

A background illustration in grey tones. It features a city skyline with several buildings of varying heights on the left. A winding river or path flows from the left towards the right, curving around a tree on the right side. The river is depicted with a solid line and a dashed line, suggesting a path or boundary. The entire scene is set against a white background.

**DESIGN CRITERIA
MANUAL
CHAPTER 2 DRAINAGE**

MUNICIPALITY OF ANCHORAGE

**PROJECT MANAGEMENT &
ENGINEERING DEPARTMENT**

MARCH 2007

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Acronyms and Abbreviations

µm.....	micron
AAC.....	Alaska Administrative Code
AASHTO.....	American Association of State Highway and Transportation Officials
Ac.....	Acre
ADEC.....	State of Alaska Department of Environmental Conservation
ADNR.....	State of Alaska Department of Natural Resources
ADT.....	Average Daily Traffic
AMC.....	Anchorage Municipal Code
ANC.....	Ted Stevens Anchorage International Airport
BMP.....	Best Management Practice
BOD.....	Biological Oxygen Demand
cfs.....	cubic feet per second
cm.....	centimeter
CGA.....	Contributing grassed area
CMP.....	Corrugated Metal Pipe
CPEP.....	Corrugated Polyethylene Pipe
DCI.....	Directly connected impervious
DCM.....	Design Criteria Manual
DOT&PF.....	State of Alaska Department of Transportation and Public Facilities
DPW.....	MOA Department of Public Works
EPA.....	Environmental Protection Agency
FEMA.....	Federal Emergency Management Administration
fps.....	feet per second
IDCI.....	Indirectly connected impervious
lbs.....	pounds
LID.....	Low Impact Development
M.A.S.S.....	Municipality of Anchorage Standard Specifications
MEP.....	Maximum Extent Practicable
mg/L.....	milligrams per liter
mm.....	millimeter
MOA.....	Municipality of Anchorage
MS4.....	Municipal Separate Storm Sewer System
NEC.....	National Electric Code
NPDES.....	National Pollutant Discharge Elimination System
NVEG.....	undisturbed naturally vegetated
PBR.....	Pollutant Build-up Rate
PL.....	Pollutant Load
PM&E.....	MOA Project Management and Engineering
Ppm.....	parts per million
ROW.....	Right-Of-Way
sf.....	square feet
TMDL.....	Total Maximum Daily Loads
WMS.....	MOA Watershed Management Services

Glossary

10% point - the point downstream of a project or development along a real or designed drainage conveyance route at which the project area represents just 10% of the total area contributing flows to the 10% point (see Figure 2-1).

Adverse impact - Drainage impacts that include flooding, erosion, siltation, degradation of water quality, damage to land or structures caused by erosion, damage to downstream property or storm water conveyances by flooding, icing, erosion, siltation or overtopping. Adverse impact shall be indicated when the analyses performed as specified in this section shows that increases in runoff volume or peak flow rates or peak flow duration from the proposed project will cause an increase in surcharge, backwater, overbank flooding, erosion sedimentation or icing due to project flows.

Bankfull width – the average bank-to-bank width of an applicable reference reach (see definition for reference reach) measured at the elevation of the bankfull stage. The bankfull stage for a given stream reach is the elevation of the stream flood having an average return interval of 1.5 years.

Base elevation - the elevation of the standing water at zero flow conditions.

Critical Point - Any location along a 10% conveyance route at which post-development flows may be conducive to failure or overtopping of the conveyance system. Critical points include, at minimum:

- The project discharge point;
- The 10% point;
- Confluences of any runoff basins tributary to the 10% conveyance route;
- Crossings, conduit, or channel sections along the 10% conveyance route at which overflow may occur; and
- Points where flow constriction, backwater, changes in flow momentum, or channel or bank erosion are likely to occur.

Detention – temporary storage of runoff for later, metered release.

Extended detention time - the time difference between the center of mass of the control inflow hydrograph and the center of mass of the control outflow hydrograph.

Major drainageway; major storm drain systems – drainageways that do or systems that convey storm water runoff from a contributing area larger than 40 acres in size.

Minor drainageway; minor storm drain systems – drainageways that do or systems designed to convey smaller, more frequently recurring runoff events. Contributing areas are generally 40 acres or smaller

Project Discharge Point - Any point at which surface flows carried by project conveyances, or generated within a project drainage area, exit the project.

Reference reach – a portion of a stream that represents a stable channel (dimension, pattern, profile) within the geomorphic context that exists in that segment and can represent a natural or a stable, modified condition

Retention - prevention of runoff.

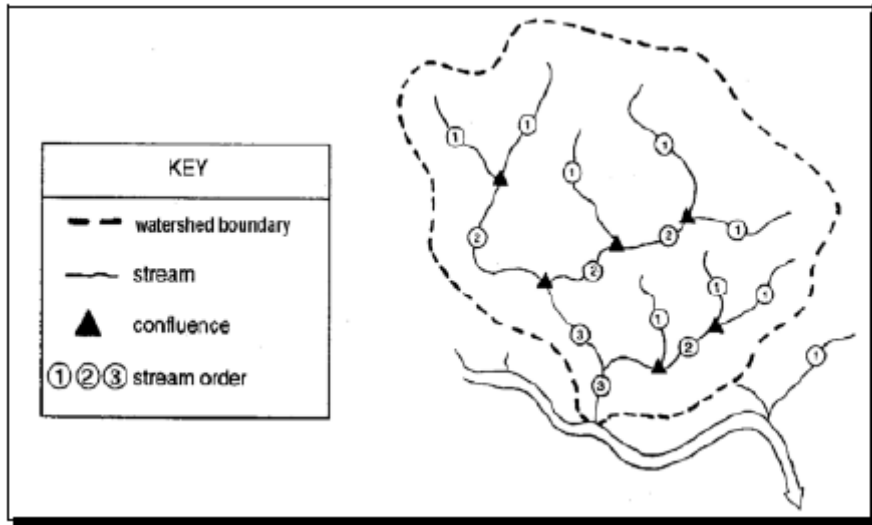
Regulated Stream - Any watercourse meeting the criteria of a stream, as specified by the Municipality of Anchorage, and along which flood hazard areas have been mapped and approved by the Federal Emergency Management Agency, or any stream designated as a regulated stream by the Project Management and Engineering Department

Short-circuiting - The reduction in residence time in the basin due to flow path shortening, which reduces the pollutant removal efficiency.

Slope ratio – the ratio of the culvert bed slope to the upstream reach or reference reach channel slope.

Stream order – A stream network classification system that designates 1st order streams as ‘fingertip’ headwater features at the source of a stream network; a 2nd order stream as the feature resulting from the confluence of two 1st order streams; a 3rd order stream as the feature resulting from the

confluence of two 2nd order streams, etc. Stream order designations for Municipality of Anchorage stream mapping are developed and assigned by the Project Management and Engineering Department's Watershed Management Services (WMS) and proposed ordering of streams not yet mapped must be approved by WMS.



2. DRAINAGE

SECTION 2.1 OBJECTIVE

Ongoing land development and re-development, including roads and drainage projects, usually disrupt natural drainage patterns and groundwater recharge. This is most prominent in urban areas because larger percentages of natural settings are replaced with impervious surfaces such as buildings and pavement that reduce or eliminate drainage infiltration and increase runoff velocities. The resulting increase in storm water runoff volume, coupled with flow concentration, can have a substantial adverse impact on adjacent properties.

The objective of this chapter is to provide Municipal drainage standards and policies, and make them accessible to designers of new land developments, re-developments, roads, and drainage projects in compliance with local, state, and federal requirements for storm water management. The consistent application of this information will result in decreased flooding, erosion, and reduced adverse impacts. Discussion in this chapter is provided on drainage codes and permitting.

This chapter also addresses general drainage topics such as area drainage studies, required drainage impact analyses, runoff calculations, and storm water quality. Specific drainage facilities discussed include piped storm water infiltration systems, open channels, retention, detention, and infiltration systems, stream restoration, and snow disposal site criteria. Identified water quality measures include sedimentation basins, oil and grit separators, biofiltration facilities, and erosion and sediment control practices.

The design criteria in this manual reflect the current considerations for drainage and water quality control. Water quality controls are required under the joint Municipality of Anchorage (MOA) and State of Alaska Department of Transportation and Public Facilities (DOT&PF) Municipal Separate Storm Sewer System (MS4), National Pollutant

Discharge Elimination System (NPDES) permit for discharges of storm water. The MOA Project Management and Engineering Department (PM&E) evaluates design storms and storm water structures to assure currency. Check with PM&E for the most current information and detailed design guidance.

All reference documents, which are incorporated or incorporated by reference in this Design Criteria Manual (DCM), shall be the latest edition, unless otherwise noted.

END OF SECTION 2.1

SECTION 2.2 DRAINAGE CODES, VARIANCES, POLICIES, AND PERMITS

2.2 A Objective

Storm drainage design within Anchorage is accomplished by (1) municipal projects, (2) state projects, and (3) private development. These design standards do not apply to State construction projects within State rights-of-way (ROW). However, this information does apply to other public roads, site developments, and drainage designs within the MOA ROW, whether done by PM&E or private industry.

2.2 B Codes and Regulations

Storm drainage design is subject to regulations established on local, state, and federal levels. Some regulations require permits, which are discussed in later sections. Titles 21 and 24 of the Anchorage Municipal Code (AMC) specifically relate to storm drainage construction.

AMC Title 21 Land Use Planning. This chapter has several sections that deal with the requirement for storm drainage construction.

AMC 21.05 establishes Municipal policy by adopting publications as such. The section identifies the *Water Quality Management Plan, August 1979*, as Municipal policy. This publication is an adaptation of Section 208 of the Clean Water Act of 1972, specific to Anchorage.

AMC 21.45.210 establishes standards for work within stream protection setbacks.

AMC 21.60 provides provisions for work within floodplains.

AMC 21.67 provides for storm water runoff restrictions and plan reviews.

AMC 21.85.140 requires that storm drainage systems constructed as part of subdivision improvements be approved by PM&E.

AMC 21.85.180 requires that erosion and sediment control practices for subdivision improvements be approved by PM&E.

AMC Title 24 Streets and ROW. This chapter has several sections that deal with construction within street ROWs and public places.

AMC 24.20.030 requires that plans be approved by PM&E prior to the start of work within dedicated ROWs or easements. This section also states that such work shall be performed in accordance with MOA standards and specifications. Therefore, design in accordance with this manual is required by Municipal ordinance.

AMC 24.30.030 provides the design submittal requirements for all ROW permit applications.

Clean Water Act of 1972, including 1977, 1987, 1994, and 2002 amendments, establishes water quality standards.

The Environmental Protection Agency's (EPA) MS4 NPDES Permit No. AKS 05255-8 provides stipulations on the MOA for storm water discharge.

The EPA's Construction General Permit No. AKR100000 provides stipulations for construction projects that disturb one or more acres.

State of Alaska 18 Alaska Administrative Code (AAC) 70 Water Quality Standards provides standards for water quality.

State of Alaska 18 AAC 72 Wastewater Disposal requires plan reviews for all non-domestic waste treatment and discharge systems.

State of Alaska Wastewater Disposal General Permit for Excavation Dewatering, Permit No. 2004DB0101 provides stipulations for the disposal of construction related dewatering operations.

2.2 C Design Variances

These Design Criteria, the *Drainage Design Guidelines*, and other references herein are the minimum standards for projects under the jurisdiction of the Municipality of Anchorage. At the sole discretion of the Municipal Engineer, the MOA may impose greater standards and

criteria when deemed appropriate to protect the safety and welfare of the public.

Whether expressly stated or not throughout the criteria any deviation from these standards shall require a written variance from the Municipal Engineer. Approval of plans containing deviations from the criteria shall not constitute tacit approval of the deviation or approval of a design variance.

1. Request Submittal. Variance requests shall be in writing and shall contain information, justification and suggested resolutions. Variances shall be approved prior to submittal of applicable plans and/or the reports.
2. Documentation. Variance requests shall include complete discussion and documentation supporting proposed methods and parameters. Documentation must include citations of current research and manuals of practice published or sponsored by well-known, credible public and private agencies. Complete copies of supporting documentation must be provided as part of the application. Economic hardship shall not be adequate justification for a variance.
3. Review. The Municipal Engineer will consider variance requests and accept or deny the request in writing. Appeal of decisions regarding variances shall follow the procedures detailed in Policy and Procedures No. 10, "Contesting and Appealing Decisions" found on the municipal website: www.muni.org.

2.2 D Policies

The purpose of MOA drainage policies is to ensure that adequate drainage is provided with land development activities including public facility projects. Adequate drainage is the conveyance of storm water and other surface waters into natural watercourses or drainage facilities without adversely impacting adjoining or nearby properties and receiving waters. The following objectives and policies shall be met:

1. The drainage system shall be sized to handle

the designated design storms as specified on Table 2-1 and provided in the latest version of PM&E's *Drainage Design Guidelines*.

2. The size and capacity of the system, including the outfall, shall be based on runoff flows and volumes assuming full development under existing zoning of the entire area that will contribute to the system. Projected post-development landcover conditions and parameters are specified in the *Drainage Design Guidelines*.
3. The system shall follow drainageways and drainage basins as established in current MOA Watershed Management Services (WMS) mapping and area drainage studies, or, where no mapping or drainage study information exists, along existing drainageways and natural drainage swales and divides. Stream and drainage features used in drainage analyses shall be approved by WMS.
4. The drainage system shall be compatible with improvements and alignments proposed in existing drainage studies and as mapped by WMS.
5. The drainage system shall be designed to account for both on-site and off-site surface waters and base flows, including footing and other subdrains.
6. Proposed drainage systems shall convey drainage into an established natural watercourse or an existing storm drainage facility at discharge rates and volumes as specified in Table 2-1.
7. Peak flows and volumes generated by a project system and the storm water controls applied to that system shall conform to the conditions outlined in Table 2-1 and the *Drainage Design Guidelines*. This includes project sites for both subdivisions and single parcels, under either initial development or redevelopment. Projects shall demonstrate acceptable control of potential for both downstream adverse impacts and downstream flood path impacts to the 10% point, as defined in Figure 2-1 and the Glossary.

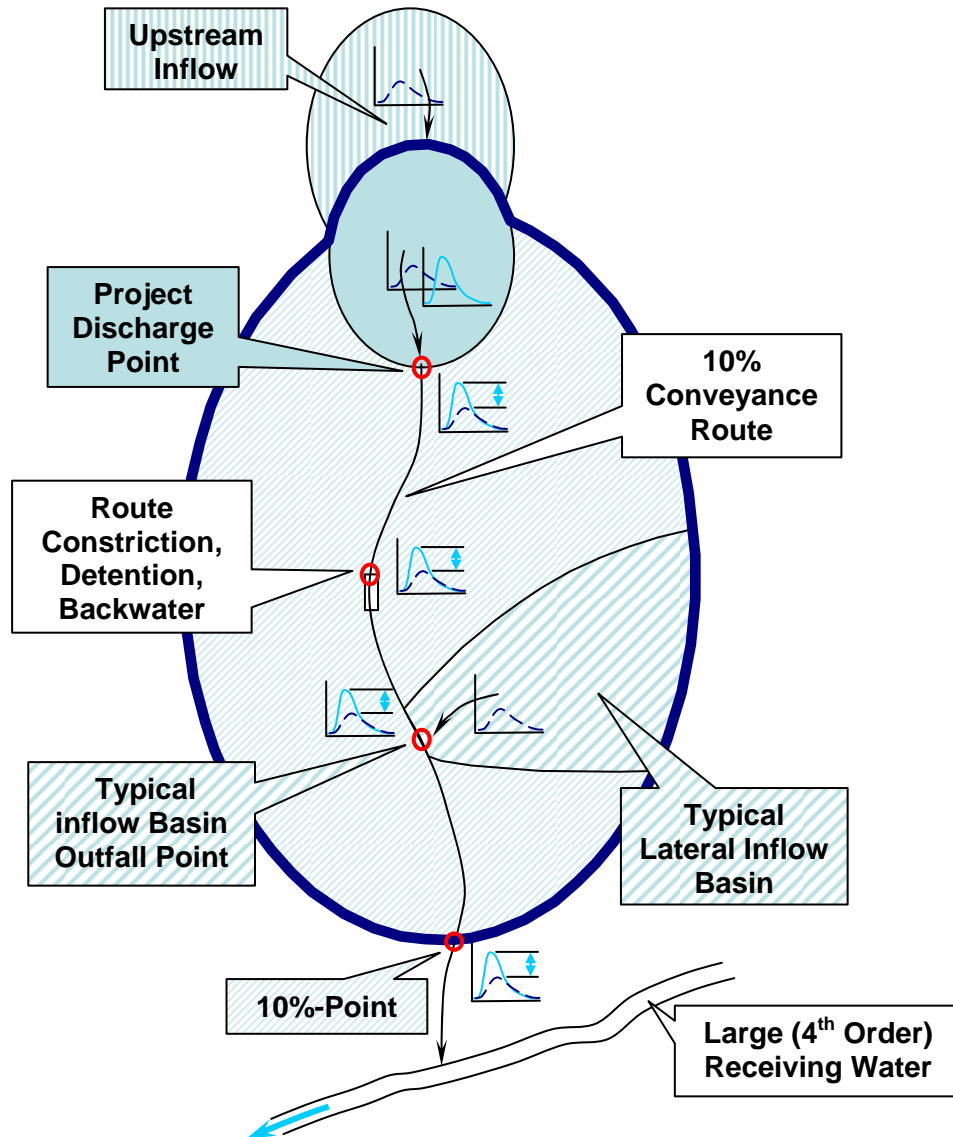
TABLE 2-1: DRAINAGE SIZING AND ANALYSIS CRITERIA

Design Requirement	Conditions	Purpose	Criteria
A. Conveyance Design			
Design for peak conveyance shall be based on the sum of all contributing flows, i.e., both project area flows and upstream and lateral inflows.	Size conveyances to pass design peak runoff flows.	Size conveyances to pass peak runoff flows for the 24-hour duration design storm with a return period based on watercourse type as listed below. Minor Drainageway ¹ 10 year Major Drainageway ¹ 10 year Non-Regulated ¹ Stream of 1 st or 2 nd order 50 year Non-Regulated Stream of $\geq 3^{\text{rd}}$ order 100 year Regulated ¹ Stream 100 year	
B. Wetlands Permit Compliance			
Provides a design storm event for projects that require a Section 404 permit and must demonstrate compliance with permit conditions that involve hydrologic analyses for 2-year events.	Comply with Army Corps of Engineers Section 404 permit	Control the 2-year 6-hour storm runoff volume from wetland areas according to conditions in permits issued the U.S. Army Corps of Engineers under Section 404 of the Clean water Act.	
C Water Quality Protection			
Must be provided for all projects or developments other than single or duplex residential units unless existing community systems can be shown to provide adequate treatment capacity.	a. Treat first flush pollutant loading.	Treat the initial 0.5 inch of post-developed runoff from each storm event	
	b. Provide a minimum treatment rate.	Provide a water quality treatment rate for post-developed runoff at a minimum of 0.005 inches per minute.	
D. Project Drainage Controls			
<p>Projects and developments shall provide controls for extended detention (channel protection), flood hazard protection, and project flood bypass within the project area.</p> <ul style="list-style-type: none"> Projects within an area containing storm water and drainage systems maintained by the Municipality (e.g., Anchorage Roads and Drainage Service Area), on-site storm water controls may be designed on the basis of runoff differences between projected post-development landcover elements and baseline pre-development landcover elements provided in the <i>Drainage Design Guidelines</i>. Projects lying outside Municipal storm water maintenance areas shall design controls on the basis of actual pre-development conditions, unless it is shown that existing controls will meet the intended function. 			
1. Extended Detention Controls to protect downstream channels from upstream development and re-development.	Protect streams and channels from erosion, siltation, and icing from smaller, more-frequent storm flows.	Provide 6 hours of detention for the post-development project runoff in excess of pre-development runoff volume for the 1-year, 24-hour storm.	




TABLE 2-1: DRAINAGE SIZING AND ANALYSIS CRITERIA




Design Requirement	Conditions	Purpose	Criteria
<p>2. Flood Hazard Protection Controls for flood conveyance protection shall prevent an increase in frequency and magnitude of downstream overbank flooding</p>		<p>a. Control project peak flow to minimize impacts from changes in magnitude or timing.</p>	<p>Maintain the post-development project runoff peak flow from the 10-year, 24-hour storm to ≤ 1.05 times pre-development runoff peak flow at all project discharge points.¹</p>
		<p>b. Ensure channel stability for all project conveyances.</p>	<p>Control flows so that transport of particles sized D50 and greater will not occur for the post-development, 10-year, 24-hour storm runoff flows in conveyance channels. Provide adequate icing protection.</p>
<p>3. Project Flood Bypass Controls to prevent an increased risk of flood damage from large storm events with upstream development and re-development.</p>		<p>Ensure safe bypass of runoff from the 100-year, 24-hour storm for all project structures.</p>	<p>Design bypass diversions for the post-development, 100-year, 24-hour storm runoff event or show an unobstructed, overland flow path safely bypassing project structures and / or overtopping project conveyance routes without impact to property affected by bypass route.</p>
<p>E. Downstream Impact Control Downstream adverse impacts¹ shall be mitigated at a minimum by controlling project flows to maintain acceptable routed peak flows and peak flow durations downstream to the 10% point. Projects must demonstrate an unobstructed downstream flood path with adequate hydraulic capacity for the 100-year 24-hour event along the full length of each 10% conveyance route.</p>			
<p>1. Magnitude and timing</p>		<p>Control project peak flow to minimize impacts from changes in magnitude or timing.</p>	<p>Maintain the post-development project runoff peak flow from the 10-year, 24-hour storm to ≤ 1.05 times the pre-development runoff peak flows at all downstream critical points.</p>
<p>2. Duration</p>		<p>Control project peak flow to minimize impacts from changes in duration.</p>	<p>Where downstream overtopping occurs pre- or post-development, control project peak flow from the 10-year, 24-hour storm to achieve post-development overtopping duration ≤ 1.05 times the pre-development overtopping duration.</p> <p style="text-align: center;">OR</p> <p>Improve downstream conveyance to yield no adverse impact.</p>
<p>3. Hydraulic capacity</p>		<p>Ensure safe routing of runoff from the 100-year, 24-hour storm downstream of project area.</p>	<p>Demonstrate the post-development, peak runoff from the 100-year, 24-hour storm can safely bypass structures and / or overtop conveyance routes without impact to property along an overland route to the 10% point, a 4th-order stream, or tidewater.</p> <p style="text-align: center;">OR</p> <p>Control the post-development peak flow from the 100-year, 24-hour storm event to ≤ 1.05 times the pre-development peak flow.</p>

¹ See Glossary for definition.



Legend

-  Upstream Inflow Area
-  Project Area (10% of total)
-  Downstream Area (90% of total)

-  pre-Project Hydrograph
-  post-Project Hydrograph
-  post-Project Routed Test

-  10% Conveyance Route
-  Critical Point

FIGURE 2-1 10% POINT ANALYSIS

8. There shall be no adverse impact on existing drainage or on a downstream property or watercourse except as provided in 2.2.D.9. All adverse impacts shall be addressed through addition of infiltration, retention and/or detention controls within the project or through correction of downstream conveyance limitations or problems sufficient to achieve compliance with conditions stated in 2.2.D.6. and Table 2-1.
9. Where flow from a proposed system that may incur adverse impacts is directed across property lines, a notarized letter of non-objection shall be obtained from the owner of any downstream property that could be affected. Concentrated drainage flows shall not be discharged onto downstream properties unless the owner of the affected land has granted an easement expressly authorizing such discharge. The only exception is when the discharge is into an established natural drainage way or other watercourse capable of handling the additional runoff without causing flooding, icing, erosion, or siltation on adjacent properties or otherwise adversely impacting the watercourse on adjacent properties.
10. Natural and constructed drainageways shall be incorporated into development designs as drainage collectors, collecting runoff from adjacent properties. Drainage structures shall be constructed and appropriate easements established for both constructed and natural drainageways so that they are accessible to maintenance personnel and can be maintained at a reasonable cost, as determined by the Street Maintenance Department. Easements shall be in place or acquired by the proposed project.
11. Improvements shall be designed and constructed to mitigate adverse impacts due to higher erosion potential that exists during construction. Temporary mitigation measures may include silt fences, berming, and retention areas. For more information on temporary mitigation measures, refer to the *MOA Stormwater Treatment Plan Review Guidance Manual*.
12. Drainage and cut bank impacts on existing on-site septic systems affected by the project shall be mitigated in land development, re-development, road, and drainage projects.
13. Improvements shall be designed and constructed in a manner that minimizes the potential for icings in streams, or constructed or natural drainageways.
14. Subdrains or curtain drains which serve parcels with on-site sewer systems shall not be permitted to drain directly into drainage pipes, ditches, or swales, unless it can be clearly demonstrated that there are no related health hazards.
14. Drainage patterns shall not be altered in a manner that impedes runoff from adjoining property or otherwise causes an accumulation of water or reduction in flow capacity that may impact drainage from or into adjacent properties.
15. State regulations (18 AAC 72.020) require minimum horizontal separations between storm drain facilities such as pipes, basins, structures, etc. and drinking water systems. Greater separations apply to public and private water sources (18 AAC 80.020).
16. Roof drainage concentrated by downspouts or similar devices shall not be directed across sidewalks, driveways, or parking areas.
17. Driveways and buffer areas of commercial projects or residential projects of triplex size or greater shall be designed so that no surface drainage originating off of the right-of-way is permitted to drain onto the traveled way of the public road.

2.2 E Permits

The requirements for obtaining permits can substantially drive the project design. The designer shall determine which permits are needed and coordinate with each granting agency early in the design process. Permits that apply to construction projects in general are listed in Chapter 1, Section 1.2. A partial listing

of various permits that apply specifically to drainage projects includes:

Title 41 Fish Habitat Permit. This permit is required whenever work is proposed in or adjacent to a waterway identified by the State of Alaska Department of Natural Resources (ADNR), Office of Habitat Management and Permitting, as supporting anadromous or resident fish. The designer shall contact that department for additional information.

Storm Water Site Plan Review. The Alaska Department of Environmental Conservation (ADEC) has established project permitting and plan review requirements to improve and better manage storm water runoff to conform to state and federal laws and regulations. Authority for plan review by ADEC is vested in 18 AAC 72.600 (a). The MOA and ADEC agreed that plan review activities for storm water runoff would be better accomplished at the local government level. ADEC transferred the plan review responsibilities to the MOA Department of Public Works (DPW) on May 10, 1999. Storm Water Site Plan Review requirements are outlined in the MOA *Stormwater Treatment Plan Review Guidance Manual*.

