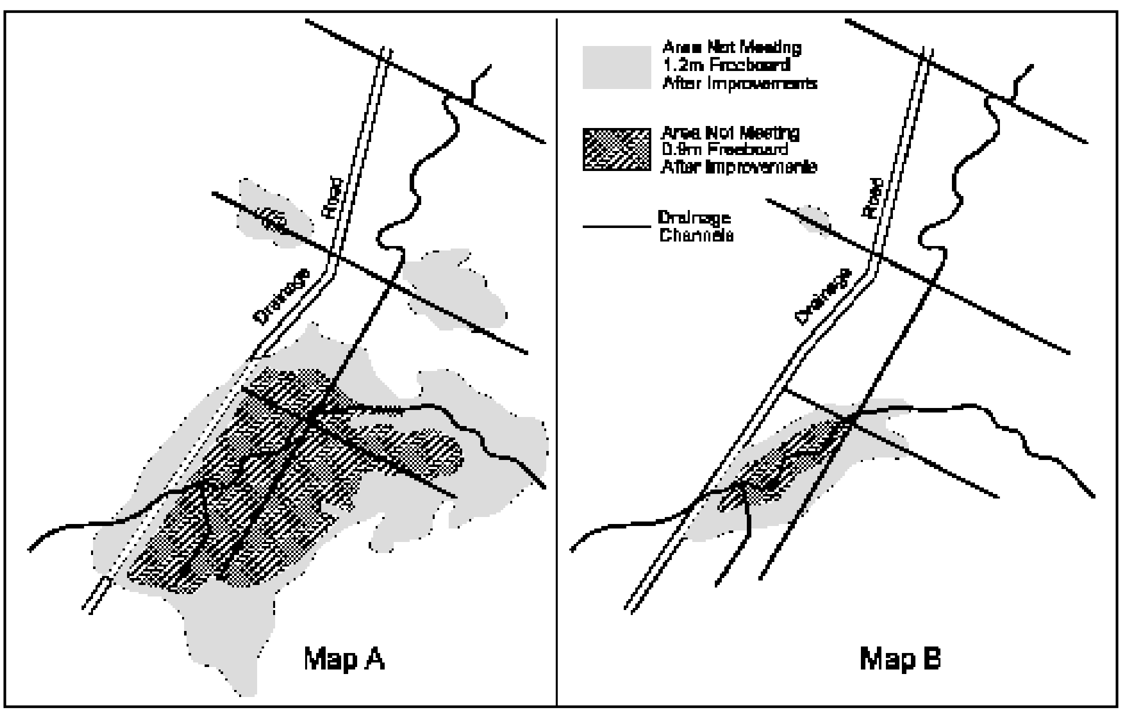


Figure 4 Regional Drainage Assessment Maps

Assessment Summary

Summarizing the affects of changes in the drainage system or drainage improvements in tabular and map form is a convenient method of displaying all the options. The table should include the changes that could be expected in flows, duration or saturation and the land area affected during the storm stage due to proposed changes in the watershed.

Regional overview of agricultural drainage

Figures 4 and 5 are examples of mapping the results of the drainage assessment. Figure 4, Map A and Map B, give an overall regional view of the areas that will still be affected after the proposed drainage improvements have been implemented. A map like this may also include lot boundaries. This map may then be used to show stakeholders which lands can reasonably be expected to be drained and which cannot.

Table 1 gives an example of summary information that may accompany these figures. The table may also contain other relevant information.

It is then possible to easily compare the options. The drainage improvements in Option B meet the agricultural drainage criteria in 95% of the drainage area. The areas not meeting the criteria only experience an extra day of flooding and have a 0.7m to 0.75m freeboard, which is acceptable for some crops. For Option A there will be some areas that do not meet the drainage criteria. However, the cost for Option A is quite a bit less than Option B.

The farmers and other stakeholders in the area can use this information to decide if the extra costs of the drainage improvements are justified.