MS4 NPDES Permit No. AKS 05255-8. New and re-development projects will be constructed under the requirements of the MS4 NPDES Permit. Prior to the commencement of any work, projects must be presented to PM&E for plan review with specific details and information concerning storm water control and treatment systems. A stormwater treatment plan as described in the MOA *Stormwater Treatment Plan Review Guidance Manual* must be submitted to DPW for review and approval. Submission and approval of a storm water treatment plan to the MOA does not relieve the owner or contractor from the requirements contained in the EPA's Construction General Permit. The minimum storm water treatment plan requirements are specific to site and development characteristics.

Flood Hazard Plan Review. All construction within the Municipality must be reviewed to determine its regulation under the FEMA flood

hazard program. Applicants placing structures or land modifications within or near designated flood hazard zones must submit plans for review and perform such work to meet specific FEMA criteria to ensure maintenance of nationally-sponsored community flood insurance rates. Flood plain regulations for the Municipality are documented at AMC 21.60 Floodplain Regulations.

Storm Water/Water Separation Waiver. This waiver is required when the clearance between a storm drain and water line is less than 10 feet. Waiver requests shall be submitted to ADEC.

END OF SECTION 2.2

SECTION 2.3 DRAINAGE STUDIES

A major consideration in water quality and drainage control is determining where drainage can and should be directed. The Municipality is continually studying and mapping drainages throughout the Municipal area. These studies usually encompass streams mapping, drainageway delineation (including constructed ditches, pipes and natural swales), drainage basin boundary mapping, drainage problem identification, as well as existing and required major drainage system components and their flows. Land development, road, and drainage projects shall design drainage facilities in accordance with current studies and mapping, unless waived by the Municipal Engineer. Current drainageway, subdrainage basin, stream, and watershed mapping information is available through the WMS. A list of historic drainage studies is included in Appendix 2-A and an updated list is available through PM&E. The MOA will provide available drainage information when requested. However, in all cases the most current mapping and projected project-specific and actual conditions shall be applied in planning and design analyses. The Engineer shall contact MOA and determine which studies are current and approved for reference in the project area.

END OF SECTION 2.3

SECTION 2.4 SITE DRAINAGE PLANS**2.4 A Drainage Project Notification**

All projects subject to these criteria are required to include with site drainage plans mapping of all watercourses (streams and major drainageways) within the project area that has been reviewed and approved by WMS. Watercourse mapping must completely and accurately identify all waters of the United States and major drainageways in the project area, for both pre- and post-development conditions. For streams mapping, applicants may either prepare mapping independently and submit it to the MOA for review, or may request mapping by WMS by submitting a drainage Project Notification form, available in the *Drainage Design Guidelines*, and providing permission for MOA to access the property. The process for Drainage Project Notifications and review is described in the *Drainage Design Guidelines*.

2.4 B Drainage Impact Analysis

In the Municipal land development process, submissions of drainage impact analyses are required with platting applications and/or during construction permitting. In general, the analyses shall delineate the location and character of the proposed new drainage system, describe the estimated on-site and off-site drainage impacts from development, and describe proposed mitigation of any adverse impacts in conformance with Municipal design criteria. The drainage impact analysis shall address at minimum those drainage policies and requirements described in Section 2.2.D Policies.

Drainage impact analysis submittal is required at a preliminary design level as part of a plat application submittal and at a final design level prior to building permit approval and final plat approval. At every stage of any drainage analysis, sufficient information shall be provided to demonstrate that drainage improvements proposed in the analysis can reasonably be expected to work without adversely impacting

surrounding properties and downstream watercourses including both drainageway and stream features.

2.4 C Drainage Plan Submittal

Drainage impact analyses and site drainage and grading plans shall be submitted as a stand-alone Drainage Report. The report shall address analyses and proposed design elements as generally required in this DCM and as specified in PM&E's *Drainage Design Guidelines*. All Drainage Reports must be outlined and formatted as specified in the *Drainage Design Guidelines*. No Drainage Report submittal will be accepted for processing until it is complete and formatted in accordance with *Drainage Design Guidelines* standards.

Submittal of a Drainage Report in both preliminary and final form may be required. Preliminary and final reports are required for all projects greater than 5 acres. At the discretion of Municipal Engineer, preliminary reports may also be required for smaller projects where downstream systems are sensitive, or for small projects intended for other than low-density residential landuses.

1. A Preliminary Drainage Report shall provide a detailed analysis of conceptual drainage plans for larger and more complex projects. A Preliminary Drainage Report shall be submitted to the Planning Department as part of the application packet for public facility site reviews, site plans, conditional uses approvals, and long and short plats. The Planning Department will route the Preliminary Drainage Report to PM&E as part of the planning case review.
2. The Final Drainage Report shall be submitted as part of an application for a Building Permit, Subdivision Agreement, or Improvement to Public Places Agreement. No Building Permit or Notice to Proceed for a Subdivision Agreement or Improvement to Public Places Agreement will be issued until a Final Report has been submitted and approved.

2.4 D Drainage Plan Guidelines

Site grading and drainage plans and the drainage report shall be signed and stamped by a Professional Engineer licensed in the State of Alaska. The drainage report and plans shall be prepared, formatted and submitted as described in these Criteria and as specified in PM&E's latest version of the *Drainage Design Guidelines*. The submittal must include an electronic copy of input to hydrologic or hydraulic model, if used in developing the plan. In addition, the Report and plans shall generally meet the following guidelines:

1. The plan shall show the location and proposed connectivity of all proposed drainage features, including both constructed and natural features, from the project boundaries to the 10% point. The plan shall identify general conveyance type (natural swale, ditch or piped systems) and shall include arrows showing proposed flow directions.
2. The plan shall show existing and proposed drainage facilities including where drainage will enter existing constructed storm drainage systems or natural drainageways. The plan shall also identify the ultimate receiving water(s) for the new drainage and the expected route of flow continuously from the project site to the receiving water or to the 10% point, whichever is further.
3. The plan shall tabulate the landcover types as percentages of undisturbed naturally vegetated, directly connected impervious, indirectly connected impervious areas, and contributing grassed or other landscaped areas for the proposed fully developed conditions. It shall include estimates for building lots and for all transportation and drainage infrastructure areas.
4. Points where site drainage is proposed to exit the development shall be clearly marked on the site grading and drainage plan.
5. The plan shall include descriptions of methods, assumptions and data sources, calculations, and results of any work performed to estimate runoff flows and

- assess potential for downstream adverse impacts. The site grading and drainage plan shall be clearly marked to reference the location of boundaries of storm water runoff contributing areas, routing segments, and points of peak flow or volume calculations.
6. The plan shall include the ordinary high water and 100-year surface water elevations for water bodies within the project boundary or affected by project discharges.
 7. The plan shall include a description of post-construction revegetation plans.
 8. For sites requiring on-site wastewater disposal, the plan shall show proposed septic systems, areas designated for future septic systems, expansions, locations of septic systems on adjacent properties, and all water wells within 200 feet of the project's property boundaries.
 9. Site grading and drainage plans shall include, but not be limited to, the following information:
 - a) A plan scale of 1 inch equals 50 feet (1"=50'), or more detailed.
 - b) Existing and proposed property and zoning boundaries.
 - c) All easements, including platted and document easements, development and stream setbacks, flood hazard areas, wetland boundaries, and other waters of the United States.
 - d) Existing and proposed topography shall be presented with a contour interval of 2 feet or less. The contour interval may be 4 feet in areas with a slope greater than 10%. Topographic information shall extend a minimum of 50 feet beyond the plat or project boundary and shall include existing and proposed spot elevations at each property corner, and the existing grade of adjacent utility easements. Proposed topographic information shall be based on final placement of 4 to 6 inches of topsoil when applicable.
 - e) Proposed grade breaks and grade break elevations.
 - f) Relevant cross-sections to demonstrate proposed cuts and fills.
 - g) Proposed roads, sidewalks, pathways, parking lots, and other impervious surface elevations and dimensions.
 - h) Typical building footprints on each lot or tract with finish floor elevations.
 - i) Proposed finish grade within all utility easements.
 - j) Existing and proposed drainage facilities on-site, within 50 feet of the project boundaries, and in adjacent ROW including, but not limited to, storm drains, inlets, manholes, culverts, ditches, retention/detention/infiltration features, outfalls, ripped areas, energy dissipators, and swales.
 - k) Finish ground contours as follows:
 - (1) 1-foot intervals, if average grade is less than 3%.
 - (2) 2-foot intervals, if average grade is between 3% and 10%.
 - (3) 4-foot intervals, average if grade is over 10%.
 - l) Soils information including test hole locations, soil boring analyses, soil erodibility, maximum allowable slopes, infiltration or percolation rates, water table elevations, and potential dewatering requirements.
 - m) Drainage arrows and existing and proposed drainage easements indicating the conveyance of surface runoff to a suitable point of treatment or outfall.
 - n) Drainage patterns at all property lines.
 - o) Drainage patterns and ground elevations between all buildings.
 - p) Specific locations of appropriate erosion and sediment control measures and construction dewatering operations.

- q) Areas of vegetation to be retained. In all cases, the Report and plans shall specify the percentage of each building lot required to be retained in naturally vegetated landcover by individual builders.
 - r) Required landscape areas.
 - s) Information on impaired water bodies or water bodies with approved total maximum daily loads (TMDLs) adjacent to or downstream from the project site.
 - t) On-site septic systems located on properties adjacent to proposed drainage structures, stormwater control facilities, or surface conveyances to which drainage is directed or discharged.
10. Drainage plans shall also tabulate the maximum flow rate and velocity for the undeveloped and fully developed conditions. The location of peak flows shall be shown on the plans, and the pre- and post-development runoff volumes shall be provided.
11. The plan shall list any future MOA, DOT&PF, and Anchorage Water and Wastewater Utility projects that may affect the proposed drainage plan.
12. Construction plans submitted for a flood hazard permit in a 100-year floodplain shall be accompanied by hydraulic calculations that demonstrate that the floodplain limits are not extended.

2.4 E Storm Water Treatment

New projects shall be constructed under the requirements of the MS4 NPDES permit. Improvements to storm water quality can be achieved by incorporating physical, structural, and/or procedural practices into project design and construction. Incorporation of these practices will tend to benefit downstream water resources through reduction of pollutant loads and concentrations, and by reducing stream bank erosion. These practices are commonly called Best Management Practices (BMPs).

Control policies and BMPs for the post-construction and operational phases of projects are included in the MOA *Stormwater Treatment Plan Review Guidance Manual*. Additional BMPs are included in Sections 2.11 through 2.16 of this DCM.

2.4 F Engineer's Responsibility

It is the engineer's responsibility to identify all drainage features applicable to the project's drainage impact analysis and subsequent drainage plan.

This shall not relieve the engineers of his/her responsibility to accurately analyze the project site and the site's contributing area during drainage analysis and design.

END OF SECTION 2.4

SECTION 2.5 RUNOFF QUANTITY**2.5 A Objective**

The accuracy of estimated storm runoff volumes is a critical component of storm drainage facility design. This section specifies general hydrologic analysis standards required for use in preparation of drainage analyses, plans and reports. Detailed standards are described in PM&E's latest version of *Drainage Design Guidelines*, included by reference in these Criteria.

2.5 B Precipitation for Design Storms

The designer shall determine the design storm characteristics for each project area and design criteria using the following information and procedures:

1. Design storms shall be based upon the 24-hour duration event occurring at the Ted Stevens Anchorage International Airport, except for the 2-year 6-hour event used in calculating detention or retention volumes in compliance with U.S. Corps of Engineers Section 404 permits. Design storm volumes, distributions and intensities shall be based upon guidance published in the latest version of PM&E's *Drainage Design Guidelines*.
2. Adjustments for orographic effects within the Municipality shall be made by applying the proportional indices found in Figures 2-2 or 2-3 to appropriate baseline rainfall volumes as specified in the *Drainage Design Guidelines*. Estimate the proportional multiplier to be used at a specific location to the nearest one-tenth by interpolating between adjacent isohyetal contours shown on these figures. For areas within the Municipality for which orographic effects have not been determined, orographic effects multipliers shall be identified by a method approved by the Municipal Engineer.

2.5 C Runoff Analysis

Many methods exist for estimating hydrologic response of an area for use in practical drainage design. Little information exists for the Municipality area, however, that calibrates these methods to local conditions. Until better calibration of local models is available, the Municipality intends to ensure reasonably representative and reproducible drainage analyses through enforcement of standardized method and parameters coupled with continuing research and development of locally applicable hydrologic tools and standards.

To support this strategy, these Criteria allow flexible use of a range of hydrologic analytical tools under Municipally-specified standard methods and parameters described in detail in the *Drainage Design Guidelines*.

In addition to complying with requirements contained in the latest *Guidelines* version, drainage analyses reports and plans shall conform to the following:

1. The designer shall use design rainfall volumes, distributions and intensities as specified in the *Drainage Design Guidelines*.
2. Storm drainage water quality improvements shall be designed for the flow rates and volumes specified in Table 2-1.
3. Design calculations shall be based on approved estimates of projected post-development landcover conditions.
5. All drainage analyses and designs shall be performed on the basis of actual, or estimates of actual, land cover percentages except where pre-development landcover percentages adjustments are allowed to reflect zoning, storm water management jurisdiction, and proposed land uses for a specific project as specified in the *Drainage Design Guidelines*. Landcover characteristic and coverage shall be estimated and tabulated as specified in the *Drainage Design Guidelines*.
6. Spatially lumped estimates of landcover character or runoff numbers or coefficients

shall be approved only where sufficient information is provided to demonstrate that the lumped values reasonably reflect the actual or projected landcover characteristics of the project area.

7. Hydrologically non-homogenous basins shall be divided into subbasins and the flows from the separate subbasins routed, combined or addressed separately as necessary to accurately assess the overall basin response.

2.5 D Snow Melt

The impact of snow melt on runoff is important because it can cause flooding during spring break-up. Substantial runoff volumes can be produced because frozen ground is relatively impermeable and infiltration is minimal.

PM&E has conducted a study of snow melt in Anchorage using meteorological data collected at Anchorage International Airport over the period 1968 to 1977. The March 10, 1969 event was selected as representing the model or most frequently occurring snow melt event. The March 23, 1974 event was selected as representing an event with approximately a 5-year recurrence interval. The equivalent snow melt hyetograph for the peak period of each of these two events is shown in Table 2-2.

Until better snow melt data are developed, design snow melt runoff shall be computed by using the five-year recurrence hyetograph in Table 2-2. The snow melt hyetograph should be applied to all areas without orographic adjustment. However, the engineer should note that the 10-year design storm event rather than snow melt usually governs for pipe sizing.

END OF SECTION 2.5

TABLE 2-2 SNOW MELT HYETOGRAPH			
Model Event (March 10, 1969)		5-Year Recurrence (March 23, 1974)	
Time (hours)	Snow melt (inches) *	Time (hours)	Snow melt (inches)*
1	.02	1	.01
2	.02	2	.02
3	.02	3	.02
4	.02	4	.02
5	.02	5	.02
6	.02	6	.02
7	.03	7	.03
8	.03	8	.03
9	.03	9	.03
10	.02	10	.02
11	.02	11	.02
12	.02	12	.01
13	.01	13	.01
14	.00	14	.02
15	.00	15	.01
16	.01	16	.01
17	.01	17	.01
18	.01	18	.00
19	.00	19	.00
20	.00	20	.00
		21	.00
		22	.00
		23	.00
		24	.01
		25	.03
		26	.04
		27	.05
		28	.04
		29	.04
		30	.05
		31	.06
		32	.06
		33	.06
		34	.05
		35	.04
		36	.03
		37	.02
		38	.01
		39	.00
		40	.00

* Inches of water

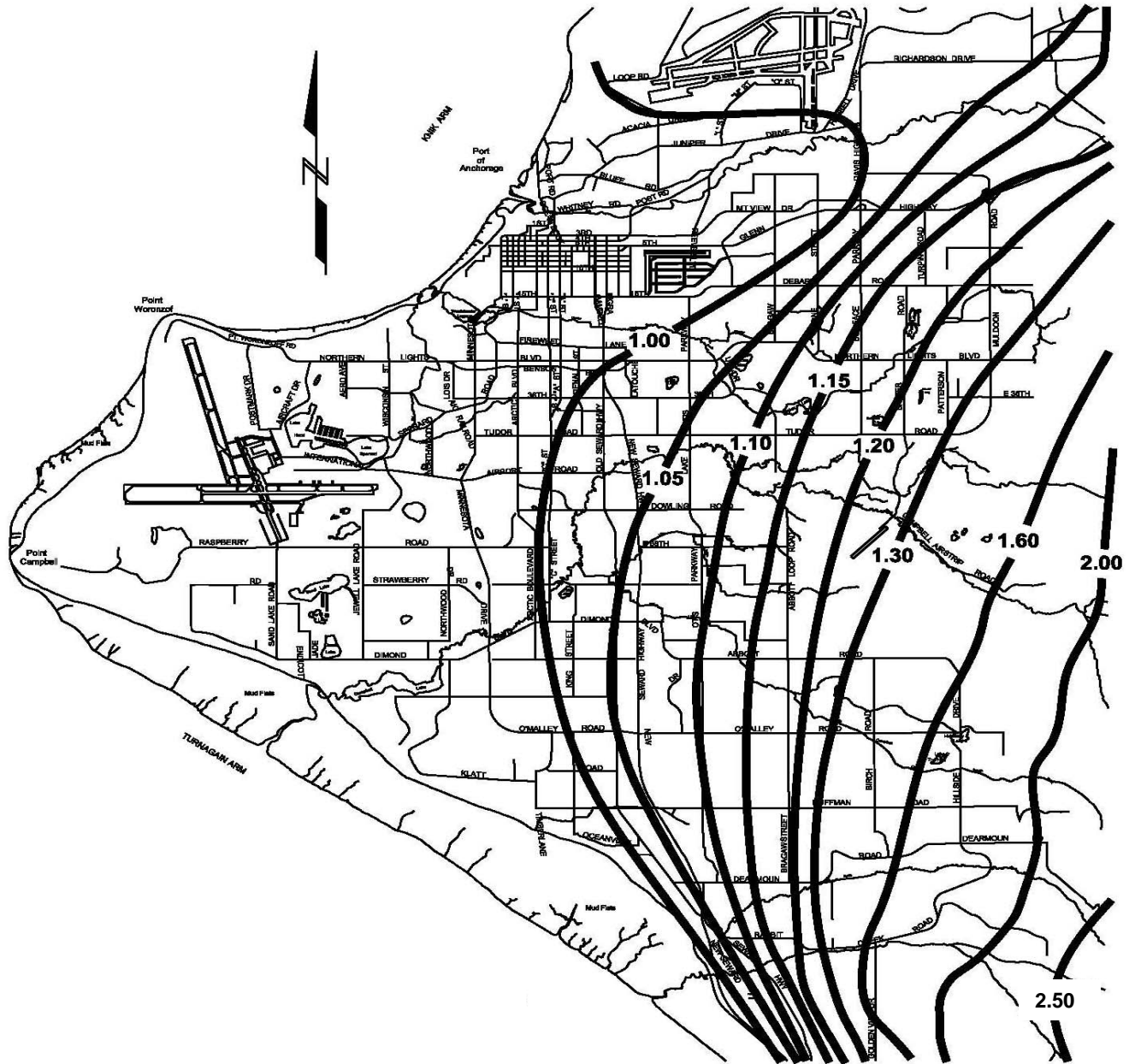


FIGURE 2-2 OROGRAPHIC FACTOR MAP (ANCHORAGE)

SECTION 2.6 RUNOFF QUALITY

Storm drainage impacts on the water quality of MOA water bodies, streams and lakes are a significant concern. All drainage facilities shall be designed to minimize pollution of these water resources by storm water runoff or snow melt water to the Maximum Extent Practicable (MEP).

2.6 A Controls at Outfalls

Water quality controls shall be designed to meet regulatory criteria and are required for all outfalls under the guidelines listed below:

1. Water quality controls shall be individually designed for each outfall and will be dependent on the receiving water quality, sensitivity, and TMDLs. Water quality controls shall include devices that remove sediment, oil, and debris from storm water. Outfalls shall incorporate wetlands in the configuration where possible.
2. The Municipal goals for storm water discharge are to include all controls necessary to reduce the discharge of pollutants from the MS4 to the MEP through employment of BMPs, control techniques, system design and engineering methods, and other appropriate provisions using the best available technology.
3. All water quality control facilities shall be designed in accordance with this manual or as otherwise approved by the Municipal Engineer.

2.6 B Water Quality Modeling

The MOA currently has not selected a model to evaluate runoff quality. ILLUDAS does not support runoff quality analysis. SWMM is presently being developed to analyze runoff quantity and quality, and is currently used for joint MOA and DOT&PF NPDES requirements. Users are encouraged to contact PM&E for information about this model and its development, particularly for runoff quality modeling. Pollution elements of particular concern are:

- Biological Oxygen Demand (BOD₅)

- Suspended Solids (SUS-SOL)
- Settleable Solids (SET-SOL)
- Total Dissolved Solids (TDS)
- Ammonia Nitrogen (NH₃)
- Nitrate Nitrogen (NO₃)
- Total Phosphorus (TOT-P)
- Grease and Oil (GRS-OIL)
- Fecal Coliform (FE-COL)

Removal of suspended sediments is critical because many other pollutants adhere to them. An effective strategy for reducing trace metals and organic pollutants is through the collateral pollutant removal when suspended sediments are removed. Design criteria for sedimentation basins are found in Section 2.11; for oil and grit separators in Section 2.13; and for snow storage sites in Section 2.16. Suspended sediment, oil, and grit are principal contaminants for water quality treatment design purposes.

The determination of a pollutant load (PL) carried by runoff is dependent on two primary factors: the type of land use, and the amount of time that pollutants have been allowed to build-up. Frequent storms reduce the amount of pollutants carried in a single storm. Table 2-3 gives representative daily pollutant build-up ranges (PBRs) for different land use types in Anchorage based on national literature and historical studies.

Estimated pollutant loads are determined using Table 2-3 and build-up periods (T) of 150 days for snow melt events and 60 days for rain storms. The following formula is used, given that A is the area in acres:

$$PL = (PBR) (T) (A)$$

The impact of the proposed development is the difference between the existing and proposed land use pollutant contribution.

The MOA has collected and analyzed pollutant loading data for Anchorage. These data are currently being used to develop a SWMM model for Anchorage to analyze runoff quantity and quality for

joint MOA and DOT&PF NPDES requirements. Users are encouraged to contact PM&E for information about this model and its data and application to specific design situations.

Typical annual sediment yields are presented in Table 2-4.

TABLE 2-3 DAILY POLLUTANT BUILD-UP RANGES

Land Use	BOD ₅ (lbs/Ac/ Day)	SUS-SOL (lbs/Ac/ Day)	SET-SOL (lbs/Ac/ Day)	TDS (lbs/Ac/ Day)	NH ₃ (lbs/Ac/ Day)	NO ₃ (lbs/Ac/ Day)	TOT-P (lbs/Ac/ Day)	GRS-OIL (lbs/Ac/ Day)	FE-COL (BILLION MPN/ Ac/Day)
Commercial	0.33-0.43	4.9-5.0	0.004-0.005	0.8-1.3	0.005-0.010	0.002-0.006	0.007-0.25	0.20-0.23	0.009-0.15
Industrial	0.35-0.60	7.5-7.5	0.0075-0.01	1.0-2.0	0.005-0.010	0.0005-0.003	0.0053-0.10	0.30-0.34	0.002-0.01
Multiple-Family Residential	0.12-0.34	0.50-1.6	0.001-0.005	0.40-1.3	0.005-0.015	0.0012-0.0015	0.0035-0.08	0.06-0.10	0.0008-0.007
High-Density Residential	0.10-0.49	0.20-1.0	0.003-0.004	0.3-0.8	0.002-0.016	0.001-0.002	0.002-0.15	0.03-0.04	0.002-0.002
Low-Density Residential	0.05-0.10	0.15-0.7	0.001-0.002	0.25-0.3	0.002-0.005	0.0005-0.001	0.0014-0.02	0.01-0.02	0.001-0.0015
Cleared and Pervious	0.02-0.05	0.10-0.5	0.001-0.001	0.2-0.3	0.002-0.0005	0.0001-0.0005	0.0007-0.01	0.001-0.002	0.001-0.001
Bogs and Marshes	0.01-0.02	0.0-0.0	0.0-0.0	0.1-0.2	0.0001-0.0002	0.0001-0.0001	0.0007-0.0007	0.0-0.0001	0.0001-0.001
Lowland Forest	0.01-0.01	0.0-0.0	0.0-0.0	0.1-0.1	0.0001-0.0002	0.0001-0.0001	0.0007-0.0007	0.0-0.0001	0.0001-0.001
Upland Forest	0.01-0.01	0.0-0.0	0.0-0.0	0.1-0.1	0.0001-0.0002	0.0001-0.0001	0.0007-0.0007	0.0-0.0001	0.0001-0.001
Natural Pervious	0.01-0.01	0.0-0.0	0.0-0.0	0.01-0.1	0.0001-0.0002	0.0001-0.0001	0.0007-0.0007	0.0-0.0001	0.0001-0.001

TABLE 2-4 ANNUAL SEDIMENT YIELD

Land Use	Annual Sediment Yield (ft ³ /acre)
Industrial	23
Commercial	15
Multi-Family Residential	3.2
High-Density Residential	1.8
Low-Density Residential	1.3
Cleared Pervious	0.9
Bogs and Marshes	0
Lowland Forest	0
Upland Forest	0
Natural Pervious	0

Modified from the *Campbell Creek Drainage Study* - Task Memo No. 7, 1979

END OF SECTION 2.6

SECTION 2.7 PIPED STORM SYSTEMS

2.7 A Objectives

The primary benefit of an underground system over ditches is increased safety due to better control of glaciation and erosion. Piped storm systems shall be designed to pass peak flows for the design storm based on contributing area or watercourse type, as applicable, presented in Table 2-1. The primary detriment of an underground system is the potential for adverse impacts on water quality.

The objective of this section is to provide design standards for various components of underground storm systems. Construction specifications on each component are found in the Municipality of Anchorage Standard Specifications (M.A.S.S.).

2.7 B Pipe Sizing and Standards

Because of on-going corrosion problems in the Anchorage area, storm pipe shall be Type S Precoated Corrugated Metal Pipe (PCMP) or Type S Corrugated Polyethylene Pipe (CPEP). PCMP and connecting bands shall be coated to conform to latest revisions of the following the American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications: M245 and M246, and the coating shall be 10 mils minimum on each side. CPEP and fittings shall meet the latest revision of AASHTO Standard Specifications: M294 and M252 and have a smooth inner liner. The following criteria shall apply in the design of storm drain systems:

1. The diameter of storm drain pipe is determined using the Manning's equation or other generally accepted engineering practice. Approved Manning's "n" values are provided in Table 2-5.
2. The minimum diameter of storm drain pipe is 12 inches.
3. Catch basin lead minimum sizes are 10-inch diameter for MOA projects and 12 inches in DOT&PF ROW.
4. The minimum pipe slope is 0.3 percent.
5. The pipe placement between manholes shall be in a straight line. A curved pipe alignment may be allowed for pipes over 36 inches in diameter upon approval by the Municipal Engineer.
6. The upstream storm drain pipe terminus shall be a manhole or a catch basin manhole. Cleanouts may be used only at a subdrain terminus.
7. The storm drain system shall not be surcharged during the design storm event.
8. If a variance for surcharging is authorized, the maximum allowable hydraulic gradient of the storm drain system at the design flow is 0.5 feet below the elevation of inlet grates and manhole covers.
9. Water velocity in storm drain pipe is determined using Manning's equation. At the design flow, the minimum pipe flow velocity is 2 feet per second (fps) and the maximum pipe flow velocity is 13 fps.
10. Outlet screens shall be provided where subdrains outfall to surface drainage.
11. Separation distance between storm pipe and water mains and services shall meet ADEC regulatory requirements. Separation distance between storm pipe and AWWU sanitary sewer or water facilities shall conform to AWWU requirements.

TABLE 2-5 MANNING'S "N" VALUES FOR CHANNEL FLOW	
Conduit Material	Manning's "n"
Closed conduits	
Asbestos-cement pipe	0.011-0.015
Brick	0.013-0.017
Cast iron pipe	
Cement-lined & seal coated	0.011-0.015
Concrete pipe	0.011-0.015
Helically corrugated metal pipe (12" - 48")	0.013-0.023
Corrugated metal pipe	
Plain annular	0.022-0.027
Plain helical	0.011-0.023
Paved invert	0.018-0.022
Spun asphalt lined	0.011-0.015
Spiral metal pipe (smooth)	0.012-0.015
Plastic pipe (corrugated)	
3- 8 in. diameter	0.014-0.016
10- 12 in. diameter	0.016-0.018
Larger than 12 in. diameter	0.019-0.021
Plastic pipe (smooth interior)	0.010-0.015
Vitrified clay	
Pipes	0.011-0.015
Liner plates	0.013-0.017
Open Channels	
Lined channels	
a. Asphalt	0.013-0.017
b. Brick	0.012-0.018
c. Concrete	0.011-0.020
d. Rubble or riprap	0.020-0.035
e. Vegetation	0.030-0.40
Excavated or dredged	
Earth, straight and uniform	0.020-0.030
Earth, winding, fairly uniform	0.025-0.040
Rock	0.030-0.045
Unmaintained	0.050-0.14
Natural stream channels	
Fairly regular section	0.03-0.07
Irregular section with pools	0.04-0.10

Source: American Society of Engineers. 2005. Standard Guidelines for the Design of Urban Storm Sewer Systems.

2.7 C Culverts

1. General

Culverts are intended to safely pass flow under road crossings. Criteria are designed to protect, maintain, and enhance public health, safety, and the environment. Where culverts convey streams, additional standards are established to minimize impairment of stream functions and fish passage.

- a) The minimum inside diameter of driveway and cross road culverts is 18 inches on MOA and State streets except that within the MOA ROW, smaller diameter culverts may be allowed if it can be demonstrated that glaciation will not be a problem, the pipe will handle peak flows, pipe cover is adequate, and ditch depths are sufficient. Actual culvert sizing shall be based on peak flows from recurrent events specified in Table 2-1 and glaciation potential.
- b) The minimum cover over a culvert is 12 inches. Culvert cover depth shall be based on an evaluation of traffic loads, culvert gauge thickness, material used for culvert fabrication, and glaciation potential. The crossing design must demonstrate that it can support the expected traffic loads without compromising structural integrity.
- c) Culvert ends shall be designed to minimize length and entrance and exit losses that lead to erosion at both the inlet and outlet ends with headwalls or flared end sections. Headwalls or flared end sections are required on all culvert ends.
- d) The minimum pipe slope is 0.5 percent. The slope shall be selected such that the velocity of the design flow causes neither siltation nor erosion
- e) Culverts over 100 feet in length shall meet requirements of Section 2.7 D, which specifies location and minimum spacing of manholes.

- f) Culverts in series shall be spaced at least 20 feet between each other.
- g) Non-stream culverts shall be designed without submerged inlets at the design flows except that culverts 18-inches in diameter (and smaller) and less than 20 feet long may have submerged inlets at the design flow but shall include energy dissipation and erosion control measures immediately downstream of the outlet.
- h) Culvert inverts shall match the drainageway or ditchline, subject to 2.7.C.1.d, above.
- i) Culvert slope shall be within 25% of the slope ratio (see Glossary).

2. Stream Crossing Culverts

- a) All stream crossing projects shall consult with the appropriate state agency to determine fish presence. Alaska Statute Title 41 (Fishway Act and Anadromous Fish Act) requires maintenance of fish passage. If the stream reach is determined to harbor fish, refer to fish passage criteria in Section 2.7.K.
- b) Stream crossing culverts shall use erosion control measures, such as terracing, vegetation, headwalls, and grading to adjacent vegetated areas to reduce erosion into the stream from surrounding fill.
- c) Stream culverts shall be designed without submerged inlets at the design flow except in tidally influenced areas. Stream crossing culverts shall have a headwater depth to culvert height ratio of less than one.
- d) Stream crossing culverts on 3rd order or higher streams shall be at least the diameter of the bankfull width of the channel (see Glossary).
- e) Stream crossing culverts on 1st and 2nd order streams shall be designed to reduce glaciation potential. This can be achieved by maximizing cover and low flow stream depth, as described in the *Drainage Design*

Guidelines, but must satisfy fish passage requirements (Section 2.7K) if fish are determined to be present per Section 2.7.C.2.a.

- f) A single culvert for a stream is required. Under special circumstances, other design considerations, such as multiple stream channel culverts, can be considered but in these circumstances a bridge is the preferred option.
- g) Floodplain culverts, also known as relief culverts, shall be used as an alternative to obtain required design flow capacity while maintaining creek dimensions and reducing glaciation potential.
- h) Stream culverts shall be designed to be aligned as closely as possible with the natural alignment of the stream channel in order to minimize backwater effects from flood events and potential blockages.
- i) Peak flows used to size stream crossing culverts shall consider fully developed tributary area conditions, as discussed in Section 2.2.D.
- j) The potential for erosion at culvert outlets shall be evaluated and appropriate treatment provided in the design. Such treatment measures shall not impede fish passage or trap debris during flood events.

2.7 D Manholes

- 1. A manhole shall be installed at major junctions, places where there are changes in vertical or horizontal alignment, and at locations where there are changes in pipe size or shape.
- 2. Maximum manhole spacing is 300 feet because of MOA Maintenance and Operations Department pipe cleaning equipment limitations.
- 3. Manholes within street ROWs are to be located in accordance with M.A.S.S. standard locations for new utilities.

Manholes within storm drain easements are to be centered in the easement. Whenever possible, locate manholes outside of wheel paths. Depress manhole lids per M.A.S.S.

- 4. The minimum invert elevation difference across a manhole is 0.05 feet.
- 5. The absolute minimum inside manhole diameter is 4 feet. The designer shall refer to manhole standard details in the M.A.S.S. to determine minimum manhole size.
- 6. A minimum 18-inch trap shall be provided on all manholes.

2.7 E Subdrains

- 1. Subsurface flow volumes are estimated by using the water table elevation, the depth from the water table elevation to the subdrain invert, and the hydraulic conductivity of the soil.
- 2. The need for subdrains to collect and transport subsurface waters is determined by the engineer. Storm drain pipes may be perforated to collect subsurface drainage as a secondary function.
- 3. The diameter of subdrain pipe will be determined using Manning's equation and Table 2-5 or other generally accepted engineering practice.
- 4. Subdrains are to be constructed of perforated pipe surrounded by filter material. Filter fabric (geotextile) shall be placed around the filter material; however, wrapping filter fabric directly around the pipe is not acceptable.
- 5. Subdrains and basement sump pumps shall discharge into the storm drain or subdrain by buried pipe. Discharge over land into the ROW is prohibited because of glaciation concerns.
- 6. An upstream subdrain pipe terminus shall be a standard cleanout or manhole.

7. Subdrain outfalls to surface drainage shall include an outlet screen or flap gate to prevent animals from entering the pipe.
8. Evaluation of the possible nature and extent of contaminated groundwater in the area of the subdrain and its possible collection by the subdrain must be completed as part of the subdrain design.

2.7 F Cleanouts

1. Due to the difficulty in cleaning and thawing storm drain cleanouts, a cleanout may be used as the upstream terminus for a subdrain or storm pipe only with the written approval of the Street Maintenance Superintendent and concurrence of the Municipal Engineer.
2. The maximum allowable distance between a cleanout and the next downstream manhole is 150 feet.
3. The minimum cleanout pipe diameter is 12 inches. A cleanout shall connect to the existing storm drain or subdrain pipe with an adaptor as shown in M.A.S.S.

2.7 G Outfalls

1. Erosion protection is required when the storm drain outfalls at the surface adjacent to a channel, ditch, or stream. An energy dissipator is an accepted method for protection against erosion as described in Section 2.14. If the natural channel is subject to flooding, the outfall shall be protected from erosion by a headwall, gabions, or other suitable means. If riprap is used for erosion control at outfalls, it shall be evenly graded stones with a top size based on the outfall velocity from Table 2-6.

Velocity (fps)	Diameter (feet) Riprap
4	0.2
6	0.4
8	0.6
10	1.0
12	1.5
14	2.1
16	2.7
18	3.5

2. Flared end sections or headwalls are required on all storm outfalls.
3. The invert elevation of a storm drain or subdrain outfall shall be a minimum of 1-foot above:
 - a) the ordinary high water surface elevation of lakes and ponds,
 - b) the 100-year water surface elevation for regulated streams, and
 - c) the bankfull water surface elevation for non-regulated streams.

This is to provide storage for ice accumulations, discourage fish passage and prevent blockages of outfalls due to storm flows.

4. Drainage outfalls or spillways to natural ground from curbs and gutters, pavements, drainage swales, ditches or other drainageways shall be designed and constructed to provide positive drainage, prevent ponding within the ROW, and to create or cause no impacts on adjoining property(ies). Drainage outfalls or spillways shall be designed and constructed to achieve a minimum fall of 2.5 feet to the natural ground surface. The outfall or spillway shall have a slope no flatter than 3 horizontal to 1 vertical (3:1) and no steeper than 2:1. Drainage outfalls or spillways shall be protected with appropriate energy dissipation, erosion control measures, and protection against icing.

5. Provision for an electric thaw system is required for all storm drain outfalls where heat trace is installed. A standard detail for a meter base is provided in M.A.S.S. The designer shall prepare and submit an application for service to the utility providing the electricity. The contractor is responsible for hookup after construction as outlined in M.A.S.S.
 6. Discharge permits shall be obtained from the appropriate agencies for all new storm drain outfalls.
 7. Grates with an opening no more than 4 inches are required on outfalls 12 inches or larger in diameter when the outfall may be a hazard for children or animals. Grates shall be equipped with security bolting to allow appropriate maintenance and prevent/minimize vandalism.
- c) Lift stations shall be accessible by maintenance personnel year round on roads or trails which will support a 70,000 pound loading and which are readily traversable by maintenance vehicles. Where the lift station is not located in or immediately adjacent to a developed roadway, a gravel pad of sufficient size to accommodate all lift station components and maintenance operations shall be provided. No lift station shall be located in a ditch or within a snow storage area.
 - d) Suitable and safe means of access shall be provided into all dry wells, wet wells, and vaults containing mechanical or electrical equipment requiring maintenance. All controls, sensors and pumps shall be removable without entering the wet well, dewatering, or disconnecting any piping on any station where this equipment is submerged in the wet well.
 - e) All equipment within a lift station must be serviceable, removable, and replaceable through the provided accessway(s).

2.7 H Dry Wells

The use of dry wells is limited to areas where a piped storm water drainage system is not nearby and where a soils test, as described in the Drainage Design Guidelines, indicates a well-draining soil. Comply with ADEC regulatory separation criteria and register dry wells with the EPA's Underground Injection Control Program.

2.7 I Lift Stations

1. General

- a) The use of storm water lift stations is considered to be the solution of last resort and must be approved in writing by the Municipal Engineer.
 - b) Lift station design and construction shall conform to the latest edition of M.A.S.S. and all work shall be in accordance with International Building Code, International Mechanical Code, Uniform Plumbing Code, National Electric Code (NEC), and National Fire Protection Association, all as revised, accepted, and adopted by the MOA.
- b) The lift station wet well and pump capacity shall be sufficient to:
 - i. Accommodate the design year storm event (see Table 2-1), without surcharging the wet well inlet pipe.
 - ii. Accommodate the 5-year design event without surcharging the inlet pipe with any one pump non-operational.
 - c) Wet wells shall be:
 - i. Constructed of poured in place or precast concrete; or prefabricated from

- fiberglass. Steel wet wells shall not be used. Precast concrete wet wells shall include exterior joint waterproofing membrane in addition to the gasket material between sections. Poured in place concrete wet wells shall utilize waterstop materials at all construction joints.
- ii. The wet well and other vaults shall be completely ballasted against flotation under flood conditions.
 - iii. The wet well shall be sized to limit motor starts to not more than 6 starts per hour per pump.
 - iv. The wet well shall be designed with a sump or other accommodation for collection of rocks and stones. In general, wet well sumps shall be designed to avoid directing debris into pump intakes.
 - v. Wet well and vault covers shall be of a suitable material, design and construction for the station installation as required to accommodate imposed loads and as required to protect the lift station and the public. Station covers shall accommodate H-20 traffic loading unless the cover is at least 30 inches above finish grade. All station covers located within or adjacent to roadways surfaces, sidewalks, trails, etc, shall accommodate H-20 traffic loading.
- d) Pumps:
- i. May be submerged within a wet well, or located within a dry pit. Where pumps are located within a dry pit, the pit shall be completely protected from flooding. Alternatively, submersible pumps shall be installed in the dry pit.
 - ii. Whenever possible, pumps shall be three-phase. All pumps 5-horsepower and larger shall be three-phase. Where three-phase power is not available, and pumps 5-horsepower or larger are required, a frequency inverter drive unit shall be provided to synthesize the third phase. Current-limiting motor starters (soft starts) shall be provided, when required by the electrical utility, to limit electrical starting loads.
 - iii. Pumps shall be capable of passing spheres at least 3-inches in diameter. Station piping shall be at least 4-inches in diameter. Use of smaller pumps or piping requires the written approval of the Municipal Engineer.
 - iv. Pumps shall be self-priming or flooded suction type.
 - v. Each pump shall have an individual intake.
 - vi. Where only two pumps are provided, they shall have the same capacity. Where more than two pumps are provided, they shall be designed to fit the actual flow conditions, such that with the largest unit out of service, the remaining pumps have adequate capacity as specified herein.
 - vii. Pumps shall be Underwriters Laboratories and/or Factory Mutual approved for the NEC hazardous area classification they are installed within. In general, submersible pumps installed within a wet well shall be rated explosion proof for use within a NEC Class I, Division I/II Hazard Area.
- e) Valves:
- i. Isolation valves and check valves shall be provided for each pump.
 - ii. Non-clog ball-style check valves may be installed vertically in the wet well of submersible pump lift stations. All other styles of check valve shall be installed horizontally in a vault or other accessible location above the wet well liquid level during normal operations.

- iii. Isolation valves shall be plug, gate, or butterfly valves as determined by size of the pump. Valves of appropriate design may be buried provided they are equipped with suitable valve boxes and operating nuts. Operators shall be provided for all valves installed within vaults.
 - iv. Isolation valves shall be provided on the suction line of each pump in a dry pit installation.
- f) Ventilation:
- i. Wet wells shall be passively ventilated via schedule 40 steel gooseneck vent pipe with bird screen.
 - ii. Where pumps are installed in a dry well, mechanical ventilation and humidity control shall be provided.
3. Controls / Electrical
- a) Controls shall provide for manual and automatic operation of pumps and other equipment provided. Controls shall include:
 - i. Circuit breakers and disconnects as required.
 - ii. Pump controller with automatic alternation. The pump controller shall allow for easy adjustment of all pump and alarm operating points.
 - iii. Hand/off/automatic switches for each pump.
 - iv. Motor starters.
 - v. Pump run time monitors for each pump, and one for two pumps and three pumps running together as appropriate.
 - vi. Indicator lights for pump and alarm status.
 - vii. Alarm light and horn annunciators.
 - viii. Panel heater with adjustable thermostat as appropriate.
 - ix. Transient voltage surge suppressor.
 - x. Phase converters and/or variable frequency drive units, where required, may be integral to the control panel, or remotely mounted units. Phase converters shall be solid state. Rotary converters shall not be used.
 - xi. Provisions for connection to emergency generator. Larger lift station installations may require automatic standby generation with automatic transfer switches at the discretion of the Municipal Engineer.
 - xii. Convenience features such as ground fault circuit interrupter receptacles and panel lights as specified by the Municipal Engineer.
 - xiii. Other items as required for proper lift station function.
- b) Control enclosures shall be National Electrical Manufacturers Association (NEMA) 3R or 4X, as determined by weather exposure. The enclosure shall have a lockable exterior door, and an interior dead front with safety interlocks on the main circuit breaker. All user controls and indicators shall be mounted on the dead front such that they are operable without exposing the user to hazardous voltages.
 - c) All equipment installed within the wet well shall be rated for use within a NEC Class I Division I/II Hazard Area, and/or listed as intrinsically safe.
 - d) Control enclosures shall be located outside of the NEC Class I Division I/II hazardous location boundary, and shall be separated from the hazardous area by appropriate conduit seals and construction. Appropriately rated junction boxes shall be provided within the wet well for control and power cables termination to allow

equipment to be removed and replaced without disturbing the conduit seals.

- e) Transducers shall be solid state, floats designed to be resistant to fouling, or a combination thereof. In all cases, the transducers shall be capable of calibration and/or adjustment and capable of replacement without entering the wet well. In all cases, a float shall be provided for the high level alarm.
- f) Audio and visual alarms shall be provided at all lift stations. Where specified by the Municipal Engineer, auto-dialing phone alarms shall also be provided. Alarm signals shall include as a minimum:
 - i. Power failure
 - ii. Pump failure (both thermal and seal failures)
 - iii. High level alarm
 - iv. Low level alarm (i.e. pump shut off failure)
 - v. Transient voltage surge suppressor failure
 - vi. Phase loss/phase converter failure
 - vii. Temperature (freeze) alarm

4. Force Mains

- a) Force mains shall be high-density polyethylene, Size Dimension Ratio 17 pipe and fittings or greater where required by operating pressure. Ductile iron pipe or steel pipe may be used for station piping provided suitable corrosion protection is provided. All piping and fittings shall be designed to resist pipe thrust and water hammer conditions.
- b) Whenever possible, the force main shall be sloped downward such that the force main drains completely between pumping cycles. Where topography or the geometry of the

storm drain system require, the force main may be sloped upward.

- c) The force main shall be designed with consideration for elimination of or control of entrapped air. Combination air release/vacuum valves shall be installed within access vaults at points of grade reversal which may trap air.
- d) The force main shall be sized to maintain a minimum of at least 3 fps flow velocity within the force main during average operating conditions.
- e) Appropriate energy dissipators shall be provided at the outlet of the force main.
- f) The force NEC Class I Division I/II hazardous location boundary main shall be pressure tested to 150 percent of the pipe design pressure.

5. Freeze Protection

- a) Freeze protection shall be provided using insulation and/or heat tracing. Degree of freeze protection required varies with depth of the lift station. As a minimum, the lift station structure, lid, and access hatch shall be insulated to the expected frost depth.
- b) All force mains shall be protected from freezing with insulation, heat tracing, or sufficient depth of cover. Where the force main or discharge piping remains full and does not drain freely, both heat trace and insulation shall be provided unless thermal analysis is provided demonstrating that insulation or depth of cover alone will prevent freezing.

2.7 J Freeze Protection Criteria

- 1. The minimum depth of cover over storm pipe without thaw protection is 4 feet, measured from the street or ground surface to the top of the pipe.

2. Insulation is required for pipe diameters less than 30 inches if the depth of cover is less than 4 feet.
3. When necessary, roadway culverts shall include provisions for thaw wire or heat trace. The use of steam thawing techniques requires the written approval of the MOA Maintenance and Operations Department.
4. Oversizing of the outlet pipe may be used as a means of freeze protection if information demonstrating its effectiveness is provided.

2.7 K Fish Passage Criteria

1. General

Determination of fish presence is required for all stream crossings. The designer shall refer to MOA Stream Reach Maps to determine if a waterway is listed as a stream, and contact the appropriate state agency determine whether fish are present. In addition, culvert design shall conform to the regulatory requirements of Alaska Statutes Title 41 Fishway Act and Anadromous Fish Act.

Within the Municipality of Anchorage, there are two main methods of designing for fish passage: the stream simulation method and the hydraulic method.

In general, the stream simulation method shall be the primary method applied to stream crossing culverts where fish passage is required except as noted in this Section.

- a) All culverts less than 100 feet long in streams with less than 6% slope shall be designed using stream simulation method criteria. Stream simulation will be the preferred design alternative in streams up to 6% slope.
- b) In cases where stream simulation is desired for lengths greater than 100 feet, the design must meet state requirements for a fish passage permit under Alaska Statutes Title 41. Site-specific

evaluation is necessary because over 100 feet, the effects of culvert length on streambed stability and configuration are not yet sufficiently understood.

- c) Stream channel slopes greater than 6% shall require additional stability analyses for stream simulation to be authorized. Culvert design methods such as hydraulic, zero-slope, or other design options shall be authorized when site-specific conditions preclude use of the stream simulation design.

2. Stream Simulation Method

Stream simulation methods of culvert design at road crossings emulate the natural functions and physical conditions within the stream channel of a stream, facilitating sediment transport, fish passage and reducing glaciation issues in some cases. The intent is to mimic the local stream features so that the crossing represents no more of a fish and debris passage challenge than the natural channel itself, while satisfying other road crossing design criteria. Information on this methodology is available at Alaska Department of Fish and Game Sport Fish Division (<http://www.sf.adfg.state.ak.us/SARR/fishpassage/fishpass.cfm>) and at the USDA Forest Service (<http://www.stream.fs.fed.us/fishxing/>).

All stream simulation designs and methodologies must comply with the following criteria.

- a) Culvert slope shall approximate the stream slope through the reach in which it is being installed or appropriate reference reach (see Glossary). The slope ratio (see Glossary) shall not vary more than 25% to minimize adverse effects on channel conditions.
- b) Stream crossing culverts on 3rd order or higher streams shall be at least as wide as the product of 1.2 times the bankfull channel width plus 2 feet, but may be subject to limitations due to cover requirements.

- c) Stream crossing culverts on 1st and 2nd order streams shall be at least as wide as the bankfull channel width, rounded to the nearest foot.
 - d) Culverts shall be embedded over the entire length with streambed material of sufficient depth to withstand maximum scouring at the design flow or shall be embedded at least 40% of the culvert diameter for round culverts and 20% of the maximum height in pipe arch culverts.
 - e) Substrate material will be designed for at least two flow conditions:
 - i. Streambed material shall be sized to be dynamically stable to at least the 50-year event and mimic the natural streambed material within this stability requirement.
 - ii. Streambed material shall maintain the natural low flow and depth of the reach as surface flow unless the reach is documented to naturally go dry during low flow periods under normal hydrologic and climatic fluctuations.
 - f) The cross-section shall simulate an appropriate reference stream channel cross-section and shall be designed to be dynamically stable at the design flow. Channel sides can be continuous or rockbands utilized as necessary to maintain channel shape. Continuous channel sides are required to reduce glaciation potential. In other cases, rockbands can be utilized, providing they are spaced the lesser of either five times the width of channel or such that the maximum vertical difference between crests is less than 0.8 feet.
- available at Alaska Fish and Game Sport Fish Division (<http://www.sf.adfg.state.ak.us/SARR/fishpassage/fishpass.cfm>), the Federal Highway Administration (<http://www.fhwa.dot.gov>), and the USDA Forest Service Stream Systems Technology Center (<http://www.stream.fs.fed.us/fishxing/>).
- a) The design fish shall be a 55 mm (2.16 in) juvenile coho salmon for anadromous streams and a 55 mm (2.16 in) Dolly Varden char for nonanadromous streams. These criteria may change based on ongoing research by federal and state agencies.
 - b) Fish passage high flow design discharge will not exceed the 5% annual exceedance flow or 0.4 times the 2-year peak flow, whichever is lower and has the most supporting hydrologic data.
 - c) Fish passage low flow design discharge shall ensure a minimum 6-inch water depth or natural low flow and depth within the reach the crossing occurs. In cases where local conditions preclude natural low flow characteristics, backwatering or in-culvert structures shall be considered.
 - d) In cases where flared end sections with aprons are necessary and fish passage is required, water depths and velocities that satisfy fish passage criteria must be demonstrated across the apron in addition to within the culvert.
 - e) Fish passage criteria for all culvert design options must be satisfied 90 percent of the time during the migration season for the design species and age class pursuant to Alaska Statute 41.14.840. Tidally-influenced streams may sometimes be impassable due to insufficient depth at low flow and low tide. If the tidal area immediately downstream of a culvert is impassable for fish at low tide, the 5-percent exceedance criterion shall apply only to the time during which fish can swim to the culvert. Tidally-influenced fish passage structures shall satisfy Alaska Statute 41.14.840 for an average of at least

3. Hydraulic Method

The hydraulic method uses the swimming capability and migration timing of target design species and sizes of fish to create favorable hydraulic conditions throughout the culvert crossing. Information on this methodology is

90% of the tidal cycles, excluding periods when the stream channel is not accessible to fish because of natural conditions at low tide.