Table 1 SUMMARY OF DRAINAGE IMPROVEMENTS AND COSTS

	Option A	Option B
Description of work	Clean channels. Install small pump station	Clean and Improve channels. Install large pump stations.
For winter storm events		
Area not meeting 1.2 freeboard	92 ha	20ha
Area not meeting 0.9m freeboard	82 ha	11ha
% of area meeting drainage criteria	74%	95%
Freeboard achieved within criteria time period (within zone not meeting 0.9m freeboard)	0.4m	0.7m
Time required to meet the 1.2m freeboard*	9 days	6 days
For summer storm events (maps not shown)		
Area not meeting 1.2 freeboard*	85 ha	5 ha
Area not meeting 0.9m freeboard	75 ha	5 ha
% of area meeting drainage criteria	76%	98%
Freeboard achieved within criteria time period (within zone not meeting 0.9m freeboard)	0.7m	0.75
Time required to meet the 1.2m freeboard*	3 days	3 days
Economics		
Costs of Improvement	$250,000	$600,000
Benefits to Agriculture**	$225,000	$500,000

* This is assuming that the 1.2 m freeboard criteria is met when there are no storm events.
** Analysis by professional agriculture consultant. This includes improvements in crop yield, higher value crops, improved growing season, crop quality, management implications and any increases in production costs

How drainage affects individual properties

Figure 5 shows how poor drainage may affect a single property. It is important to consider not only the overall area within a region, but also how individual lots will affected by drainage. Lot 1 in Figure 5 experiences poor drainage on over 75% the property, half of the property does not meet the 0.9m freeboard and possibly a third would not meet a 0.6m freeboard.

This property owner of Lot 1 may not able to productively farm a large portion of their land under this drainage scenario. Lot 2 also experiences poor drainage while Lot 3 is not affected.

This information would be used to determine the agricultural productivity of an area. Lot 1 may not be farmed because it is not worth the management effort to put a small portion of land into production. In that case the entire area of Lot 1 would not be included in the area receiving benefits in the summary information.

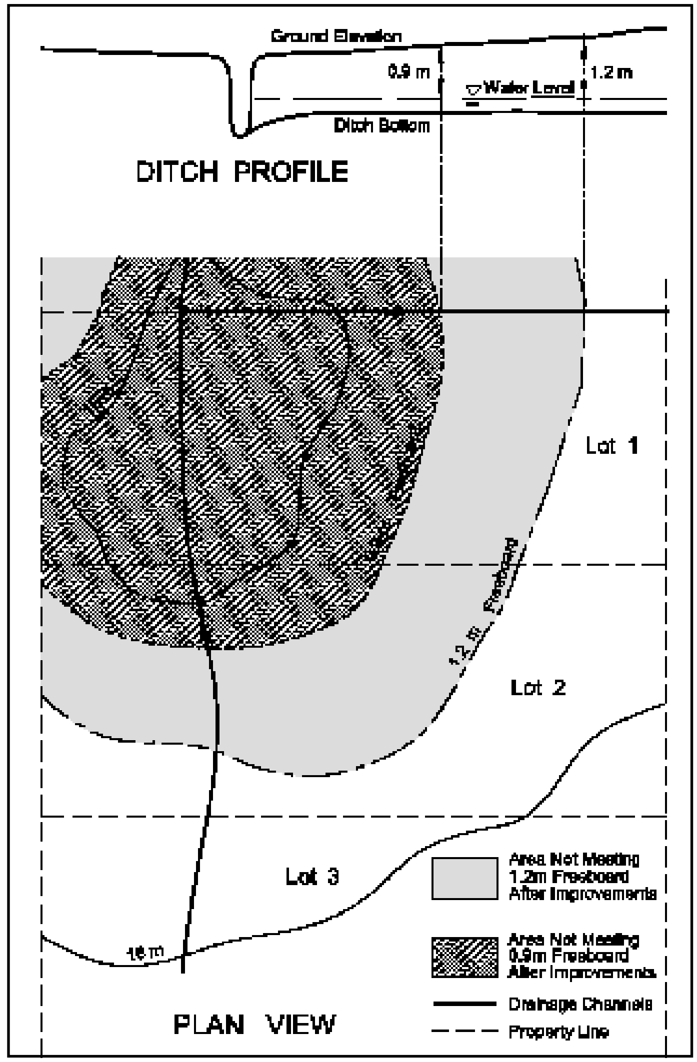


Figure 5 – Regional Drainage Affecting Individual Property

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Wilson, Ken. 1980. ***Design Criteria for the Farm Drainage Outlet Assistance in the Lower Fraser Valley***.   B.C. Ministry of Environment, Lands and Parks.

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