2.7 L Maintenance Considerations

In the preparation of plans for construction of drainage facilities, engineers shall include life cycle maintenance and operation costs of these facilities as a primary design consideration. The following considerations shall be made in the design process:

1. All access ways shall be designated on the plans and cleared, graded, and constructed with the facility construction.
2. Major facility designs such as sedimentation basins and oil and grit separators shall consider access by maintenance vehicles and be approved by the MOA Maintenance and Operations Department. At least one all-weather access roadway capable of supporting a 70,000 pound load shall be provided.
3. The length of the access way shall be minimized.
4. Specific access easements or agreements that preclude planting of shrubs, construction of fences, and other structures within the access area shall be obtained. Standard drainage easements are not acceptable for access (unless they are modified to specifically allow it).
5. The sloping of access ways around facilities shall have a maximum cross slope of 5 percent and be designed in a manner to accommodate maintenance vehicles.
6. Drainage facilities shall be designed in order to minimize potential tampering impacts.

END OF SECTION 2.7

SECTION 2.8 DRAINAGE CRITERIA FOR STREETS

2.8 A Curbs and Gutters

In urban areas, curbs and gutters are usually required to pick up drainage from streets and adjacent properties. The longitudinal grade shall match the edge of the street grade. An exception is on street grades of less than 1 percent where the gutter may be depressed to direct drainage into a catch basin. Curb and gutter design guidelines and types are discussed in Chapter 1.

2.8 B Ditches

In rural areas, roadside ditches usually pick up drainage from streets and adjacent properties. Standards for ditches are provided in Section 2.9.

2.8 C Storm Drain Inlets

1. Inlet spacing shall be designed so that no more than 20 to 25 percent of the gutter flow reaching each inlet will pass on to the next inlet downstream and in accordance with Section 2.8.E. The spacing of inlets along curbs and gutters shall be supported by engineering calculations or a tabulation of inlet capacity compared to design flow and shall not exceed 1,100 feet.
2. Inlet spacing evaluation shall also include:
 - a) The flow velocity on street grades over 5 percent; and
 - b) Evaluation of the effects of 50 percent of the inlet opening being obstructed (such as by trash, debris, and leaves).
3. At intersections where storm drains are available, catch basins shall be used instead of valley gutters. In unpaved areas, the placement of an asphalt or concrete pad that slopes toward the inlet is required. The asphalt pad shall extend at least 2.5 feet from the outside edge of the inlet to the outside of the pad.

2.8 D Valley Gutters

1. Valley gutters shall be provided to carry drainage through street intersections and across commercial driveways where it is impractical to intercept the drainage with a storm drain inlet.
2. The minimum grade for a valley gutter is 0.4 percent when constructed of portland cement concrete, and 1 percent for asphalt concrete construction.
3. The use of portland cement concrete valley gutters is discouraged and will be evaluated on a case by case basis by PM&E.

2.8 E Pavement Encroachment

1. No curb overtopping on residential streets shall occur during the 10-year design storm event.
2. The maximum acceptable drainage encroachment for the 10-year design storm event on primary streets is to not allow curb overtopping and to maintain at least one driving lane in each direction free of water.
3. Surface drainage encroachment is not allowed on any traffic lane of a freeway or expressway.
4. The maximum acceptable drainage encroachment on paved alleyways is containment of water within the alley ROW.

2.8 F Subsurface Drainage Control

Fin drains or other subsurface drainage controls, including controls to prevent glaciation, shall be used where conditions warrant. Controls for glaciation are discussed in the *Drainage Design Guidelines*.

END OF SECTION 2.8

SECTION 2.9 OPEN CHANNELS**2.9 A General**

Open natural channels, including streams, drainageways, and water quality facilities are generally encouraged when they are:

1. A conveyor of water from a stream or natural drainage.
2. A temporary channel as part of a phased drainage project that will be replaced with pipe as full drainage improvements are developed.
3. A road ditch for a rural street section.
4. A component of a water quality improvement.

2.9 B Design Methods

1. For situations that involve re-routing or re-aligning existing streams, see Section 2.15.
2. Any temporary open ditch shall be designed to contain the design flow of the proposed permanent pipe system specified in Table 2-1.
3. The capacity of a roadside ditch shall be based on a design storm event specified in Table 2-1 with a minimum channel freeboard of 1-foot.
4. Open channels are designed using Manning's "n" values in Table 2-5 based on expected mature growth conditions of the channel 10 years after construction.
5. The design storm shall be used to evaluate the need for erosion control measures.
6. When the channel is part of a water quality improvement, the channel capacity shall be the same as the capacity of the water quality facility.

7. The final profile of constructed channel segments shall reflect the natural character of the profile of undisturbed channel segments immediately upstream and downstream of the re-routed or re-aligned segment of the stream. Transitions between constructed and undisturbed channel segments shall be gradual, and constructed in a manner that does not induce erosion or sedimentation.

2.9 C Side Slopes

Channel side slopes shall be no steeper than 2 feet horizontal to 1-foot vertical (2:1) except in streams as discussed in Section 2.15. Erosion control is required in accordance with Section 2.9.E.

2.9 D Flow Velocity

The maximum flow velocity in a channel shall be such that no erosion or scouring will occur to the channel sides or bottom for flows up to, and including, the design storm flow. For unlined channels, this scour velocity is determined by soil conditions shown in Table 2-7. Where channel lining, check dams, or erosion control devices are used, the design will be evaluated on a case-by-case basis. Check dam criteria are included in Section 2.17.C.6.

2.9 E Erosion Protection

1. Erosion protection of open channels shall be provided when channel design velocities exceed the limits shown in Table 2-7.
2. Erosion protection shall consist of one or more of the following:

- a) Riprap (see section 2.7.G)
 - b) Vegetation (grasses, shrubs, and trees)
 - c) Erosion control mats
 - d) Other PM&E-approved manufactured materials for control of channel erosion.
3. Variation in channel width or alignment shall be gradual.

TABLE 2-7 MAXIMUM VELOCITIES FOR UNLINED CHANNELS

Type of Material in Excavated Section	Velocity of Clear Water (fps)
Fine sand (noncolloidal)	1.5
Sandy loam (noncolloidal)	1.7
Silt loam (noncolloidal)	2.0
Ordinary firm loam	2.5
Volcanic ash	2.5
Fine gravel	2.5
Stiff clay (colloidal)	3.7
<i>Graded material:</i>	
Loam to gravel	3.7
Silt to gravel	4.0
Gravel	5.0
Coarse gravel	5.5
Gravel to cobbles (6")	6.0
Shales and hardpans	7.0
<i>State of California, Department of Public Works, Division of Highways, Planning Manual of Instructions, Part 7--Design, 1963.</i>	

END OF SECTION 2.9

SECTION 2.10 RETENTION / DETENTION FACILITIES

2.10 A Objective

Land development, re-development, road, and drainage projects sometimes occur in areas with inadequate infrastructure to address the increased runoff. In these cases, there are two options. One is to construct or enhance drainage facilities to handle increased runoff; the other is to provide on-site drainage detention so the pre-development runoff flow rates are not exceeded. Retention facilities are preferred over detention facilities where conditions are suitable for infiltration. The objective of this section is to establish criteria for both temporary and permanent facilities.

2.10 B Design Considerations

1. Drainage detention or retention is mandatory where downstream adverse impacts will occur due to discharges from the project and where the expansion or improvement of the downstream system is either financially prohibitive or unacceptable for aesthetic or other compelling reasons.
2. An on-site retention/detention facility shall be provided as required by Table 2-1 and the *Drainage Design Guidelines*.
3. The rooftops of buildings may be used for detention or advanced low impact development (LID) storm water management technologies such as Green Roofs, if approved by the Building Safety Division of the MOA Development Services Department. Care shall be taken to design the buildings to accommodate the additional live loading and potential glaciation impacts.
4. Designs shall ensure that such facilities do not become nuisances or health and safety hazards.
5. Facilities shall be designed to minimize maintenance costs. On-site retention/detention facilities shall be maintained by the landowner unless otherwise approved by the Municipal Engineer. The maintenance responsibility,

public or private, shall be clearly stated on the plans.

6. In cases where future storm drain construction is expected to provide a means of drainage, platting and other land development actions may identify such retention/detention facilities as temporary measures.
7. In proposed subdivisions, drainage retention or detention areas may be used as required open space if the requirements of open space in the AMC are satisfied. For example, some facilities could be used for active recreational use if they do not present a safety hazard.
8. When retention/detention facilities are proposed with water depths exceeding 1 foot at any time, safety considerations shall be included in the facility design. Considerations may include one or more of the following:
 - a) Side slopes of flatter than 4 horizontal to 1 vertical (4:1) to facility easy escape
 - b) Safety ledge grading around the perimeter
 - c) Warning signs
 - d) Fencing
 - e) Low, dense planting of thorny, noninvasive species of shrubs

2.10 C Facility Options

If the designer determines that on-site retention/detention facilities are appropriate for a particular project, then concept proposals shall be submitted to PM&E for consideration.

A list of potential retention/detention facility options includes:

- Rooftop storage
- Wetland storage
- Parking lot storage including surface ponding, underground systems, or infiltration trenches
- Retention and detention ponds
- Recreation area storage
- Open space area
- Other LID technologies such as rain gardens

2.10 D Retention / Detention Facility Design

Natural and constructed wetlands, and small ponding areas created by constructing low earth dams across natural drainage courses or by excavating and regrading of a development site, can provide for storm water runoff retention/detention. A retention facility is constructed so that most of the drainage is retained on-site for natural infiltration. Detention facilities involve metering drainage runoff from a site. In this case, only temporary ponding occurs. Design considerations are as follows:

1. The facilities may be located in areas where other site development is expensive and unsuitable or may be co-located with the site landscaping designs.
2. Storm water permanently retained in these ponds may be considered a potential resource suitable for a variety of uses including fire fighting, irrigation, visual enhancement, and recreation.
3. If embankments are used to dam natural drainage courses, they shall be designed according to accepted geotechnical engineering practices.
4. Retention/detention facilities and any primary outlet or spillway shall be designed to detain the increased runoff generated by development of a site based on performance requirements specified in Table 2-1. All facilities shall be capable of passing a 100-year frequency storm

without damage to the facility or surrounding structures.

5. All proposed detention and retention controls shall have a demonstrated recovery period not to exceed 72-hours. Size and design detention outlet orifices to prevent clogging and icing.
6. Design calculations for retention/detention facilities shall be submitted with the site grading and drainage plan and shall include the following information:
 - a) Hydrographs for all applicable design storms and the 100-year storm inflow to the facility.
 - b) Volume of storage versus depth of storage curve.
 - c) Outlet design calculations.
 - d) Head discharge curve for the selected outlet size.
 - e) The routed or discharge hydrographs from the facility for all applicable design storms and 100-year inflows.
 - f) Demonstration of peak off-site flow attenuation to the pre-development level based on routing calculations for the appropriate controlled storm outflow (as based on Table 2-1) for both the pre-development and post-development conditions.
 - g) Emergency spillway design calculations for facilities.
7. Other items that shall be addressed or included with or on the plans are:
 - a) The shape of the facility shall conform to the natural topography whenever possible.
 - b) Identification of required easements.

- c) Landscaping and fencing around retention/detention facilities when access exposes the public to unusual risk.
- d) Properly executed maintenance agreements, which clearly establish maintenance responsibilities. No agreement requiring MOA maintenance will be accepted without approval and acceptance by the MOA Maintenance and Operations Department.

END OF SECTION 2.10

SECTION 2.11 SEDIMENTATION BASINS

2.11 A General

This section provides design criteria for specific facilities to help accomplish sediment control objectives. A sedimentation basin differs from retention or detention facilities in that its purpose is to both trap sediments and meter drainage rates.

Sedimentation basins, when used as the only treatment method, may not treat storm water sufficiently to comply with federal, state, and local requirements and enhanced methods of treatment, such as filtration, may be required.

2.11 B Site Selection Considerations

A list of site selection considerations is as follows:

1. Proximity to storm drainage outfalls requiring treatment.
2. Functionality in terms of hydrologic capacity, soil and groundwater conditions, and potential impacts. The basin shall be capable of maintaining the base water elevation.
3. Potential for public nuisance due to either unsightliness or safety hazards.
4. Potential for joint use as a recreation facility.
5. Land acquisition costs.
6. Maintenance accessibility and costs.

2.11 C Design Considerations

The design of sedimentation basins shall include the consideration of several factors. This section provides discussion on various

items. The critical elements of a sedimentation basin are as follows:

- Access for removal of sediment
- Staging area
- Inlet forebay
- Main settling bay
- Polishing wetlands outfall
- Side discharge flood bypass weir

Sedimentation basins function most efficiently with a small, easily cleanable, hardened forebay at the point of inflow and a shallow wetland area providing natural filtration at the outfall. Sedimentation basins shall be designed with a forebay according to this section and wetland polishing features. Additional capacity, if any, will be in fulfillment of retention/detention/infiltration requirements specific to the site based on this chapter and other requirements.

1. Precipitation and Runoff

- a) The 2-year, 24-hour storm is the design storm for sedimentation basins, adjusted for orographic effects (Section 2.5B). The runoff hydrograph resulting from the design precipitation shall be generated based on the *Drainage Design Guidelines*.
- b) The 10-year and 100-year recurrence interval storms shall be evaluated to size the outlet facilities to pass these storm events. The duration of the design storms shall be equal to or greater than the drainage basin's time of concentration.
- c) The base flow of the storm water system shall also be considered in the sizing of a sedimentation basin. In a system containing only storm water, the base flow component would be zero. Base flows for a drainage area with high groundwater levels shall be evaluated

considering site-specific conditions. For sedimentation basins constructed on existing drainage outfalls, the base flow shall be measured during dry weather. Where storm drain outfalls at the basin site have not been constructed, a hydrogeologic study, dry weather flow measurement, or other generally accepted practice shall be conducted to estimate such flows.

2. Sediment Yield

A sedimentation basin may be designed to be constructed in stages. The first stage capacity shall be equal to or greater than that required for both the present development conditions and the currently proposed (platted) development.

3. Minimum Depth and Horizontal Velocity

- a) Sedimentation basins shall be designed as "wet" detention basins. Dry detention basins shall not be allowed.
- b) Sedimentation basins shall have a minimum depth of 5 feet above projected accumulated sediment.
- c) The basin may be designed with a variable depth in order to collect sediment in certain zones of the basin for ease in cleaning the basin.
- d) The average horizontal velocity in the basin shall not exceed the critical scour velocity of 0.04 fps.
- e) The maximum depth of the basin is 10 feet. Exceptions will be considered on a case-by-case basis and may require a State permit for a dam.

4. Basin Volume

- a) A sedimentation basin shall provide the volume for five years of sediment storage in addition to the volume required for treatment of the design flow

hydrograph. Typical annual sediment yields are presented in Table 2-4.

- b) A pre-settling pond volume of approximately one-quarter of the total volume is recommended.

5. Treatment Requirement

- a) Based on the design flow hydrograph, sedimentation basins shall remove 100 percent of inorganic sediment particles that are 20 μm in effective diameter and larger or 60 percent of all total suspended sediment influent into the basin, whichever results in the greater sediment removal, or as otherwise approved by the Municipal Engineer.
- b) The minimum size of sedimentation basins shall be based on the post-development hydrograph peak flow and the theoretical settling velocity of the target particle size as estimated using Figure 2-4.

6. Basin Shape

- a) Optimum sedimentation is expected in a basin having a length to width ratio of five to one.
- b) The shape of the sedimentation basin shall be designed to prevent short-circuiting. Short-circuiting can be reduced by strategic installation of baffles designed to increase the flow path and/or by dividing the basin into cells for pre-settling and final settling of sediments.
- c) The basin shall be designed to integrate with the environment and landscaping of the surrounding areas and to match surrounding land uses. An irregular perimeter is preferable to a rectangular shape, but must be carefully evaluated to prevent short-circuiting. Baffles may be used to channel water and resolve short-circuiting effects.

- d) Design shall provide access for easy cleanout.

7. Inlet and Outlet

- a) Drainage shall be directed into the sedimentation basin forebay in a manner that avoids erosion, distributes the inflow, and reduces short-circuiting through the system.
- b) The outlet structure of the sedimentation basin shall be designed to prevent erosion and icing, and to provide a controlled release of the impounded water.
- c) A shallow wetland feature is required before or as part of the outfall to perform as a polishing tool for water as it leaves the sedimentation basin.
- d) The outlet shall be designed to restrict the outflow discharge rate to provide detention times sufficient for sedimentation. The outlet can also be used to decrease the peak outflow rate.
- e) The design shall allow discharge of the 100-year storm without jeopardizing the structural integrity of the embankment. An emergency overflow shall be constructed above the inlet as a 100-year storm bypass. Energy dissipators shall be installed for the discharge end of the bypass.
- f) A trash rack is required at the outlet intake. Trash racks shall be curved or inclined at a minimum slope of four horizontal to one vertical (4:1) so that debris tends to ride up as the water level increases. Glaciation potential around the racks shall be minimized.

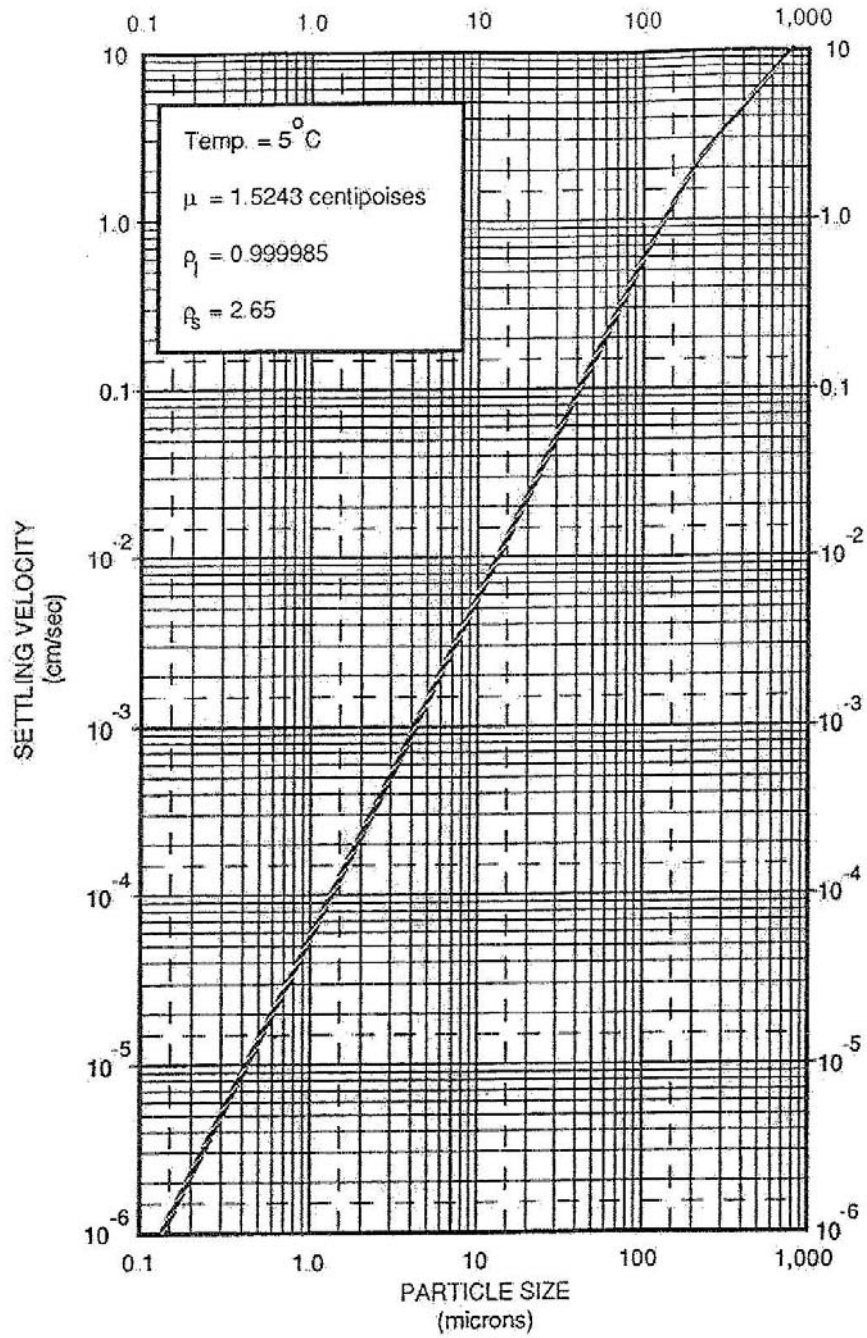


FIGURE 2-4 THEORETICAL SETTLING VELOCITY

- g) The aesthetics of the inlet and outlet structures shall be carefully considered where such structures are visible to the public. Creative designs, integrated with innovative landscaping, will enhance the appearance of the structure. Aquatic and riparian vegetation is recommended near the basin outlet. However, aesthetic features shall not compromise safety and hydraulic function.

8. Side Slopes and Erosion Control

- a) The basin side slopes above the base elevation (see Glossary) shall not exceed a slope of five horizontal to one vertical (5:1). Below the base elevation, the side slopes shall not exceed a ratio of four horizontal to one vertical. In cases where maintenance of the side slopes is not expected and where public accessibility is limited, steeper side slopes may be permitted upon approval of the Municipal Engineer.
- b) Extension of the slope above the maximum water surface elevation is required to provide a minimum 1 foot freeboard.
- c) Erosion control materials and/or revegetation shall be placed to protect and reduce erosion of the basin perimeter. Abutments shall be armored. Vegetation shall be considered for erosion control and for filtration of water. If vegetation is planted along the side slopes of the basin, a more erosion-resistant material shall be placed at the permanent water level to reduce erosion induced by wave run-up or ice scouring.

9. Maintenance

Provision for periodic basin cleaning and sediment removal is an important element in the overall design of sedimentation basins. The sedimentation basin designer shall provide the MOA with a brief manual

summarizing maintenance procedures and schedules.

Access for heavy maintenance equipment at the sedimentation basin site shall be provided for sediment removal, maintenance of inlet and outlet structures, plant maintenance, and trash removal. A hardened forebay at the inlet will be required for cleaning. A staging area shall be provided to temporarily store dredged sediment. The staging area will be designed to drain back into the sedimentation pond. Provisions shall also be made in the design for routing the base flow around the sedimentation basin to isolate the basin for maintenance activity.

10. Recreational Uses

Provisions shall be made to integrate facilities contained in the Anchorage Trails and Anchorage Park, Greenbelt, and Recreational Facility plans if the design coincides with the approximate location of the sedimentation basin. Coordination with the Parks and Recreation Department and Planning Department will be necessary if the basin location and a recreational facility coincide to mitigate water quality, aesthetic, and economic parameters. Consideration shall be given to the compatibility of other recreational uses within the basin area. Other issues of concern include:

- a) The safety of area residents and maintenance personnel shall be considered if joint use is proposed. Side slopes shall have a maximum steepness ratio of five horizontal to one vertical (5:1). Slopes shall be ten to one (10:1) where recreational users have access. Fences may be installed around areas of high risk such as the inlet and outlet structures.
- b) Measures to promote the safety of any potential users of the sedimentation basins are necessary in order to limit potential liability associated with the

operation and maintenance of the sedimentation basin.

11. Sediment Disposal

Potential locations for the disposal of sediment removed from the sedimentation basins shall be evaluated during the design phase. Sediment disposal considerations shall be coordinated with ADEC.

12. Icing Considerations

Sedimentation basins shall be designed with an increased freeboard if the basin is expected to contain water throughout the winter. This is because icing of inlet and outlet structures may restrict flow and cause flooding. Furthermore, the increased depth of ice resulting from warming and refreezing can result in overtopping of the embankment and severe erosion.

Snow melt runoff during spring break-up is expected to have elevated concentrations of pollutants and shall be routed through a sedimentation basin wherever possible. Where site conditions permit, consideration shall be given to operating a dry basin in the winter and a wet basin during the remainder of the year. The ice cover on a wet basin not only affects performance but may also produce anaerobic conditions and result in the release of odors following the melting of the ice cover.

13. Oil and Grease Skimming

Absorbent booms linked to abutment posts will be incorporated into the design. These booms will form a semi-circle around the outlet and all surface flow will move underneath them.

2.11 D Design Example

The following design methodology is suggested to evaluate the required basin area and volume.

3. Obtain hydrographs for the 2-year, 10-year, and 100-year recurrence runoff events discussed in Section 2.5.
4. Determine the base flow as discussed in Section 2.11.C paragraph 1d.
5. Establish the base elevation of the sedimentation basin above expected groundwater levels and above the ordinary high water mark of receiving waters. The lowest outlet of the sedimentation basin has its invert at the base elevation.
6. Select the required settling velocity (V_c) assuming that:
 - a) The target critical particle size to be removed is 20 μm .
 - b) A design settlement removal rate of 60 percent for a known condition. Laboratory or theoretical methods for settling column analysis can be used to determine percent removal of material for each size classification for various time intervals given a standard settling distance. The summation of removals for each size class can be balanced against required settling time.
7. Calculate the minimum pond surface area at the base elevation. This is done by allowing for theoretical settling velocity (Figure 2-4) of the target particle size at the peak flow value of the 2-year design inflow hydrograph.

For instance, if the target particle size is 20 μm , the target settling velocity is 0.023 cm/sec or 0.00075 ft/sec. The inverse of 0.00075 ft/sec is equal to 1,325.2 sec/ft, or 1,325.2 square feet (sf)/cubic feet per second (cfs). Therefore, minimum basin area to settle out a 20 μm particle from a peak flood of 30 cfs is 39,757 sf.

8. Establish the configuration of the pond at the base elevation. This is done by assuming side slopes of four horizontal to one vertical (4:1) below the base elevation, a

- five to one (5:1) length to width ratio, and volume requirements.
9. Establish stage/area and stage/storage functions for elevations above the base elevation.
 10. Establish an outlet control system to maximize detention storage of the design flow at stages above the base elevation of the basin. Outlet control can also be used to control peak discharge rates and volume requirements. Set the emergency overflow elevation for passage of larger events. Select an outlet elevation such that the maximum pool elevation of a 10-year runoff event is below the invert elevation of the storm drain inlet into the sedimentation basin.
 11. A minimum sedimentation basin depth of 5 feet below the base elevation is required to avoid scouring of settled particles along the bottom of the sedimentation basin. This 5 feet is measured above a 5-year accumulation of sediments. Select a reservoir open water depth and width such that average forward velocity through the basin at the peak 2-year storm design flow hydrograph is less than 0.04 fps.
 12. Compute the incremental detention time in the basin by dividing the sedimentation basin volume by the inflow hydrograph discharge ($T=V/Q$) for each 5-minute time increment during the peak 15 minutes of the design flow. The mean of the incremental detention times is the mean detention time during the storm. The mean detention time shall be equal to or greater than the time required to retain the target particle in the basin. If the mean detention time is insufficient, the volume below the base elevation shall be enlarged.
 13. Provide for passage of the 10-year and 100-year recurrence storm hydrographs. Check for freeboard on side slopes and overflow structure discharge capacity.
 14. Establish retention/detention peak and/or volume control goal for the 2-year, 24-hour event. Route the inflow hydrograph through the basin and outlet structure. Adjust size and volume of basin if larger area is needed and/or redesign the outlet to achieve goals. Check that detention times are sufficient for target particle removal.
 15. After minimum hydraulic and geometric criteria and site restoration have been satisfied, additional basin area shall be considered for aesthetic treatment of the slope line and surrounding site area.

END OF SECTION 2.11

**SECTION 2.12 WETLANDS
CONSTRUCTION AND
ENHANCEMENT
GUIDELINES**

Wetlands construction and enhancement guidelines are currently being developed. Check the *Stormwater Treatment Plan Review Guidance Manual* for available criteria and wetlands guidance.

END OF SECTION 2.12

**SECTION 2.13 OIL AND GRIT
SEPARATORS****2.13 A General**

The oil and grit separator is a structure designed to improve storm water quality primarily by removing floatable pollutants such as oil and grease and by removing coarse sediments.

Oil and grit separators are required for paved off-street parking lots where the lots:

1. Commercial parking lots with 40 or more parking spaces unless other treatment or flow reduction are provided, or
2. Serve a fleet of 10 or more diesel vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.).

Oil and grit separators shall also be considered on all outfalls from drainage basins with up to 5 acres of connected impervious areas, including parking lots not subject to the traffic listed above, and drainage basins in which a large percentage of the total road area is arterial roads.

Oil and grit separators are available commercially that meet annual sediment removal criteria; many structures are on the market. Manufacturers of high efficiency commercial sediment traps include CDS, Vortech, Hydro International, and Stormceptor. These and other manufactured devices may be approved by PM&E provided they conform to the design criteria standards herein. Fabricated separators may also be used, but commercially manufactured units are preferred.

2.13 B Design Criteria

The treatment goal for water quality improvements, including oil and grit separators, is to minimize pollution of receiving waters by storm water or snow melt runoff to the MEP. As a means to this goal, this DCM establishes oil and grit separator performance based on annual snow melt and storm water runoff.

The MOA has not currently selected a model to evaluate runoff quality on an annual basis. ILLUDAS does not support annual hydraulic modeling or any water quality modeling. SWMM is presently being developed to analyze runoff quantity and quality. Users are encouraged to contact PM&E for information about this model and its development, particularly for runoff quality modeling.

1. Facility capacity shall be designed based on the water quality protection flow (Table 2-1). A facility bypass system is required to bypass higher flows. It must also allow the complete diversion of drainage through bypass during maintenance.
2. Removal goals for oil and grit separator performance are based on the typical annual precipitation hyetograph, typical annual build-up, washoff loads (Table 2-3), and effects of current street and parking lot sweeping practices on resulting runoff. Street sweeping is an ongoing practice for paved streets in the MOA and its effects should be incorporated in modeling sediment runoff. Based on previous studies that included sweeping effects, it is estimated that greater than 95 percent of the sediment mass in runoff is composed of particles less than 100 μm in diameter. Based on what is currently known about the characteristics of runoff in the MOA, and current treatment technologies, annual performance goals are:
 - a) A 100 percent reduction of floatable pollutant particles 1.0 millimeters in diameter and larger
 - b) An 80 percent reduction of inorganic sediment particles equal to or greater than 100 μm
 - c) A 25 percent reduction of inorganic sediment particles less than 100 μm
3. A side-splitting diversion is required for flood bypass, unless another device is approved by the Municipal Engineer.

4. The sediment storage volume shall be twice the anticipated one-year accumulation. Typical annual sediment yields are presented in Table 2-4.
5. An access port for maintenance shall be designed for each chamber. Facility widths greater than 9 feet require two access ports for each chamber. Additionally, chambers greater than 9 feet in length require at least one access port every 4.5 feet of length. Access ladders shall be provided to the bottom of each cell.
6. Install a heavy truck access route adjacent to the oil and grit separator inlet, outlet, and cleanout manholes for maintenance.
7. Incorporate straight-line access to entire trap compartment for a Vactor wand. All sediment trap areas must be accessible in a straight line from access manholes.

2.13 C Oil and Grit Separator Operational Practices

1. Oil and grit separator installed on private property shall be maintained by the property owners.
2. Maintenance shall include
 - a) A minimum of two cleanouts per year, one following the snow melt season (May) and one prior to winter (September).
 - b) Annual, or more frequent, collection, removal, and proper disposal of oil and used sorbent material.
 - c) Annual inspection and corrective action as necessary for damage, including reduced capacity, corrosion, settling, and other factors that may compromise its effectiveness.
7. An operations and maintenance plan is required as part of PM&E's storm water review (see *Stormwater Treatment Plan Review Guidance Manual*).

END OF SECTION 2.13

**SECTION 2.14 EROSION AND
SEDIMENT CONTROL****2.14 A Objectives**

Road construction, land development, and re-development projects can substantially accelerate erosion and sedimentation resulting in adverse impacts on adjacent lands and waterways. Because of this, erosion and sediment control measures shall be provided both during and after construction on all work discussed in this manual. The *Stormwater Treatment Plan Review Guidance Manual* establishes standards to minimize the impact on land and water resources, and is available from PM&E.

END OF SECTION 2.14

**SECTION 2.15 STREAM
RESTORATION**

Streams function as fish and wildlife habitat, flood attenuating drainageways, and natural greenbelts in developed areas. Construction in streams must consider these factors. This section provides additional design criteria for this work.

2.15 A Hydrology

1. Floodplain design discharges shall be selected in accordance with FEMA regulations, or the maximum recorded flood flow, whichever is greater.
2. The restored main channel design discharge shall be the 2-year recurrence interval flood, unless otherwise approved by the Municipal Engineer.
3. The shape of the restored main channel shall be consistent with the shape of undisturbed channel reaches immediately upstream and downstream of the constructed channel.
4. Average summer flows shall be identified for use in the evaluation of fish habitat.
5. The channel improvements shall not extend the 100-year floodplain limits.

2.15 B Stream Channel Alignment

1. Selection of the stream alignment shall incorporate the following considerations:
 - a) Match the original alignment of the creek when possible.
 - b) Match the original length when the original alignment is known but the restored channel is unable to follow it. The alignment of the stream channel shall be such that the length of the restored channel is approximately equal to the original length of the natural stream channel.

- c) Match a natural gradient when the original alignment is unknown. Compute the length of channel using the slope of undisturbed reaches immediately upstream and downstream of the project site, and the elevation drop through the site.
 - d) Select an alignment and a gradient that alleviates defined problems such as glaciation, flooding, and enhances wildlife habitat.
2. The longitudinal profile of the restored stream bed shall be similar to the existing profiles upstream and downstream of the reach being designed.
 3. Sharp bends shall be removed from the alignment whenever possible.
 4. The alignment of a restored and/or reconstructed floodplain may be relatively straight but the restored main channel shall meander within the floodplain.
 5. Locate the restored stream channel adjacent to undisturbed vegetated areas whenever possible. Construction equipment may be confined to the excavated channel or previously disturbed areas to avoid disturbing naturally vegetated areas.

2.15 C Erosion Control and Bank Protection

1. Erosion control and bank protection shall be provided whenever work is performed in or adjacent to a creek.
2. The design of stream alignment or grade change improvements shall include a hydraulic and hydrologic analysis to determine the need for erosion control and/or bank protection.
3. Where stream bank stability is critical, riprap in conjunction with bioengineered vegetative erosion control above the Ordinary High Water line is the recommended method for stream channel

protection. In areas where bank stability is not critical, bioengineering methods such as fascines, coir logs, brush layering, and other methods incorporating vegetative materials shall be considered. The use of riprap without the incorporation of vegetative materials is discouraged.

4. The recommended floodplain protection method is the planting of grass and natural woody vegetation.
5. Access to the creek by MOA maintenance personnel shall also be considered.

2.15 D Stream Channels

The design of restored stream channels shall consider the undisturbed, pre-development conditions of the stream. In-stream structures that are constructed solely for the creation of habitat shall be designed so that changes in local stream hydraulics do not cause bed scour, bank erosion, or deposition in the vicinity of the habitat feature as the stream adjusts its configuration. Habitat features designed for use in areas with bed or bank protection shall be designed with caution since the desired natural readjustment in the cross-section may be inhibited by the presence of the protection structures. Stream channels shall be designed using the following guidelines.

1. Identify a reference reach or most likely pre-development condition of the stream channel. Identification is subject to approval by the Municipal Engineer.
2. Design channel to mimic the stream geomorphology of the approved reference reach or undisturbed, pre-development condition.

2.15 E Riparian Habitat Enhancement and Floodplain Construction

1. The purpose of providing riparian habitat enhancement and a floodplain along a restored reach of stream is to create habitat diversity for fish and wildlife, and provide natural flooding characteristics in the stream

- valley. Riparian vegetation provides shade, cover, and insect food sources for fish, and food, resting, and nesting sources for wildlife.
2. A floodplain bench shall be constructed at an elevation corresponding to the level of the two-year recurrence interval flood. The bench shall be revegetated as described in Section 2.15.F to provide the desired riparian habitat.
 3. Restored and/or reconstructed floodplain side slopes above the two-year recurrence interval flood level shall be no steeper than two horizontal to one vertical (2:1) and shall be roughened prior to revegetation as described in Section 2.11.F.
 4. Restored and/or reconstructed floodplains shall be designed to accommodate, at a minimum, the 100-year recurrence interval flood. Intermediate floodplain benches that are designed to accommodate the 25-year flood may be incorporated as appropriate.
- f) Aids in water recharge of streams during low flow periods;
 - g) Provides wildlife habitat; and
 - h) Supports recreation such as fishing, bird watching, nature study, and photography.
2. Revegetation plans shall be developed concurrently with design.
 3. Side slopes shall be contoured to slopes no steeper than two horizontal to one vertical (2:1). Benches included on the side slopes shall:
 - a) Intercept surface flow on side slopes;
 - b) Provide a stable surface for revegetation; and
 - c) Distribute flow over a wider area to reduce scour potential.
 4. Side slopes and benches shall be roughened prior to revegetation to create small pockets, which provide a more favorable growing environment for plants.
 5. Ground cover and/or seedlings shall be planted on side slopes to reduce erosion. No seedlings shall be planted below the elevation of the two-year recurrence interval flood in the channel.
 6. Large, woody plants shall be planted on benches to establish a root mass that will stabilize the stream bank (see Chapters 2 and 3 for plant selection details).
 7. Maintenance includes frequently checking the revegetated side slopes and benches until the vegetation becomes established and to identify and stop any localized erosion that may develop. Fertilizer may be used provided water quality impacts are addressed.

2.15 F Revegetation

1. The purpose of revegetation in stream restoration projects is to provide a filter for surface flow to the creek, provide stream bank stability, and to provide fish and wildlife habitat. Revegetation in the riparian zone (frequently flooded zone adjacent to the stream channel) and inactive floodplain (infrequently flooded zone adjacent to the riparian zone) shall be accomplished in a way that:
 - a) Reduces erosion and stabilizes stream banks and side slopes;
 - b) Provides protective cover for fish;
 - c) Traps sediment and other pollutants;
 - d) Provides nutrients to streams;
 - e) Supports growth of aquatic insects that are eaten by fish;

END OF SECTION 2.15

SECTION 2.16 SNOW STORAGE AND SNOW DISPOSAL SITE DESIGN CRITERIA

2.16 A Introduction

Snow disposal sites provide storage areas for snowfall that exceeds the storage capacity of street ROW and other public facilities. The criteria established in this section are for snow disposal sites managed by the MOA, the DOT&PF, and private disposal sites.

Guidance for on-site private snow storage and ice control is included in a white paper in Appendix 2-B. Contact PM&E for updated information.

1. Objective

The objective of these design criteria is to provide project managers and site designers with information needed to site, design, and operate snow disposal sites that are safe, efficient, and protective of surface water and groundwater quality. Water quality concerns for melt water include chloride and other salts, suspended sediment, turbidity, and metals associated with sediment and turbidity.

Besides storing snow, snow disposal sites are designed to discharge melt water through a combination of infiltration and surface discharge. Siting criteria, design features, and operational procedures described in this section are all intended to manage the impacts of discharges on receiving waters and potable groundwater resources by these three principles:

- a) Maximize appropriate infiltration
- b) Minimize sediment and other pollutants in melt water
- c) Provide for pollutant dilution

2. Codes and Review Process

These siting, design, and operational criteria function as a framework for preparing plans for commission reviews or approvals required under various portions of the Anchorage Municipal Code (AMC), as listed below. Note that the AMC is continually being revised; always refer to the most recent printed edition.

For all sites:

- a) AMC 21.15.015 - Public facility site plan review requires a review by the Planning and Zoning Commission of any snow disposal site.
- b) AMC 21.15.025 - Public facility project landscaping review by the Urban Design Commission is required for public facilities and land use permits.

In addition, for private and State sites:

- c) AMC 21.40.200.B.1 - I-1 Light Industrial District lists snow disposal sites as a conditional use that requires an annual administrative permit.
- d) AMC 21.15.055 - Annual administrative permit establishes the annual administrative permit.
- e) AMC 21.15.030 - Approval of site plans and conditional uses outlines general requirements for site plan approval.
- f) AMC 21.50.270 - Conditional use standards - snow disposal sites outlines specific requirements for snow disposal sites. In particular, this section requires submitting a drainage and water quality plan and a dust and litter control plan.
- g) AMC 21.67 - Stormwater discharge establishes storm water discharge restrictions and requires a system plan review.
- h) AMC 15.70.080 - Property line noise emission standards establishes noise standards.

- i) AMC 21.05.115 - Implementation - Anchorage Wetlands Management Plan establishes guidelines for managing wetlands.

2.16 B Site Selection Criteria

Site selection criteria consider effects of on-site infiltration and effects of surface discharges on surface water, including lakes, streams, and wetlands.

1. Snow disposal sites are not permitted within 200 feet of a Class A or B well or within 100 feet of a Class C well (18 AAC 80.020, Table A). For disposal sites that are located more than 200 feet and less than 1,000 feet upgradient from a Class A or B well, or more than 100 feet and less than 1,000 feet upgradient from a Class C well, perform an engineering evaluation of the potential impact of dissolved solids on groundwater.
2. Snow disposal sites are not permitted within 500 feet upgradient of an on-site sewage disposal system.
3. Avoid areas with high potential for contaminating potable water aquifers. The intent is to prevent melt water having a high salt content from entering and contaminating these aquifers.
4. Assess potential for such infiltration for both the site itself and for the complete flow path of the melt water. Infiltration assessment procedures are provided in the *Drainage Design Guidelines*. This site selection criterion shall be addressed by a Professional Engineer, hydrogeologist, or other professional experienced in Anchorage area surficial geology and in the hydrology and interaction of groundwater and surface water.
5. Avoid areas with high potential for contaminating closed lake or wetland systems. Melt water from snow disposal sites shall not be discharged to closed basin surface water features that have few or no surface water outlets.

6. Avoid sites that would discharge to streams with a base (winter) flow of less than 3 cfs. Minimum receiving water discharge is based on probable adequacy for assimilation of chloride releases from snow melt to achieve compliance with EPA and State water quality criteria. PM&E can provide maps of streams, site-specific channel geometry, baseline stream chemistry, and estimates of stream base flow throughout the MOA.

On-site dilution of snow site melt water may be performed prior to discharge to meet treatment goals listed in 2.15.D.2.

7. Select sites that offer optimum opportunity for infiltration to shallow, non-potable groundwater systems. This site selection criterion is secondary to criteria protecting potable aquifers, wetlands, lakes, and streams.
8. Avoid sites that would negatively impact wetlands. Melt water from snow disposal sites shall not be discharged to wetlands such that the discharge significantly reduces overall functionality (as catalogued in the *Anchorage Wetlands Management Plan* and its cited documents) of either the entire contiguous wetland feature or the impacted fraction alone.
9. Research of storm water impacts to Anchorage wetlands is continuing. Planners and designers should review the criteria and contact PM&E for site-specific and/or more current information.
10. Select sites that offer optimum opportunity for slope and aspect orientation. Sites shall be selected that are generally suitable for constructing storage pads that are sloped down from south to north. Note that the aspect of sites need not be northerly, but sites should be amenable to constructing pads sloping generally from south to north.

2.16 C Design Information

The following information is required for snow disposal site design:

1. Soil Investigation

A soils investigation is performed to provide knowledge of the soil and potential problems with geotechnical concerns such as freeze/thaw effects, deep and shallow groundwater infiltration characteristics, and other constraints to site construction. Soils analyses shall conform to information criteria in this DCM.

A detailed soils report is required for determination of marginal conditions for site stability due to high groundwater, high infiltration rate, high potential for saturation, or erosion concerns.

2. Surveying and Mapping

A map shall be created to document watercourses, storm water features, and other criteria that may be affected by the site. Mapping shall include the following features:

- a) Site topography with 2-foot or more detailed contour intervals;
- b) Existing roads, culverts, ditches, storm drains, and other drainage features;
- c) Location and depth of domestic wells and on-site sewage disposal systems within 500 feet of site boundaries;
- d) Surface water features within 500 feet of a site, including wetlands, creeks, and lakes;
- e) Ultimate receiving waters for melt water flows.

3. Groundwater Investigation

A site-specific groundwater investigation shall be conducted to protect potable aquifer supplies and receiving waters. Site-specific ground water levels (seasonal high and low), gradient, direction, uses of the local aquifer, and probable hydraulic connections to potable groundwater aquifers within a

1,000-foot radius shall be compiled or determined. The investigation shall also specifically address shallow non-potable ground water systems that may be suitable for receiving infiltrated snow melt water from the disposal site.

2.16 D Specific Design Criteria

In snow disposal site design, include a constructed pad for snow storage, with separate area(s) for any other wastes to be stored at the site, and design features for water retention and discharge. Manage discharged water to meet stated water quality objectives. These site-specific design criteria serve as the basis of the drainage and water quality plan required under AMC 21.50.270.

1. Snow Storage Pads – See Figure 2-5.

- a) Pad Orientation. Orient V-swale snow storage pads preferentially with the downslope (discharge) ends of swale axes to the north.
- b) Pad Design. Snow disposal shall take place on a compacted working surface composed of competent native material or select imported fill. Construct snow disposal pads to have single or multiple V-swale cross-sections. A V-swale shall have a 2 percent side slope and a longitudinal slope of 1 to 2 percent. Each V-swale shall have a minimum width from crest to crest of 150 feet. Pads may be constructed of a single V-swale spanning the width of an entire site, or of a continuous series of V-swales. However, given the operational requirements of V-swales and the required side slopes, a series of minimum-sized V-swales may be generally preferable to one large swale.
- c) Berm Design. Berms shall be a minimum of 3 feet in height and generally placed continuously along the outer perimeter of the snow disposal site pad. Berms are constructed with competent native material or select imported fill. Construct berms to have two horizontal to one vertical (2:1) side

slopes and a 1-foot minimum crest width. Place armor and seepage protection as specified under the section on channel and berm armoring. It is not intended for snow to be placed against the berms and berms are intended to be free from the erosional forces of melt water flows.

- d) **Pad Vegetation.** Vegetate all unarmored snow storage pad surfaces. A vegetated surface is essential to properly operate a snow disposal site. Vegetation resists pad erosion, traps fine sediments mobilized in snow melt, and promotes absorption of metals and other pollutants. Select and design a vegetative mix that is resistant to seasonal shallow burial (1 to 2 inches of loose sand fill annually) and to elevated concentrations of salt and metals. Recommended seeding specifications are provided in Appendix 2-C.

When constructing pads, cat-track all V-swale side slopes immediately prior to revegetation. Cat-tracking consists of imprinting the ground surface with crawler tractor tread marks along the fall line (i.e., trafficking directly upslope and downslope).

- e) **Channel and Berm Armoring.** Armor all critical pad surfaces and flow channels, provide permanent and temporary setback markers, and accommodate for icing storage in select armored channels. Maintain the elevation of all armored surfaces slightly depressed below and feathered to the vegetated pad surfaces to assure flow of melt water onto and across armored surfaces and not parallel to it. All armor shall be at least 6-inches thick with all finished armored surfaces feathered to the finished grade of the vegetated pad. Size armoring material according to expected flow velocities (peak discharge of snow melt from snow disposal sites can be up to 1 cfs) and

Table 2-6. In particular, perform the following:

- (1) Construct armored surfaces along the centerline of each V-swale; along the crests of all multiple, interior V-swales; along the toe of all perimeter and interior berms; along all discharge channels; and at all discharge points (Figure 2-5).
- (2) Armor from an elevation of 1 foot up from the toe of each berm and extending down the side of the berm and across the pad surface for a distance of 15 feet from the toe of the berm.
- (3) Armor a 20-foot wide band in front of the toe of the end perimeter berm for the full width of the lower end of each V-swale.
- (4) Armor both sides of the crest of each interior V-swale for a distance of 10 feet from the top of the crest.
- (5) Armor the central (longitudinal) channel of each V-swale to a minimum width of 15 feet.
- (6) Immediately beneath the surface armor along the centerline of each V-swale install a french drain 1 foot by 1 foot in cross-section comprised of washed rock wrapped in geotextile cloth. End each french drain structure at an outlet drain structure 6 feet wide by 12 feet long and 1.5 feet thick with one end of the outlet drain placed against the upstream face of the V-swale's outlet weir. The outlet drain shall be comprised of washed rock contained on the sides and bottom with geotextile cloth, with the top of the washed rock placed flush with the surface of the surrounding perimeter pad armoring.

- (7) Provide subdrain or other design elements along all discharge channels to accommodate decreased channel flow capacity lost to icing storage early in the melt season.
- f) Pad Outlet Weirs. To accommodate flow measurements and melt water sampling, construct rectangular outlet weirs or other device acceptable to PM&E at the end of each V-swale, or at each pad outlet point where multiple V-swales are served by a single discharge channel.
- g) Snow Poles. Set permanent snow poles as snow storage setback guides at a distance of 10 feet from the toe of the end perimeter berm and 5 feet from the toe of all interior and lateral berms. Poles shall be at minimum 12 feet in height and marked with reflective tape along the top 1 foot. Where multiple V-swales are constructed, provide supports for temporary setback poles along the interior crests of all V-swales.
- a) Detention Pond Design. Detention pond design is primarily based on hydrologic characteristics of the melt water from snow sites and secondarily on sediment removal rates. Design detention pond for minimum storage volume at the beginning of winter. Minimum storage volume in ponds above allotted sediment and ice/snow storage shall include all runoff from the March 23, 1974, snow melt hyetograph for a 40-hour duration (Table 2-2).

The pond treatment goal for sediment, as measured at the point of pond discharge, is 95 percent removal of all particle sizes $\geq 100 \mu\text{m}$ in diameter.

Storage volume goals for ponds above allotted sediment and ice/snow storage shall provide for dilution of melt water so that treatment goals for chloride are met.

Melt water properties for design purposes are:

- 7-day average concentration of 3,000 parts per million (ppm) chloride in 1 cfs of melt water.
- 30-day average concentration of 1,000 ppm in 0.5 cfs of melt water.

Melt water properties are based on 1998-2001 winter street maintenance practices. Melt water properties could significantly change with changes to these Municipality-wide maintenance practices. Please contact PM&E for any changes to these design criteria.

Thresholds for chloride exposure recommended by the MOA are shown in Table 2-8. These values may change; check with PM&E for current chloride threshold values.

2. Melt Water Detention and Discharge

Provide ponds for early season melt water detention and/or infiltration and for late season sedimentation. Specific design criteria for detention basins are included in Section 2.10. Supplementary criteria and criteria deserving emphasis are described below.

Exposure Duration	Fish and Invertebrates	Vegetation
Acute (less than 1 week)	3,600 mg/L	6,400 mg/L
Acute (up to 30 days)	1,200 mg/L	3,200 mg/L
Chronic (continuous)	300 mg/L	640 mg/L

- b) Outlets. Provide floating oil-absorptive booms guyed around all detention pond outlets. Provide cleanout access aprons at all inlets to detention ponds. Provide heavy maintenance vehicles access to all pond control structures. Provide for dispersion of all melt water discharge into wetlands and for flow energy dissipation at discharge points into lakes and streams. Design wetland dispersion structures to limit the size of wetland impact zones while assuring flows low enough to prevent erosion and extended, artificial ponding.

3. Waste Sediment Areas

Provide separate storage areas with proper drainage and access for any waste sediment storage proposed for sites. Access to storage areas shall not require the traversing of any part of snow storage areas or their immediate access routes. Drainage from any sediment storage areas may be directed to snow site detention ponds but shall not be directed across any portion of snow storage pads.

2.16 E General Design Criteria

General site design criteria, including lighting, noise control, parking, signage, landscaping, fencing and traffic access, are specified in AMC 21.50.270 and in Chapters 3 and 5 of this DCM. Supplementary criteria are described below.

1. Traffic Access

- a) Prohibit uncontrolled vehicular access to the site. A lockable gate shall be provided.
- b) Construct access driveway with a minimum width of 24 feet and a maximum width of 34 feet.

2. Lighting/Illumination

- a) Install permanent lighting at all disposal sites anticipated to be operated while dark. Safety is the primary reason for

lighting; lighting for disposal operations is a secondary concern.

- b) Strategically locate lighting at vehicular access points, retention basins, or other necessary areas. Provide a minimum of 0.3 foot-candles at these locations. Pay particular attention to adjoining property users to meet glare requirements of AMC 21.45.080 Paragraph W.4.a. Additional information on lighting is provided in Chapter 5 of this DCM.

3. Landscaping

The MOA Urban Design Commission must approve landscaping plans for snow disposal sites; DCM Chapter 3 provides guidelines. Supplementary criteria are described below.

- a) Ensure that landscaping on the outside of site berms and buffer areas provides year-round visual enhancement where possible. Plant woody vegetation away from equipment circulating and maneuvering areas.
- b) Provide vegetative ground cover for non-armored areas of snow disposal pads. Ground cover is necessary for proper functioning of pads. Select salt-tolerant plants and perform maintenance as necessary on an annual basis.
- c) Install an inexpensive irrigation system to be used at least during plant establishment periods.

4. Noise

The facility design must address noise at adjacent and other affected properties per AMC 15.70.080.

2.16 F Snow Disposal Operational Practices

Operations include managing litter, placing snow in winter, and maintaining vegetation in summer. Proper operation of snow disposal sites is essential to snow site performance.

Improper operations of snow disposal sites will result in increased pollutant release. In case of private sites, these considerations are incorporated into dust and litter control plan required under AMC 21.50.270.

1. Snow Placement (see Figure 2-6).

- a) Place snow across the full width of each V-swale. If multiple interior swales are used in a site design, fill must be placed across either the full width of all swales or across the complete width of one or more swales. Swales must not be filled across some fraction of their width or only on one side along their length. Non-conformance will increase turbidity in melt water.

As necessary, install and use temporary snow poles along interior swale crests. These poles help operators prevent partial filling of adjacent swales when operations call for filling just one interior swale.

Sequence placement of hauled snow starting at the downhill side of the site and filling uphill (always across the full width of each swale cross-section) to minimize erosion of dirt released from the snowpack during the latter stages of melt.

Place snow in a single fill layer over the entire available storage space before stacking snow on top of earlier fill. Thicker snow masses substantially increase initial leached chloride concentrations.

Maintain snow fill in as compact a mass as possible—never place snow as isolated and separate piles. Place snow with as vertical sides as possible—never establish thicker fills by pushing snow up long gently sloping inclines. Compact, steep-sided snow fills reduce release of sediment from the sides of the snow fill where mobilization of these sediments readily occurs.

- b) Maintain a snow fill setback from all berms. Maintain a 10-foot setback from the end of V-swales and a 5-foot setback from all side berms. Snow fill should be placed to overlap armor adjacent to the berms but not extend past setback markers.

2. Maintain vegetation of all non-armored pad surfaces. With proper initial application of an appropriate seed mix, very little attention should be required to promote seasonal growth of vegetation across the surface of snow storage pads. Little or no mowing should be required. However, regrading of sites shall be absolutely prohibited or limited to maintaining the functionality of the site, particularly in the late melt season. Confine access to pads or to control structures to traffic along armored features.
3. Maintain all materials storage, including waste sediment, separate from snow storage pad. No temporary storage of any sort shall be allowed on pad surfaces. No traffic shall be allowed during the melt season and access shall be restricted throughout the year.

END OF SECTION 2.16

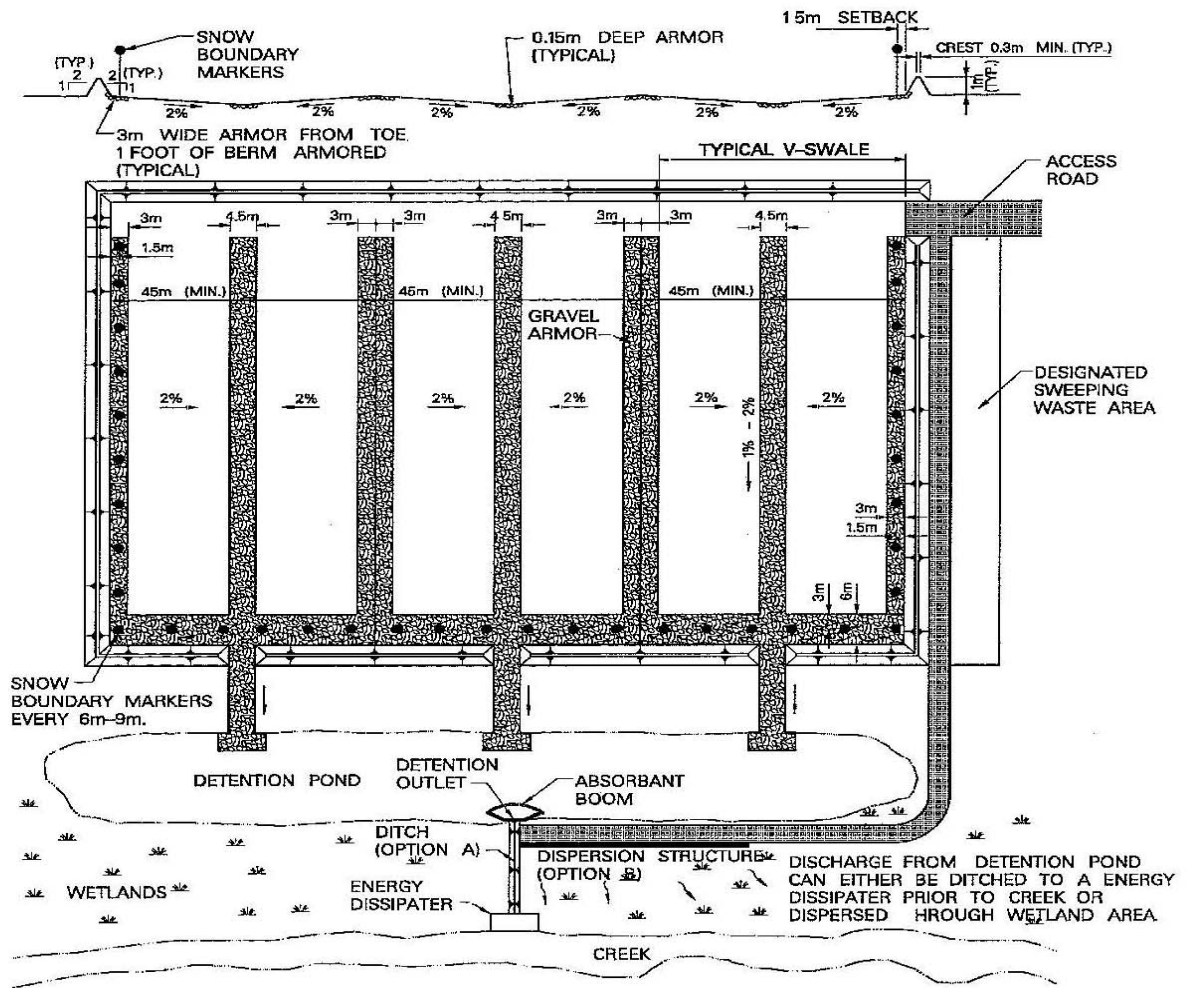


FIGURE 2-5 MULTIPLE V-SWALE SNOW SITE DESIGN CONCEPT

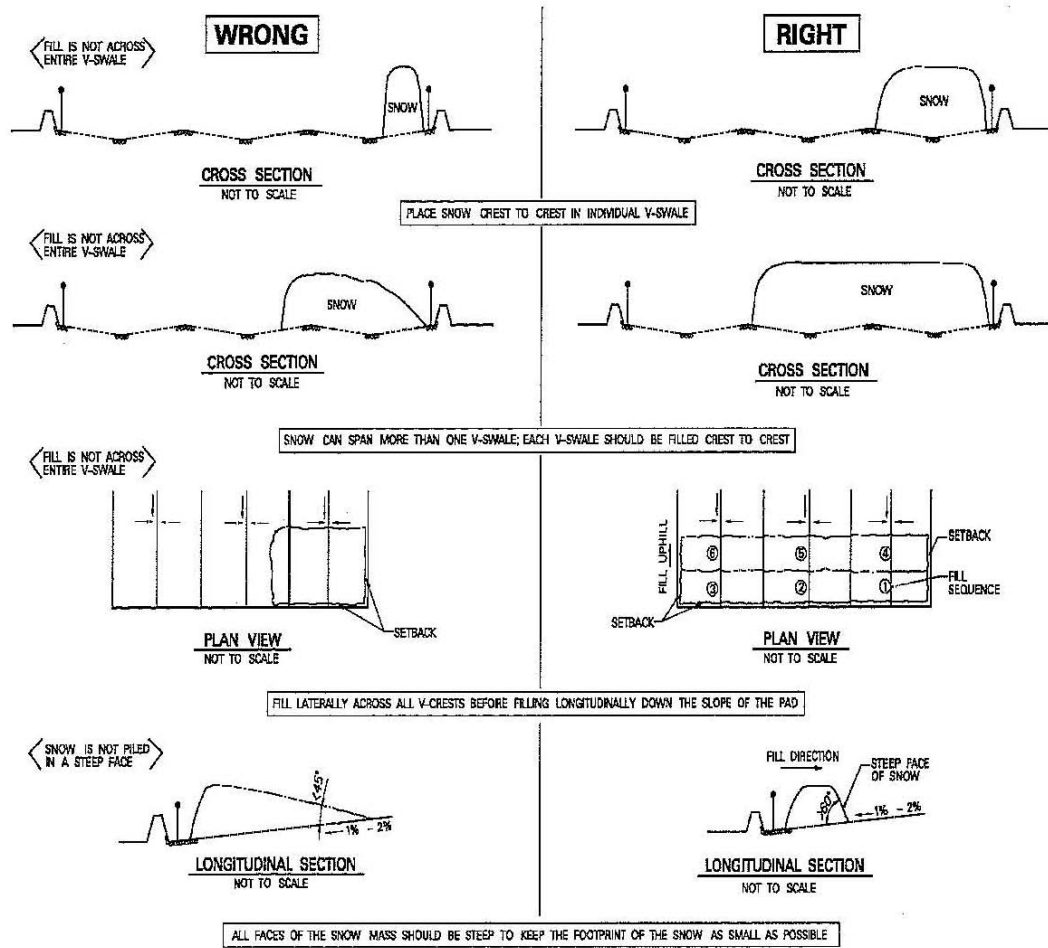


FIGURE 2-6 SNOW SITE FILL PROCEDURE

SECTION 2.17 BIOFILTRATION DESIGN CRITERIA

2.17 A Objective

General and specific criteria are presented in this section for the evaluation, siting, design, construction, and maintenance of vegetative swales and vegetative filter strips for water quality enhancement. A 'vegetative swale' is a channel lined with vegetation that treats runoff as it flows through the vegetation at a shallow depth and relatively slow velocity. A 'vegetative filter strip' is an area covered by vegetation over which runoff sheet flows at a very shallow depth and in a dispersed manner. Schematics of these two structures are shown in Figure 2-7.

2.17 B Site Selection Criteria

1. Use of natural topographic low areas for biofiltration and infiltration is encouraged.
2. Roadside ditches are significant potential biofiltration sites, but winter damage from snow plowing scrapes, de-icing chemicals, sand application, or snow storage may damage vegetation and reduce effectiveness. Road design and ditch maintenance shall be considered.
3. The infiltration rate of underlying soils may require additional design elements.
4. Biofilters can be integrated into landscape designs by use of wetland plants, wild flowers, bushes, and trees on upper areas of swales.

2.17 C Design Considerations

The success of biofiltration depends on proper construction and maintenance. The design, planning, operation, and maintenance details that follow have been adapted from the best available information, but they must be considered as interim and subject to modification as experience is gained with applications in Anchorage.

1. Design Criteria for Swales and Filter Strips

Design variables for swales and filter strips are summarized in Table 2-9. Flow is open channel, as calculated by Manning's equation.

2. Vegetation

Select plants based on their structural, aesthetic, nutrient needs, and uptake characteristics in order to provide pleasing visual characteristics, optimum structure, and contaminant removal potential. Consideration of potential contaminants shall include, but not be limited to: suspended solids, excess nutrients, non-soluble heavy metals, oil, grease, de-icing salts, and winter sanding particles. Maximize available light and warmth to encourage vigorous plant growth for the longest time possible. A southern exposure with little shade is preferred.

Three zones for plants have been established to help in the appropriate selection of plants for creating vegetated swales with more than one plant type, as indicated in Figure 2-8, which gives the technical parameters for proper plant selection. The Turf Grass Zone is shown as the lowest zone in the graphic, but if the vegetated swale will remain saturated or is within close proximity to groundwater, plants for the Reed Zone will serve most efficiently in the basin of the swale. Plants native to the Anchorage area have been cross-referenced for their applicability within these zones and are found in Table 2-10.

When specifying appropriate seed mixes for areas to be managed as turf, both the amount of maintenance an area will receive (i.e., mowing), as well as the desired aesthetic appeal shall be considered. These variables are directly related. Table 2-11 describes both the maintenance and aesthetic attributes of respective seed mixes. Turf areas shall be watered 1/2 inch per day during the first 14 days after seeding.

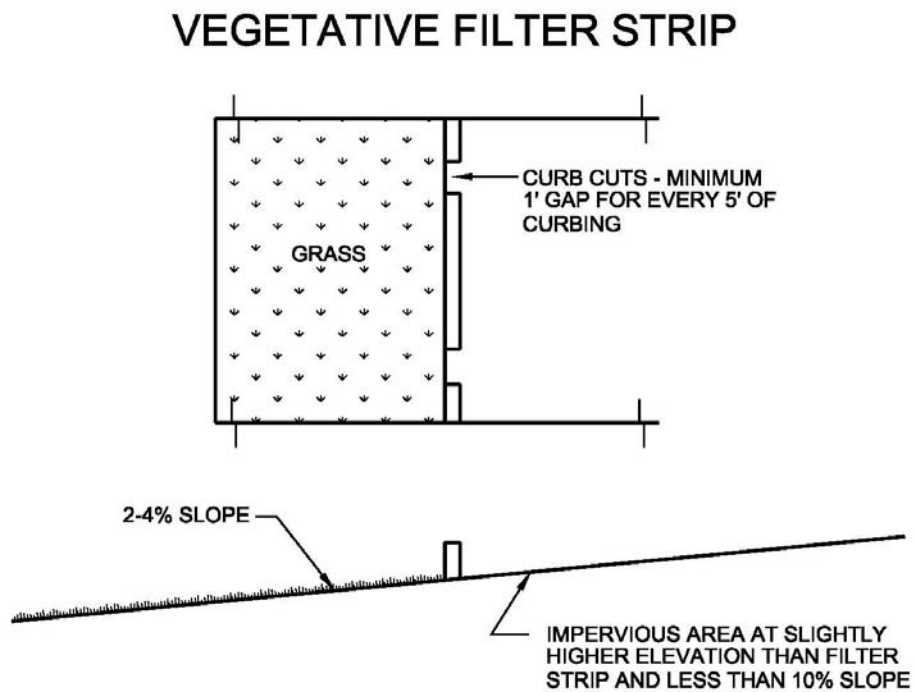
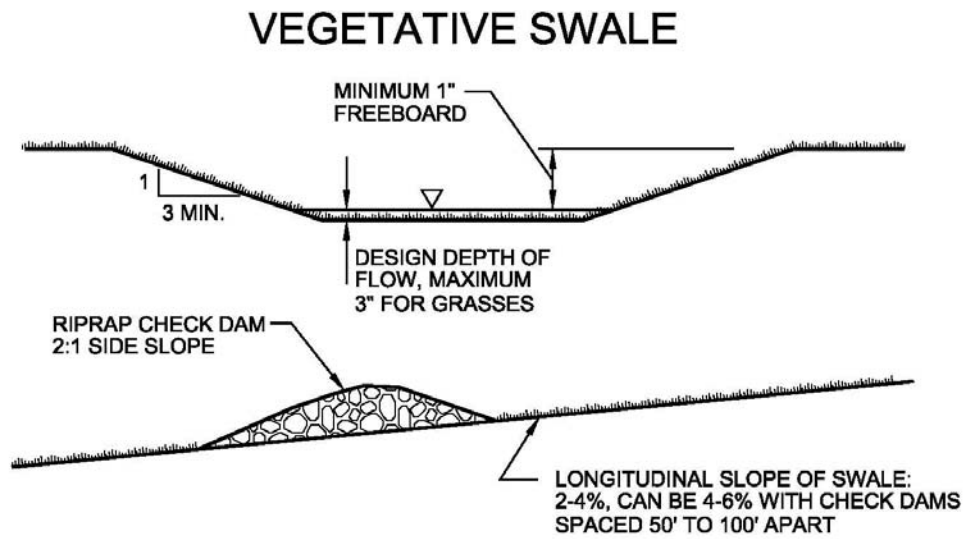


FIGURE 2-7 VEGETATIVE SWALE AND FILTER STRIP

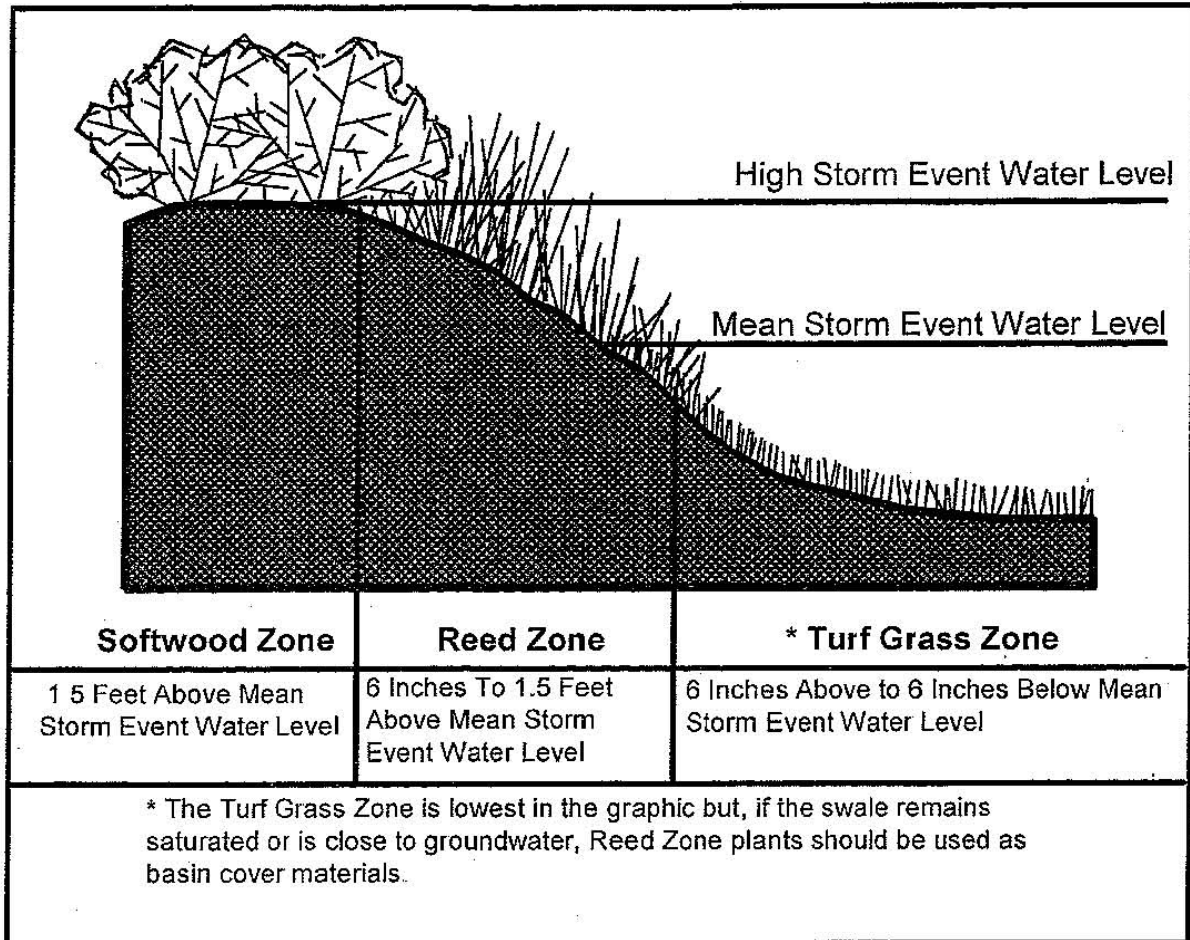


FIGURE 2-8 PLANTING ZONES

TABLE 2-9 BIOFILTRATION DESIGN CRITERIA

Criteria	Swale	Filter Strip
Width	2 foot minimum	No greater than the width for which uniform flow distribution is possible
Length ^a	sufficient to provide hydraulic residence time at design velocity	No limit
Depth of Design Flow	Grass: maximum 3 inches ($< 1/3$ height of unmowed grass, $< 1/2$ height of mowed grass) > 2 inches below normal height of wetland plants	≤ 0.5 inch
Velocity ^b	0.9 ft/s maximum	0.9 ft/s maximum
Longitudinal Slope ^c	2 to 4 percent	2 to 4 percent
Side Slope	No steeper than 3 horizontal to 1 vertical	Not applicable
Design Flow Rate	Peak flow rate for water quality protection (Table 2-1)	No greater than uniform flow will allow
Manning's "n"	0.20 for mowed grass 0.24 for untended grass	0.20 for mowed grass 0.24 for untended grass
Hydraulic Residence Time	9 minutes optimal 5 minutes minimum	9 minutes optimal 5 minutes minimum
<p>Notes:</p> <p>(a) A wide-radius curved path may be used to gain length where land is not adequate for a linear swale, but sharp bends must be avoided. In order to provide adequate treatment, 100 feet is recommended as a minimum length.</p> <p>(b) During a study in western Washington, the grass began bending from a vertical position when the flow velocity increased above 0.9 fps.</p> <p>(c) If slope is 1 to 2 percent, consider installing an underdrain with perforated pipe or, if base flow is adequate and uninterrupted, establish wetland species. With an underdrain, use topsoil with a relatively large proportion of sand. Place a 6-inch minimum diameter perforated pipe in a trench filled with 5/8-inch minus round rocks and lined with Mirafi 140 NS or equivalent filter fabric. The pipe shall be at least 12 inches below the biofilter bed. If slope is between 4 and 6 percent, add check dams at 50- to 100-foot intervals. If the slope is greater than 6 percent, traverse the grade to reduce the slope of any segment to below 4 percent, or to below 6 percent with check dams.</p>		

3. Substrate.

- a) If there is a possibility of groundwater contamination, a 12-inch bentonite clay or other impermeable liner is required unless any one of the following conditions is demonstrated:

- i. A horizontally continuous, 12-inch or thicker layer of underlying soils in one of the following frost categories: F3c, F4c, and F4d (per DCM Table 1-10) is present between the surface and the groundwater table.
- ii. The area is down gradient of any groundwater recharge or withdrawal area.

- iii. Groundwater quality is not likely to be impaired for use.

- iv. Other demonstrated mitigating circumstances are present at the site.

- b) A 12-inch layer of topsoil is recommended for all vegetated swales, consisting of:

- i. Organic (excluding animal waste) 5 to 15 percent by weight
- ii. Silt 40 to 50 percent by weight passing the #200 sieve
- iii. Sand 40 to 50 percent by weight

TABLE 2-10 VEGETATION SUITABLE FOR BIOFILTRATION IN ANCHORAGE		
Common Name	Scientific Name	Natural Indicator
<u>Shrubs and Woody Plants</u> (Softwood and Reed Zones)		
Red Twig Osier Dogwood	<i>Cornus stolonifera</i>	FAC
Pacific Willow	<i>Salix lasiandra</i>	FACW
Scouler Willow	<i>Salix scoulerana</i>	FAC
<u>Grass-Likes</u> (Reed and Turf Grass Zones)		
Water Sedge	<i>Carex aquatilis</i>	OBL
Least Spikerush	<i>Eleocharis acicularis</i>	OBL
Creeping Spikerush	<i>Eleocharis palustris</i>	OBL
Square-Stemmed Spike Rush	<i>Eleocharis quadangulata</i>	NI
Fowl Manna Grass	<i>Glyceria striata</i>	OBL
Soft Rush	<i>Juncus effuses</i>	OBL
Three Stamen Rush	<i>Juncus ensifolius</i>	FACW
Slender Rush	<i>Juncus tenuis</i>	FACW
Hard-Stemmed Bullrush	<i>Scirpus acutus</i>	FAC
Olney's Bulrush	<i>Scirpus americanus</i>	OBL
Small Fruit Bulrush	<i>Scirpus microcarpus</i>	OBL
Softstem Bulrush	<i>Scirpus validus</i>	OBL
<u>Grasses</u> (Turf Grass and Reed Zones)		
Wheatgrass	<i>Agropyron macrourum</i>	FAC
Redtop	<i>Agrostis alba</i>	OBL
Egan Sloughgrass	<i>Beckmannia syzigahne</i>	FAC
Red Fescue	<i>Festuca rubra</i>	FAC
Reed Meadowgrass	<i>Glyceria maxima</i>	OBL
Three Stamen Rush	<i>Juncus ensifolius</i>	FACW
Slender Rush	<i>Juncus tenuis</i>	FACW
Reed Canary Grass	<i>Phalaris arundinacea</i>	OBL
Small Fruit Bulrush	<i>Scirpus microcarpus</i>	OBL

TABLE 2-10 VEGETATION SUITABLE FOR BIOFILTRATION IN ANCHORAGE (Cont'd)		
Forbs (All Zones)		
Common Name	Scientific Name	Natural Indicator
Watershield	<i>Brasenia schreberi</i>	OBL
Common Hornwort	<i>Ceratophyllum demersum</i>	OBL
Lesser Duckweed	<i>Lemna minor</i>	OBL
Pigmy Water Lily	<i>Nymphaea tetragona</i>	OBL
Yellow Cow Lily	<i>Nymphaea tuteam</i>	OBL
Water Parsley	<i>Oenanthe sarmentosa</i>	OBL
Leafy Pondweed	<i>Potamogeton foliosus</i>	OBL
Grassy Pondweed	<i>Potamogeton gramineus</i>	OBL
Floating Leaf Pondweed	<i>Potamogeton natans</i>	OBL
Sago Pondweed	<i>Potamogeton pectinatus</i>	OBL
Small Pondweed	<i>Potamogeton pusillus</i>	OBL
Flat-Stemmed Pondweed	<i>Potamogeton zosteriformis</i>	OBL
Floating Leaf Pondleaf	<i>Potamogeton gramineus</i>	OBL
Floating- Leaf Pondweed	<i>Potamogeton natans</i>	OBL
Widgeon-Grass	<i>Ruppia maritima</i>	OBL
Small Burreed	<i>Scirpus minimum</i>	OBL
Seaside Arrow Grass	<i>Triglochin maritimum</i>	OBL
Broad-Leaf Cattail	<i>Typha latifolia</i>	OBL
Horned Pondweed	<i>Zannichellia palustris</i>	OBL
Eel Grass	<i>Zostera marina</i>	OBL
<p>NOTE: Natural Indicator Categories</p> <ol style="list-style-type: none"> 1. Obligate Wetland (OBL): Occur almost always under natural conditions in wetlands. 2. Facultative Wetland (FACW): Usually occur in wetlands, but occasionally found in non-wetlands. 3. Facultative (FAC): Equally likely to occur in wetlands or non-wetlands. 4. Facultative Upland (FACU): Usually occur in non-wetlands, but occasionally found in wetlands. 5. No indicator (NI): Not an indicator species. 		

TABLE 2-11 SEED MIXTURE ATTRIBUTES

Type	Aesthetic Description	Maintenance Requirements	Seed Mixes
Schedule A:	Manicured Lawn	High Maintenance	5% Annual Rye Grass, 30% "Nugget" Kentucky Bluegrass, 25% "Merion" Kentucky Bluegrass 40% Boreal Fescue
Schedule C:	Naturalized Grasses	Low Maintenance	15% Red Fescue (Boreal Arctared), 30% Meadow Foxtail, 30% Timothy (Engmo), 25% Hard Fescue (Tournament, Scaldis)
Schedule D:	Manicured Lawn	Moderate Maintenance	10% Hard Fescue (Tournament, Scaldis) 10% Clover, 20% "Merion" Kentucky Bluegrass 30% Red Fescue, 30% "Nugget" Kentucky Bluegrass

NOTE: Application rate for all types is 5 lbs/1,000 sf.
(Reference: *Municipality of Anchorage Standard Specifications, Section 75.05 Article 5.2, 1994 edition*)

iv. Gravel less than 2 percent

4. Flow Bypass

- a) If the biofilter is preceded by a runoff quantity control device, a high-flow bypass will not be needed. Consider a bypass if the biofilter discharges directly to a sensitive receiving water without flow control, in order to maintain the vegetation in an appropriate condition to treat subsequent smaller storms. Otherwise, flows exceeding the water quality protection flow rate for the proposed developed conditions shall bypass the swale in a separate conveyance to the point of discharge. If a bypass is used, it shall consist of an inlet flow regulating device and a pipe or channel
- b) A mechanism shall also be provided at the bypass point to allow the swale to be manually taken off-line for maintenance and repair.

5. Inlet

Install a flow-spreading device to uniformly distribute flow in the swale inlet or across the width of the filter strip. Shallow weirs, stilling basins, riprap, and perforated pipes provide for energy dissipation at the inlet. For riprap, 6- to 9-inch rocks shall be fitted tightly together across the bed and for a distance of 5 to 10 feet down gradient. Provide access for sediment clean out of inlet structures.

Curb cuts in a parking lot and/or a shallow stone trench installed across the top of a filter strip can serve as a level spreader. If flow is to be introduced via curb cuts, place pavement slightly above the biofilter elevation. Curb cuts shall be at least 12 inches wide to prevent clogging. Curbing for impervious areas tributary to filter strips shall be designed with a 1-foot gap for every 5 feet of curbing. An emergency bypass shall be provided for icing. The transverse

slope of impervious areas tributary to filter strips shall be level, and the impervious area cross slope shall not exceed 10 percent (Figure 2-7). Make provisions to avoid flow bypassing the filter strip.

6. Check Dam

If the longitudinal slope is between 4 and 6 percent, add check dams every 50 to 100 feet along the length of the swale, starting 20 feet downstream from the inflow point. The check dam may be constructed of:

- a) Riprap with two horizontal to one (2:1) vertical side slopes (Figure 2-7).
- b) Plants suitable for Reed and Softwood zone plantings. Plantings 2 to 3 feet in width can adequately slow velocity of water while naturalizing the appearance of the vegetated swale.

7. Maintenance Access

Access for maintenance is required along all constructed channels. Access to biofilters is necessary so that the property owner can inspect, monitor, and maintain the facility. Required access widths vary with channel top width as shown in Table 2-12.

Top Width of Swale (W)	Access Width
$W \leq 10'$	W + 10' on one side
$10' < W < 30'$	W + 15' on one side
$30' < W$	W + 15' on both sides

2.17 D Design Example

1. Initial Design

- a) Determine design flow. Estimate the runoff flow rate based on the water quality treatment criteria in Table 2-1.
- b) Establish the slope following the guidelines in Table 2-9.

- c) Select a vegetation cover suitable to the site from Tables 2-10 or 2-11.
- d) Establish the height of vegetation and determine the design depth of flow. If grass will be mowed regularly, the depth of flow shall be less than one-half of the grass height. If grass is not mowed, the depth of flow shall be less than one-third of the grass height. Taller vegetation is desired because maximizing height promotes biofiltration and allows greater flow depths and reduces the width necessary to obtain adequate capacity.
- e) Select a value of Manning's "n" from Table 2-5.
- f) Select a cross-section shape. Normally, swales are designed as trapezoidal structures (Figure 2-9). A parabolic shape best resists erosion, but is hard to construct. However, over time a trapezoidal swale may develop a parabolic shape. For the trapezoidal shape, the side slope (Z) must be greater than or equal to 3.
- g) Determine the channel width.
Manning's equation is:

$$Q = (1.49/n) AR^{0.67} s^{0.5}$$

where: Q = Design flow rate (ft³/s, cfs)
 n = Manning's roughness coefficient
 A = Cross-sectional area (ft²) (see Figure 2-9)
 R = Hydraulic radius (ft) = A/wetted perimeter (see Figure 2-9)
 s = Longitudinal slope as a ratio of vertical rise over horizontal run (ft/ft)

A value for the width based on rewriting Manning's Equation can be obtained but the equations are difficult to solve manually. The following assumptions can simplify the process. Since the top width (T) is much greater than the depth (y) and Z² (see Figure 2-9) is much greater than 1, certain terms are

negligible, so the following approximations for hydraulic radius may be used:

$$\begin{aligned} \text{Trapezoidal: } R &= y \\ \text{Parabolic: } R &= 0.67 y \\ \text{Filter Strip: } R &= y \end{aligned}$$

Using these approximations and solving for the width results in the following equations:

$$\text{Trapezoidal: } b = \frac{Qn}{1.49 y^{1.67} s^{0.5}} - Zy^2$$

$$\text{Parabolic: } T = \frac{Qn}{0.76 y^{1.67} s^{0.5}}$$

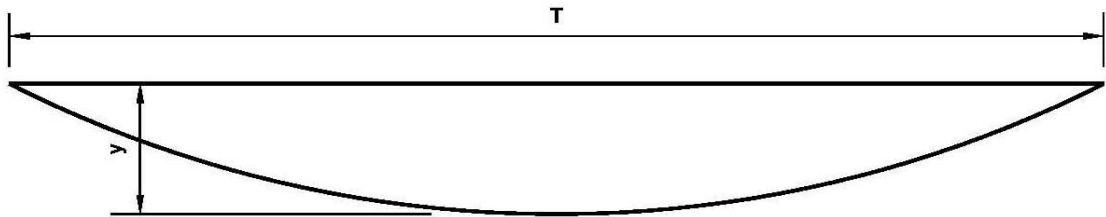
$$\text{Filter Strip: } T = \frac{Qn}{1.49 y^{1.67} s^{0.5}}$$

If b for a swale is less than 2 feet, which is the minimum allowable width (Table 2-9), set b equal to 2 feet and continue.

- h) Compute the cross-sectional area (Figure 2-9).
- i) Compute the flow velocity:
 $V = Q/A$
 If $V > 0.9$ fps, modify swale design and recalculate.
- j) Compute the swale length based on required detention time:
 $L = V*t$, where: t = 9 minutes
- k) If the result is a length greater than the space permits, check to see if Q can be reduced, or if the width or flow depth can be increased. If, after these possibilities have been exhausted, the calculated length is still too long, the detention time can be reduced, but to no less than 5 minutes.
2. Check design for channel stability and capacity

CHANNEL GEOMETRY

PARABOLIC SHAPE

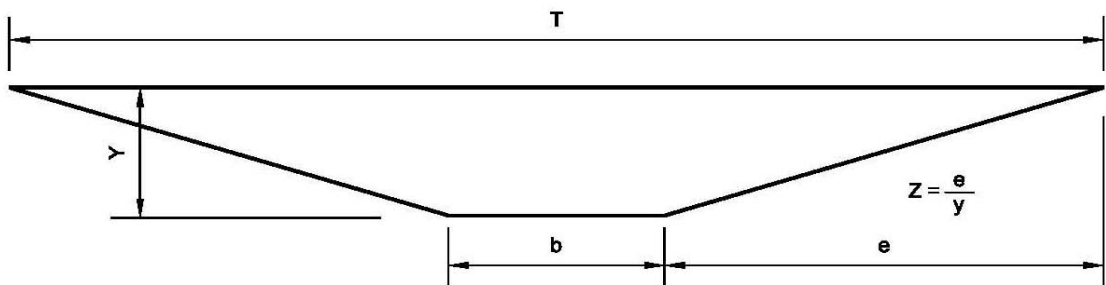


$$\text{Cross-Sectional Area (A)} = \frac{2}{3} Ty$$

$$\text{Top Width (T)} = \frac{1.5A}{y}$$

$$\text{Hydraulic Radius (R)} = \frac{T^2 y}{1.5T^2 + 4y^2}$$

TRAPEZOIDAL SHAPE



$$\text{Cross-Sectional Area (A)} = by + Zy^2$$

$$\text{Top Width (T)} = b + 2yz$$

$$\text{Hydraulic Radius (R)} = \frac{by + Zy^2}{b + 2y\sqrt{Z^2 + 1}}$$

FIGURE 2-9 SWALE GEOMETRY

TABLE 2-13 GUIDE FOR SELECTING DEGREE OF FLOW RETARDANCE				
Normal Grass Height (inches)	Very Dense Vegetative Cover		Fairly Dense Vegetative Cover	
	Degree of Retardance		Degree of Retardance	
>25	Very High	A	High	B
11-25	High	B	Moderate	C
6-10	Moderate	C	Low	D
2-6	Low	D	Low	D
<2	Very Low	E	Very Low	E

- a) Select the highest expected flow and least vegetation cover and height. Unless runoff from events larger than the water quality protection flow rate will bypass the biofilter, perform the stability check for the 100-year, 24-hour storm.
- b) Estimate the degree of flow retardance from Table 2-13 based on normal grass height and density of vegetative cover. When uncertain, be conservative by selecting a relatively low degree (higher letter) of flow retardance.
- c) Set the maximum permissible velocity (V_{max}) for erosion prevention at 4 fps.
- d) Select a trial Manning's "n." The minimum value for poor vegetation cover and low height is 0.033 (which is possible if the grass is knocked down from high flow). A good initial choice under these conditions is 0.04.
- e) Obtain a first approximation for the product of velocity and hydraulic radius (VR_{approx}), using the graph in Figure 2-10.
- f) Compute the hydraulic radius for the maximum permissible velocity:

$$R = VR / V_{max}$$

- g) Solve for the actual product of velocity and hydraulic radius and compare to the first approximation:

$$VR = 1.49/n R^{1.67} s^{0.5}$$

If they do not agree within 5 percent, select a new trial Manning's "n" and recalculate. However, if $n < 0.033$ is needed for agreement, set $n = 0.033$, repeat this calculation for the product of velocity and hydraulic radius (VR), and proceed with step h.

- h) Compute the actual velocity for the final design conditions:

$$V = VR_{approx}/R$$

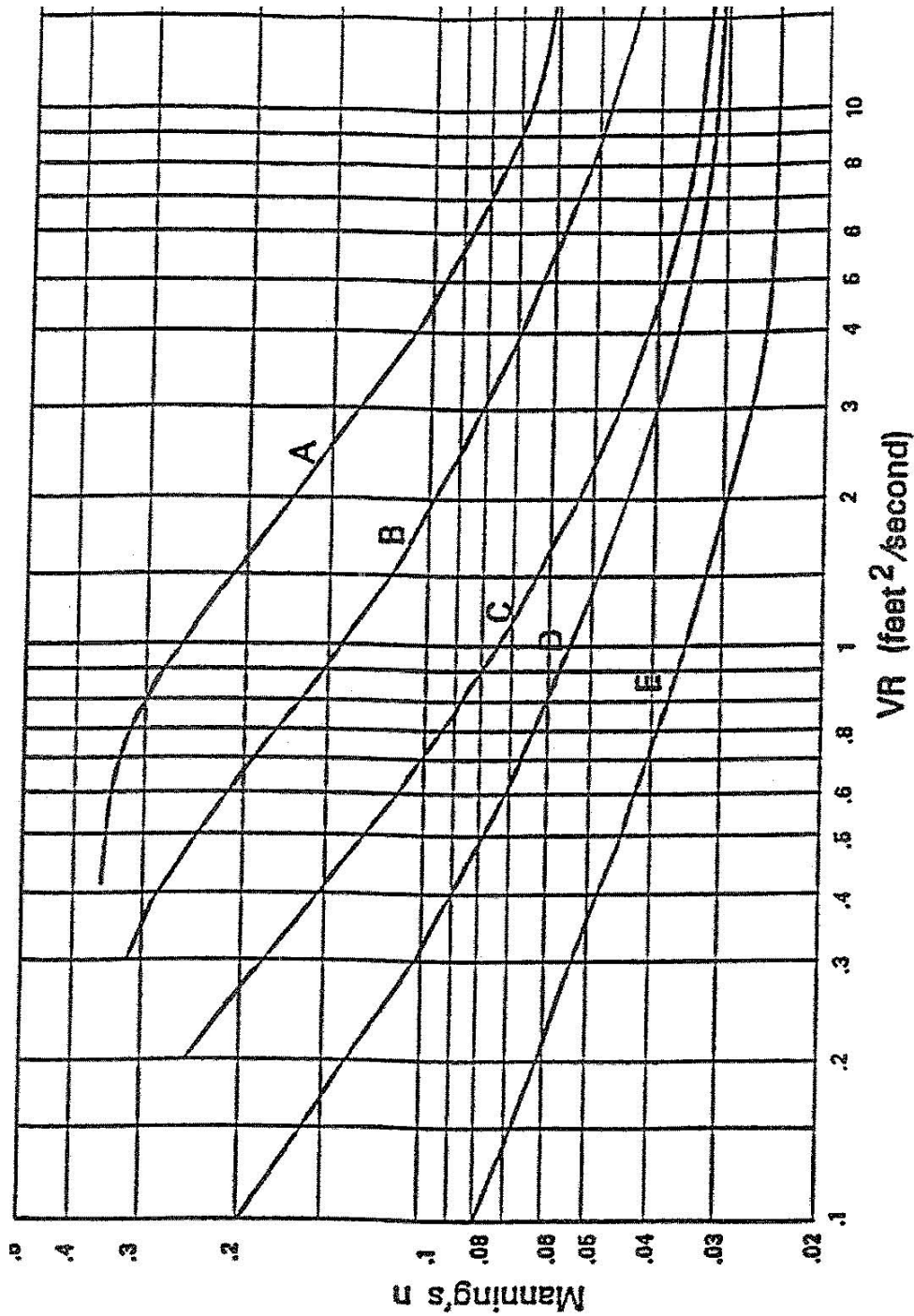
Check that $V < V_{max}$ from step c.

- i) Compute the required cross-sectional area for stability:

$$A_{stability} = Q/V$$

Compare to the design cross-sectional area. If $A_{stability} > A_{design}$, select new trial sizes for the width and depth of flow.

- j) Calculate the depth of flow at the stability check flow rate condition and compare to the design depth of flow from Step 1.d. Use the larger of the two and add 1 foot freeboard to obtain the total depth of the swale. Calculate the top width (T).



Note: VR is the product of velocity and hydraulic radius
 Source: Horner, 1993

The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A-E)

FIGURE 2-10 RELATIONSHIP OF MANNING'S "N" WITH "V*R" FOR VARIOUS DEGREES OF FLOW

- k) Check for flow capacity based on the stability check design storm and maximum vegetation height and cover. This check will ensure that capacity is adequate if the largest expected event coincides with the greatest retardance.
3. Review the general criteria and guidelines in section 2.17.C. and specify appropriate features.
- d) Party paying for the work
 - e) A method of record keeping detailing when work items were performed
2. No agreement requiring MOA maintenance will be accepted without approval and acceptance by the appropriate MOA maintenance division.
- END OF SECTION 2.17

2.17 E Maintenance Requirements

Maintenance is the responsibility of the landowner. The landowner shall maintain vigorous healthy vegetation and preserve the function of the vegetated channel. The landowner will enter into a maintenance agreement with the MOA that details the extent, timing, and scope of maintenance for the biofiltration structure(s).

1. The agreement, at a minimum, will include the following provisions:
 - a) Description of the work items to be performed, including but not limited to:
 - (1) Annual cleaning of the inlet structures following break-up, or more frequently if necessary
 - (2) Routine and post-storm event inspections
 - (3) Appropriate watering, pruning, mowing, vegetation harvesting
 - (4) Insect and pest control
 - (5) Fertilizer application
 - (6) Reseeding, plant replacement
 - (7) Sediment removal
 - (8) Trash removal and other necessary tasks
 - b) Schedule for the completion or frequency of each work item
 - c) Party performing the work

APPENDIX 2A
Drainage Studies Inventory

ANCHORAGE DRAINAGE STUDIES INVENTORY

Document Name	Mo/Year	Author	Study Boundaries	Document Location - Reference Number in WMS Library	Notes	Study Type
Storm Drainage Study – Spenard District	Mar-68	Tryck, Nyman, & Hayes	Spenard District	WMS - REP 439, REP 440	Rational Method/20 yr storm/ ILLUDAS	Drainage
Flood Plain Information- Campbell Creek	Jun-68	U.S. Army Corps of Engineers	Campbell Creek	HDR		Flood
Flood Plain Information- Chester Creek	Jun-68	U.S. Army Corps of Engineers	Chester Creek	HDR		Flood
Greater Anchorage Area Borough: Muldoon service Area – Storm Drainage Study	Sep-69	A.L. Renshaw-H.P. Nicholson	Muldoon Service Area	WMS - REP 115	Design of Open Channels	Drainage
Storm Drainage Study of Sand Lake Service Area	Jan-70	A.L. Renshaw-H.P. Nicholson		WMS - REP 378, REP 437	Rational Method / 6year storm	Drainage
Drainage and Open Space Concept Plan Chester and Campbell Creeks	Aug-71	Bomhoff, B. M.		WMS - REP 138		Other
Special Flood Hazard Report – Chester, Campbell, Fish, & Ship Creeks	Apr-72	U.S. Army Corps of Engineers	Chester, Campbell, Fish, & Ship Creeks	HDR	IRF 100 yr	Flood
Flood Plain Information – Meadow River	Apr-73	U.S. Army Corps of Engineers	Meadow Creek (Eagle River)	HDR		Flood
Campbell Heights Subdivision Drainage Study	May-73	Tork/Korman Engineers	Campbell Heights Subdivision	WMS - REP 121, REP 122, REP 446	Rational Method	Drainage
Flood Plain Information – Rabbit Creek	May-73	U.S. Army Corps of Engineers	Rabbit Creek	HDR		Flood
Flood Plain Information – Peters Creek	May-74	U.S. Army Corps of Engineers	Peters Creek	HDR	100 yr design	Flood
Spenard Flood Hazard Report - Chester Creek	Jan-75	U.S. Army Corps of Engineers	Chester Creek	HDR		Flood
MOA Interim Report on the Campbell Creek Drainage Basin	Jan-75	CH2MHill	Campbell Creek Drainage Basin	WMS - REP 29, REP 30, REP 442		Other
Special Flood Hazard Report - Campbell Creek	May-75	U.S. Army Corps of Engineers	Campbell Creek	HDR		Flood
Special Flood Hazard Report - Fish Creek	Jun-75	U.S. Army Corps of Engineers	Fish Creek	HDR	IRF 100 yr	Flood
Special Flood Hazard Report - Greater Anchorage Area - Ship Creek	Jul-75	U.S. Army Corps of Engineers	Ship Creek	WMS - TEC 181	500 yr flood	Flood
Storm Water Quality Management	Sep-78	Woodward-Clyde	Anchorage Bowl	WMS - TEC 18	HYDRA/ 2yr 6hr/ 10 & 100yr	Other

Document Name	Mo/Year	Author	Study Boundaries	Document Location - Reference Number in WMS Library	Notes	Study Type
		Consultants			3hr design storms	
Meadow Creek-Hydrologic and Hydraulics Design Study Report	May-79	MOA	Meadow Creek	HDR		Design Study Report
Sand Lake Area Drainage & Water Quality Management Study - Phase 1 Report	Aug-80	Quadra Engineering, Inc.	SE of Downtown Anchorage: N.-AIA, W.-Pt Campbell Military Reservation, S.-Turnagain Arm, E.-Minnesota	WMS - REP 170, REO 171, REP 443	SAM/ 5 & 10 yr design storms	Other
Sand Lake Drainage & water Quality Management Design Criteria	Jan-81	Quadra Engineering, Inc.	Sand Lake	WMS - REP 5	Rational/ ILLUDAS/ SAM	Other
South Glenn Highway -Storm Drainage improvements	Aug-81	OTT Water Engineers	NE Anchorage: N-Glenn, E-Muldoon, S-DeBarr, W-Boniface	WMS - REP 90	SAM/ 17 yr	Design Study Report
Sand Lake Drainage & Water Quality Management Study	Aug-81	Quadra Engineering, Inc.	SW Anchorage	HDR	Rational Method/ ILLUDAS/ SAM	Drainage
Hillside Wastewater Disposal Study	Feb-82	Arctic Environmental Engineers with CC Hewley & Associates	Hillside Area	WMS - TEC 178, TEC 179	Report on Data Collection/ Stability Analysis & Alternative Systems Evaluation - NOT MAPPED	Other
Drainage Study of First and Orca Area Rd Improvements	Mar-82	Robertson & Associates	First and Orca Intersection	WMS - REP 113	ILLUDAS/ Issard's overland flow/ grass abstraction/ Rational Method/ SCS Peak Discharge/ Unit Hydrograph	Drainage
Furrow Creek-Rabbit Creek Drainage Study Computer Output	Feb-83	URS Engineers		WMS - REP 202	STORM	Drainage
Furrow Creek-Rabbit Creek Drainage Study	Feb-83	URS Engineers	N-Klatt & O'Malley, E-Cange & Elmore, S-Rabbit Creek, W-wetlands and Turnagain Arm	WMS - REP 209, REP 210, REP 460	ILLUDAS/ Izzard's overland flow/ grass abstractions/ Rational Method/ SCS Peak Discharge/ Unit Hydrograph	Drainage
Little Campbell Creek Channel Improvements	May-83	CH2MHill	Little Campbell Creek	WMS - REP 61, REP 62, REP 412		Other
Chester Creek Improvements Study, Chester Creek Improvements: Eastchester to Muldoon.	Aug-83	Entech Engineers, Inc.		WMS - REP 108		Other

Document Name	Mo/Year	Author	Study Boundaries	Document Location - Reference Number in WMS Library	Notes	Study Type
Little Campbell Creek Drainage Study	Oct-83	OTT Water Engineers	S Anchorage: E of New Seward, S of Dowling, W of Abbott, N of O'Malley	WMS - REP 164, REP 165	SAM/ 10 & 100 yr returns	Drainage
South Anchorage Drainage Master Plan	Jan-84	CH2MHill	S. Anchorage - lower portion of Campbell Creek basin	WMS - REP 52, REP 275, REP 438	HEC-1 Model/ Modified Puls Model/ 10 & 100 yr storm events	Drainage
Engineering Report on Highway Crossings: South Anchorage Storm Drainage	Feb-84	CRW Engineering Group	S. Anchorage: Crossings at New Seward Hwy., Old Seward Hwy, and Minnesota Dr	WMS - REP 13, REP 14		other
Lake Otis Drainage Study	Feb-84	DOWL Engineers	Lake Otis: O'Malley to Abbott	WMS - REP 119, REP 120	ILLUDAS/ 10 yr 1 hr storm	Drainage
Drainage Analysis - South Creek Phase 1 Potter Creek	Apr-84	Centrum Engineering	South Creek-Potter Creek	HDR	1984 Municipal Design Criteria/ 5 yr 60 min return/ ILLUDAS Model	Drainage
Drainage of Storm runoff to Bayshore Pond	Sep-84	DOWL Engineers	Bayshore Pond	WMS - REP 107	ILLUDAS	Drainage
Chester Creek Restoration at University Lake Alternatives Analysis	Nov-84	CH2M HILL		WMS - REP 152, REP 352		Other
Decisional Document for Old Seward Highway/97th Avenue Storm Drain (DA1)	Mar-85	CRW Engineering Group		WMS - REP 96		Drainage
Lower Chester Creek Improvement Study. I. Datum Engineering and Surveying.	Aug-85	Datum Engineering and Surveying, Inc.		WMS - REP 109		Other
Little Rabbit Creek and Potter Valley Stormwater Drainage Plan	Aug-85	Ott Water Engineers, I.		WMS - REP 435		Drainage
Little Rabbit Creek - Potter Valley Stormwater Drainage Plan	Aug-85	OTT Water Engineers	Little Rabbit Creek Drainage Basin	WMS - REP 168, REP 169	SAM/ 10 yr & 100 yr storm events	Drainage
Preliminary Plan for the Eagle River Drainage Study, 84-E-51	Oct-85	MacInnis Consulting Services		WMS - REP 352		Other
Klatt Bog Storm Drain Trunk	Oct-85	Bacon, T.		WMS - REP 389, REP 390		Drainage
Fire Creek flood Study Between Lower Fire Lake and New Glenn Hwy	Jan-86	Alaska Testlab	Fire Creek: Lower Fire Lake & New Glenn	HDR	HEC-2/ 100 yr Flood Discharge	Flood

Document Name	Mo/Year	Author	Study Boundaries	Document Location - Reference Number in WMS Library	Notes	Study Type
Knik Heights Subdivision Drainage Evaluation	Apr-86	R&M Consultants	Knik Heights Subdivision	WMS - REP 57, REP 76		Other
Design Study Report: Dimond Blvd Improvements - New Seward highway to E. 88th Ave	Jul-86	CRW Engineering Group	Dimond Blvd: New Seward Hwy to E 88th Ave	HDR		Design Study Report
Final Plan for the Eagle River Drainage Study 84-E-51	Sep-86	MacInnes, J.		WMS - REP 361		Drainage
Eagle River Drainage Study	Sep-86	MacInnes Consulting Services	Eagle River	WMS - REP 184	SAM/ 10 yr, 9hr event	Drainage
Furrow Creek Channel Drainage Evaluation	Sep-86	R&M Consultants	Furrow Creek Channel	WMS - REP 73, REP 74		Other
Paradise Valley Drainage Investigation & Cost Estimation	Dec-86	R&M Consultants	Paradise Valley Subdivision	WMS - REP 22		Other
AWWU - Middle Fish Creek Trunk R&R Project	Apr-87	James M. Montgomery	Fish Creek (middle section)	WMS - REP 31, REP 32		Other
Study and Report and Decisional Document Municipality of Anchorage Stream Restoration Project South Fork, Little Campbell Creek Hook Drive to Hartzell Road	Jun-87	Tryck Nyman & Hayes		WMS - REP 100		Other
Fish Creek Water Quality Improvements at Northwood Park, Study and Report, Volume II: Illudas Data Files	Jun-87	MacInnis, J.		WMS - REP 158	ILLUDAS	Other
Fish Creek Water Quality Improvements at Northwood Park Study and Report, Volume I	Jun-87	MacInnis, J.		WMS - REP 277, REP 436		Other
Fish Creek Water Quality Improvements at Northwood Park	Jun-87	R&M Consultants	Northwood Park	WMS - REP 157 & 158	ILLUDAS/ 2, 10, & 100 yr storm events	Other
E. 82nd Ave./ Hartzell Street R.I.D. Storm Drain Trunk Study	Aug-87	CRW Engineering Group	E. 82nd Ave./ Hartzell St.	WMS - REP 118	ILLUDAS/ 10 yr & 2 yr 6hr storm/ SAM	Other
Chester Creek Water Quality Study & Improvements Investigation	Nov-87	Corwin & Associates Inc	Chester Creek: Arctic Blvd to Westchester Lagoon	WMS - REP 98, REP 99, REP 445		Other
Old Seward Hwy: Huffman Rd to Dowling Rd Design Study Report	Nov-87	DOT&PF	Old Seward Highway: Huffman Rd to Dowling Rd	HDR	100 yr flood	Design Study Report

Document Name	Mo/Year	Author	Study Boundaries	Document Location - Reference Number in WMS Library	Notes	Study Type
Anchorage Rainfall/Runoff Study - South Anchorage Hydrology Study	Feb-88	OTT Water Engineers	Study Basins: Kings Row, W. 80th, N Arctic, Campbell Lake, E 56th & A, Orbit, & College Village	WMS - REP 94, REP 95	ILLUDAS	Other
64th Ave. Drain System Study Report	Apr-88	R&M Consultants	64th Ave.: Dowling Rd. on N., 68th Ave. on S., Lake Otis on E., New Seward on W.	WMS - REP 186	ILLUDAS/ 10 yr 3 hr storm	Other
64th Avenue Storm Drain Results of Additional ILLUDAS Analysis (66th & O'Brien)	Aug-88	Coffin, J. H.		WMS - REP 226		Drainage
E. 88th Avenue/Hartzell Road Storm Drain Sedimentation Basin Design Report Final	Oct-88	CRW Engineering Group		WMS - REP 103, REP 104, REP 105		Other
Revised Design Study Report for Pleasant Valley/Kobuk Storm Drain DPW87-57.	Oct-88	Hamm, W.		WMS - REP 161		Drainage
Design Study Report for O'Brien Area Drainage Study DPW87-03.	Nov-88	Hamm, W.		WMS - REP 162		Drainage
Connors-Strawberry Bog Master Plan Draft	Jan-89	Municipality of Anchorage, DED&P. and Anchorage Audobon Society		WMS - REP 387, REP 388		Other
North Fork Little Campbell Creek Old Seward Highway to New Seward Highway Specifications and Contract Documents	May-89	Municipality of Anchorage, DPW		WMS - REP 213		Other
Wisconsin Street & Drainage Study Appendices	Aug-89	Tryck Nyman & Hayes		WMS - REP 147, REP 324		Drainage
Fish Creek Hydraulic Analysis Arctic Boulevard to McRae Road	Apr-90	Ott Engineering, I.		WMS - REP 47, REP 48		Other
Fish Creek Channelization Improvements South of Spenard Road: HEC-2 Modeling	Jun-90	Billman, D.		WMS - REP 146		Other
Pleasant Valley/Kobuk Storm Drain, DPW 87-57 Design Study Supplement Open Ditch Consideration	Aug-90	DOWL Engineers		WMS - REP 167		Drainage
Lake Otis Parkway Road Improvements Phase V O'Malley	Aug-90	DOWL Engineers		WMS - REP 81, REP 82		Drainage

Document Name	Mo/Year	Author	Study Boundaries	Document Location - Reference Number in WMS Library	Notes	Study Type
Road to Chinook Avenue Drainage Study						
Fish Creek Channelization Improvements South of Spenard Road (Maggie's Trailer Court) Phase I Specifications and Contract Documents	May-91	Municipality of Anchorage, DPW		WMS - REP 143		Other
Huffman Road Pre-Design Study Hydrology Report	Aug-91	James M. Montgomery Consulting Engineers		WMS - REP 116, REP 117		Other
Hillstrand Pond Rehabilitation Study Project 87-8	Nov-91	CH2M HILL		WMS - REP 84		Other
Chester Creek at Merrill Field Design Study	Dec-91	CH2M HILL, Ott Water Engineers, et al.		WMS - REP 86		Other
Fish Creek 91-4 Conceptual Design Report	Mar-92	HDR Engineering, I.		WMS - REP 59		Other
Little Campbell Creek 91-6 Flood Study	Mar-92	HDR Engineering, Inc.	Little Campbell Creek	HDR	Channel Hydraulic Analysis 10, 50, 100, and 500 year flood profiles/ Original FEMA Hec-2 Results	Flood
Airport Water Quality Study for Anchorage International Airport	Jun-92	HDR Engineering, Inc.	Anchorage International Airport	WMS - TEC 350, TEC 392	SYNOP	Other
Revised ILLUDAS Analysis for Chester Creek at Merrill Field	Jul-92	HDR Engineering, Inc.	Chester Creek at Merrill Field	WMS - REP 93	ILLUDAS	Other
Chester Creek 92-16 Draft	Feb-93	HDR Engineering, Inc.	Chester Creek	WMS - REP 302, REP 224	FEMA 10 & 100 yr design	Concept Design
Airport Drainage Plan for Anchorage International Airport	May-93	HDR Engineering, Inc.	Anchorage International Airport	WMS - TEC 349, TEC 383	10 & 100 yr 3 hr Design Hyetograph/ ILLUDAS/ Appendices	Drainage
Hood Creek Drainage Study	Jun-93	Montgomery Watson	Hood Creek (downstream Lake Hood)	WMS - REP 64		Drainage
Government Hill Snow Disposal Site Improvements - Design Study Report	Nov-93	CRW Engineering Group	Government Hill	WMS - REP 258	Water Sample Analysis: EPA 600 methods for Chemical Analysis of Water and Wastewater	Design Study Report
Roadway & Drainage Improvements Study - Schroeder Subdivision	Jan-94	VEI Consultants	Eagle River	WMS - REP 111	ILLUDAS	Other
Storm Sewer System Evaluation - Anchorage Railroad Yard (Phase 1)	Mar-94	CRW Engineering Group	Anchorage Railroad Yard	WMS - REP 7		Other

Document Name	Mo/Year	Author	Study Boundaries	Document Location - Reference Number in WMS Library	Notes	Study Type
48th Ave./ Crossroads Business Park Drainage Design Study (Draft)	Apr-94	CH2MHill	48th Ave. & Crossroads Business Park	WMS - REP 215	ILLUDAS/ 2 & 10 yr storm events	Design Study Report
MOA-DPW 97th Ave. & C St. Sedimentation Basin - Design Study (Vol.1)	Jul-94	Montgomery Watson	97th Ave. & C St. Sedimentation Basin	WMS - REP 107	ILLUDAS/ 2yr 6hr event/100 & 10 yr 3hr event/ Appendices (Vol. 2)	Drainage
Storm Drainage Study for Chester Creek	Aug-96	A.L. Renshaw-H.P. Nicholson	Chester Creek	WMS - REP 18, REP 19, REP 441	Rational Method / 6year storm	Drainage
Glacier-Winner Creek Access Corridor Study - Draft Preliminary Routing Report	Nov-96	DOWL Engineers	Glacier-Winner Creek	HDR		Other
97th Avenue Storm Drain - Phase III C St to Old Seward Highway (Draft)	Mar-97	HDR Alaska, Inc.	97th Ave: C St to Old Seward	HDR	ILLUDAS/ SWMM/ HEC-RAS	Design Study Report
King Street/ 100th Ave. Upgrade: Dimond Blvd to Old Seward Hwy	Mar-97	USKH	King St/ 100th Ave: Dimond Blvd to Old Seward Hwy	WMS - REP 41		Design Study Report
97th Avenue Storm Drain Phase III	Jun-97	HDR Engineering, Inc.	97th Avenue: 100th Avenue to Old Seward to C Street	WMS - REP 9	ILLUDAS/ SWMM/ HEC-RAS/ 10 yr 3 hr event	Design Study Report
Baxter Road/ Beaver Place Improvements Design Study Report	Sep-97	Lounsbury & Associates Inc	Baxter Road/ Beaver Place	WMS - REP 6		Design Study Report
MOA-Foxridge Subdivision Road Improvement District - Final Design Study	Jan-98	R&M Consultants	Foxridge Subdivision: C St & Foxridge Way	WMS - REP 208	ILLUDAS/ 10 yr storm	Design Study Report
Design Study Report: Old Seward Hwy/ International Airport Road Drainage Analysis	May-98	CRW Engineering Group	Tudor on N, Int'l on S, Cordova on W, Old Seward on E	WMS - REP 328	ILLUDAS/ 10 & 100 yr flow rates	Design Study Report
Dimond Water Quality Improvements	Jun-98	HDR Engineering, Inc.	S Anchorage - Dimond Blvd, New Seward, 100th Ave, future extension of C Street	HDR	Zoned for residential, commercial, industrial uses/ ILLUDAS Model	Design Study Report
Chester Creek Wetland Hydrologic Analysis	Oct-98	HDR Alaska, Inc.	Chester Creek	WMS - REP 372, REP 373	SWMM/ August 1989 storm	Other
Indian Creek Flood Analysis	Nov-98	HDR Alaska, Inc.	Turnagain Arm, Indian Valley	HDR	HEC-RAS/ 100 yr event	Flood
Ship Creek Trail Design Study Report	Feb-99	USKH	Ship Creek Trail	WMS - REP 330		Design Study Report

Document Name	Mo/Year	Author	Study Boundaries	Document Location - Reference Number in WMS Library	Notes	Study Type
97th Avenue Storm Drain Phase IV: Old Seward Hwy to Lake Otis Parkway	Dec-99	HDR Alaska, Inc.	97th Avenue: Old Seward Hwy to Lake Otis Parkway	WMS - REP 313, REP 336	ILLUDAS/ Appendices	Design Study Report
Alyeska Creek Floodplain Study	Sep-00	HDR Alaska, Inc.	Girdwood-Alyeska Creek	HDR	HEC-RAS/ 100 yr flood/ Technical Study Data Notebook	Flood
MOA Watershed Mapping-Hillside Drainage Atlas	Jan-03	Watershed Management Services	Hillside Area	WMS - CD 3, CD 4, CD 6		Atlas
Downtown Area Storm Drain Outfall Reconstruction Design Study Report	Jan-02	CH2MHill	Downtown Anchorage	WMS - TEC 554	MOUSE Runoff Simulation/ 10 yr storm/ 100 yr runoff	Design Study Report
Fish Creek Improvements Phase IV	Jan-03	HDR Alaska, Inc.	Fish Creek Area & Basin	HDR	XPSWMM: SCS(HEC-1) & EPA/ 10 & 100 yr 3 hr design storm/ August 1989 storm	Design Study Report
Virgin Creek Floodplain Study	Aug-02	HDR Alaska, Inc.	Girdwood-Virgin Creek	HDR	COE HEC-RAS River analysis system/Technical Study Notebook	Flood
Little Rabbit Creek and Little Survival Creek Watersheds Drainage Plan and Technical Appendices	Dec-08	HDR Alaska Inc. and WHPacific, Inc.	Little Rabbit Creek and Little Survival Creek watersheds	WMS	HEC-HMS SCS 10Y24H analysis	Drainage

APPENDIX 2B

**Private Snow Disposal Sites
White Paper**

PRIVATE SNOW DISPOSAL SITES (On-Site Snow Storage Only)

DRAFT Operations Guidance

Prepared by Scott R Wheaton, MOA Watershed Management Services
Winter 2003

In the United States, about 100 million tons of sand and 10 million tons of salt are applied to roads annually, and similar practices are commonly used on private parking lots. When snow is removed from these surfaces during plowing and snow disposal operations, part of the sand and salt applications are also removed, along with additional pollutants released by traffic. When the snow melts and discharges from snow stored at the snow disposal sites, some of these pollutants are carried away with the melt water. In addition to chloride and sediment pollutants, the high salt content of the melt water can also increase mobilization of the more toxic form of certain metals. Unchecked, these pollutants can clog drainages, damage pavements, promote noxious growths, kill or stunt ornamental and natural vegetation, contaminate surface and ground water supplies, and reduce important and valuable fish stocks.

Fortunately, a growing understanding of snow melt water processes provides operators with valuable insight into practicable methods that can be used to economically control pollutants released from snow disposal sites, both public and private. In both Canada and the United States, much new research has been directed at street deicing and snow disposal practices and their effects on the environment. Locally the Municipality of Anchorage has also focused its attention on these issues and has made progress in understanding and improving winter street maintenance and snow disposal practices. Private (on-site snow storage only) and commercial (off-site snow storage) snow disposal operations can benefit from these hard-won lessons. “Best management practices” taken as a whole are not only an optimal way to prevent environmental impacts but are also often the most beneficial approach from a business cost perspective as well. The following discussion summarizes best management practices for private (on-site snow storage only) snow disposal.

Municipal operators have discovered that the most cost-effective “best practices” include approaches that are applied at both the source of the plowed snow and at the disposal site. Like their municipal counterparts, operators responsible for plowing and on-site storage of snow from private parking lots and driveways are frequently responsible for application of winter surface treatments as well. Careful maintenance practices, including timing and types of salt and sand applications, will greatly reduce the ultimate pollutant load hauled to the snow disposal site—and reduce operation costs as well. After all, if you are plowing up salt and sand (that you have applied at great expense), it’s no longer helping improve traction across your client’s driveway or parking lot. Similarly, control of discharges of sediment and pollutants from a private snow storage site to the Municipal storm drain system is the responsibility of the site owner and operator. Up-front and practicable control of these pollutants, then, saves money and avoids fines and costly cleanup.

Though little specific information is available for privately operated on-site snow disposal operations, the pollutant sources and physical processes are similar to those that have become well documented for Municipal and commercial sites. Operational guidance for private sites can be generally based on the current understanding of the pollutants and processes observed at these larger sites. Private operators will have to adjust actual practices to reflect the specific characteristics of different operational needs, snow sources and disposal sites, but the following practices are generally applicable.

- **Use Best Deicing Materials**

Buying the cheapest product is not always the least expensive practice, as each of us knows from experience in everyday life. The same is true in winter maintenance of parking lots and driveways. More is not always better and the cheapest is not always the least expensive: applying “smart” is the key. Consider the following uses:

Use magnesium chloride for small parking lots and sidewalks

Though it costs more, a molecule of magnesium chloride ($MgCl_2$) has two chloride ions and provides twice as much chloride as a molecule of sodium chloride ($NaCl$). Magnesium chloride is also effective at lower temperatures than sodium chloride. It is far less damaging to lawns and ornamentals (because magnesium replaces the sodium) and is less corrosive than sodium chloride, reducing capital and maintenance costs of landscaping, pavement and equipment. Conversely, the sodium ion (Na) in sodium chloride can not only kill landscape vegetation outright, but can also permanently ruin the soil.

Use coarser aggregate for “sanding”

Use of a coarser aggregate to improve winter traction on parking lots and sidewalks will reduce loss of effectiveness due to burial with continued snowfall or displacement by traffic (thus reducing need for re-application) and requires smaller additions of “antifreeze” salt to keep it free-flowing during application. It is also easier to spread uniformly. All these factors can greatly reduce total sand volumes required to achieve a similar effect (the Municipality has reduced total sand use by almost half since changing to a coarser sand specification).

- **Use Best Winter Maintenance Practices**

When and how you apply deicers to remove or loosen ice from sidewalks and driveways makes a big difference in how well they work, how much you apply, and ultimately how much it costs you. Minimize those areas that you treat to keep snow-and ice-free, but for those areas that must be kept bare, consider these practices:

Lightly apply deicers just before or just as snow begins to fall

This will help prevent a bond forming between the ice and the surface, making it easier to later simply shovel or plow the ice from the surface.

Do not apply deicers during a snowfall

They may appear to work briefly immediately upon application, but with continued snowfall will rapidly dilute and refreeze to form an even icier surface, and will ultimately be removed during plowing.

Apply deicers to melt snow and ice at the end of the storm

Application will be most effective immediately *after you have removed the last of the new fallen snow*. This is because to work, salt deicers not only require some moisture (to dissolve the salt) but also some heat. The heat, which is what actually melts the snow (calcium chloride is an exception because it releases heat as it dissolves in an *exothermic* reaction), may come from warming ambient temperatures, the sun’s heat, or traffic. Applying deicers at the end of a snow storm takes advantage of these processes. You will use less deicer and have greater effect because temperatures will still be warm from the retreating storm front and the deicer will maintain greater antifreeze potency as the snow and ice melts.

Sweep or shovel surfaces free of slush and melted snow as soon as possible

A given concentration of salt is effective down to a certain temperature—as temperatures fall following a storm, melted ice will refreeze, necessitating continuing ice removal expenses.

- **Locate On-Site Snow Disposal Sites Effectively**

Avoid storing snow at locations within areas served by potable ground water wells

Salt in snow melt water is highly mobile, and mobilization of other pollutants can be promoted by high salt content. The cost for mitigating effects on ground water wells from inappropriately located or operated snow disposal sites will greatly outweigh any savings in snow hauling costs.

Avoid storing snow adjacent to residential and commercial properties

Operations at snow disposal sites typically include “high-stacking” snow. Snow also includes some sediment, trash and debris that become more noticeable as seasonal melting progresses. Because both these conditions can be visual nuisances to the site’s residential and commercial neighbors, visual separation from these land uses is preferred. Where sites are located adjacent to these land uses, incorporate trees and dense vegetation along the site perimeter to act as visual and noise buffers and maintain as low a snow storage profile as possible. A low stored snow profile not only minimizes visual impacts but also will reduce impacts (and treatment costs) from salt released in the melt water.

Avoid draining snow storage sites to small lakes or streams

Salt in melt water is very “conservative”—it does not react or adsorb to other materials and so is very mobile. The best means of treatment are through minimization of initial concentrations (control initial salt application), minimization of leaching during melting (minimize the depth of stored snow), and by dilution. Because salt in melt water from snow disposal site is at times concentrated, small waterbodies may not provide sufficient dilution, resulting in impacts to the receiving waters.

- **Operate Snow Disposal Sites Effectively**

Minimize leaching of chloride and maximize melt water detention and infiltration

The first melt water occurring at a snow disposal site can have very high salt concentrations. As each drop of melt water seeps vertically through a snow pile, salt is leached from the entire column of snow through which the drop of water flows. Early in the melt process, when the snow mass has all its original salt content, this leaching can increase salt in the melt water to concentrations much greater than that of the original pile. Conversely, as melting progresses, and when much of the salt has already been leached, salt concentrations in the melt water can become much smaller than that of the original plowed snow. A lower stored snow profile (a thinner pile) reduces the amount of snow that a drop of melt water passes through and thus reduces leaching and the peak salt concentration. As a general practice, place the snow in piles having larger footprints and lower profiles (do not exceed pile depths of 20 feet) to minimize the effects of salt leaching.

Preventing the first melt water from flowing off-site right away (“detaining” it) provides an opportunity for early, salt-rich melt water to be diluted by later melt water that has progressively lower salt concentrations. Infiltration likewise helps prevent rapid mobilization of initial salt-rich melt water, and, in addition, traps sediment on-site. Promote these effects by using as snow storage sites those areas having non-paved surfaces where possible (but only

where potable ground water resources will not be put at risk), and grade the surface to encourage shallow impoundment of melt water on-site. Where snow storage/disposal must take place on pavement, place the snow on the lowest point on the pavement surface, and, as possible, direct melt water so that it will be detained on adjacent or nearby (on-site) permeable surfaces before discharge.

Minimize mobilization of on-site sediments

Fine sediments are common contaminants in plowed snow and can be easily mobilized during melting. However, seasonal on-site snow melt in Anchorage is by nature a slow and hydraulically low-energy process and there are many opportunities for practicable on-site treatment for this pollutant. The following are the basic elements of a best management practices plan for this pollutant. Place the first plowed snow of the year at the lowest point on the site, filling upslope from the initial fill point throughout the rest of the winter season. Stack hauled snow in a compact mass to a uniform thickness, maintaining steep sides and a relatively broad base (do not pile snow to depths greater than 20 feet). Maintain a vegetated site surface where possible. Armor and protect all drainage channels crossing the site and treat melt water, particularly for turbidity and salt, prior to its exit off-site. Placement of hauled snow at the low point should encourage ponding around the melting snow mass and minimize the length of flow paths for melt water draining across the site. Because much of the sediment in melt water is generated by the collapsing snow mass, stacking the snow with very steep sides minimizes the amount of snow surface area that is most subject to this type of erosion. Piling the snow in a compact mass to uniform depths across a broad base (low stored snow heights) can significantly help reduce leached chloride concentrations in the early melt water released from the stored snow. Vegetated site surfaces help trap fine sediments, metals, and petroleum pollutants. For this reason it is important to promote spring revegetation by limiting site access and otherwise preventing trafficking and disturbance of the wet ground surface. Where snow disposal must take place on pavement, placing snow across as broad a footprint as possible, at uniform depths and at the low point on the site remains important. In these cases it even more important to minimize the drainage path from the melting snow mass to the nearest storm drain inlet or ground surface discharge point. Where melt water flow exits a paved surface onto ground, dissipate flow energy by directing flow across a rock or grass apron. In all cases, providing unobstructed, armored melt water channels is important to minimize erosion. Flag dedicated site drainage channels so that hauled snow is not accidentally placed in them, creating the potential for diverting flow to more erodible surfaces. Armor the main channels: depending on site grade and the volume of melt water, grass or very small aggregate may provide adequate armor. Where melt water is not adequately treated through detention, site layout and operational practices, further treatment in on-site sedimentation basins or oil and grit separators may be required.

Clean snow disposal sites at the end of the snow melt season

Plowing snow inevitably incorporates some trash and debris. During active snow melt this debris remains wet and relatively immobile. At the end of the melt season, remove trash and litter from the site, and perform maintenance on drainage channels and sediment traps. If it is necessary to regrade the site, complete re-grading early and limit summer access to promote revegetation. Sweep all paved surfaces as soon as they become free of snow and impounded water (do not sweep sediments into the impounded water) and clean any melt water pollutant treatment devices (e.g., oil/grit separators, sedimentation basins, etc.).

APPENDIX 2C

Snow Disposal Site Seeding Specifications

SNOW DISPOSAL SITE SEEDING SPECIFICATIONS

Section 1.0 SEEDING SNOW DISPOSAL SITES

Article 1.1 General

The work under this section shall consist of providing all labor, equipment, and materials for the preparation of ground surfaces for the application and maintenance of native grass seeded areas, fertilization, lime application (if necessary), watering and mulching at locations shown on the drawings or established by the Engineer.

All seeding shall be performed between May 1 and September 1. Seeding at other than the specified dates will only be allowed upon written approval from the Engineer. Seeding shall not be done during windy conditions or when climatic or ground conditions would hinder placement or proper germination of seed mixes.

Article 1.2

a. Seed

Seed shall conform to the following seed mix type and application rate.

Schedule A

Application rate: 4.5 lbs. /1,000 square feet

Name	Proportion by weight	Purity	Germination
<i>Festuca rubra</i>	40%	90%	85%
<i>Deschampsia caespitosa</i>	20%	90%	85%
<i>Leymus arenarius</i>	20%	90%	85%
<i>Beckmannia syzigachne</i>	20%	90%	85%

b. Fertilizer

Fertilizer shall be of a standard commercial type supplied separately or in mixtures and furnished in moisture-proof containers. Each container shall be marked with the weight and the manufacturer's guaranteed analysis of the contents showing the percentage for each ingredient contained therein. The proportion of chemical ingredients furnished shall be a mixture such as to provide the total available nitrogen, phosphoric, and potassium as required by the soil analysis or as specified in the Special Provisions.

c. Limestone

Limestone shall contain not less than 85 percent of calcium and magnesium carbonates. Agricultural ground limestone suitable for application by a fertilizer spreader shall conform to the following gradation:

<u>Sieve Designation</u>	<u>Minimum Percent Passing by weight</u>
No. 10	100
No. 20	90
No.100	50

Fertilizer and limestone for use in a hydraulic sprayer shall be soluble or round to a fineness that will permit complete suspension of insoluble particles in water.

Article 2.3 Application

a. Soil preparation

After grading of areas has been completed in conformity with the lines and grades shown on the Drawings, and before beginning seeding operations, the area to be seeded shall be cultivated to provide a reasonably firm but friable seedbed. Cultivation shall be carried to a depth of two inches. On slopes steeper than three horizontal to one vertical (3:1), depth of cultivation may be reduced as directed by the Engineer. All cultivated areas shall be raked or cleared of stones one inch in diameter and larger; all weeds, plant growth, sticks, stumps and other debris or irregularities which might interfere with the seeding operation, germination of seed, or subsequent maintenance of the seed cover areas shall be removed.

b. Fertilizer

Fertilizer shall be applied at a rate to provide 2 lbs. actual nitrogen per 1,000 square foot of area. In the absence of soil tests and the direction from the Engineer, the Contractor shall apply 16-16-16 at the rate of 12.5 lbs per 1,000 sf.

Article 2.4 Maintenance

The contractor shall protect seeded areas from damage from all traffic, whether people, animals, on or off-road vehicles, or any other causes that may damage newly seeded and maintained surfaces. Surfaces damaged shall be repaired by regrading, reseeding (including all specified amendments) as directed by the Engineer and at no additional cost to the Owner. The contractor shall otherwise maintain seed areas in a satisfactory condition until Final Acceptance of the work.