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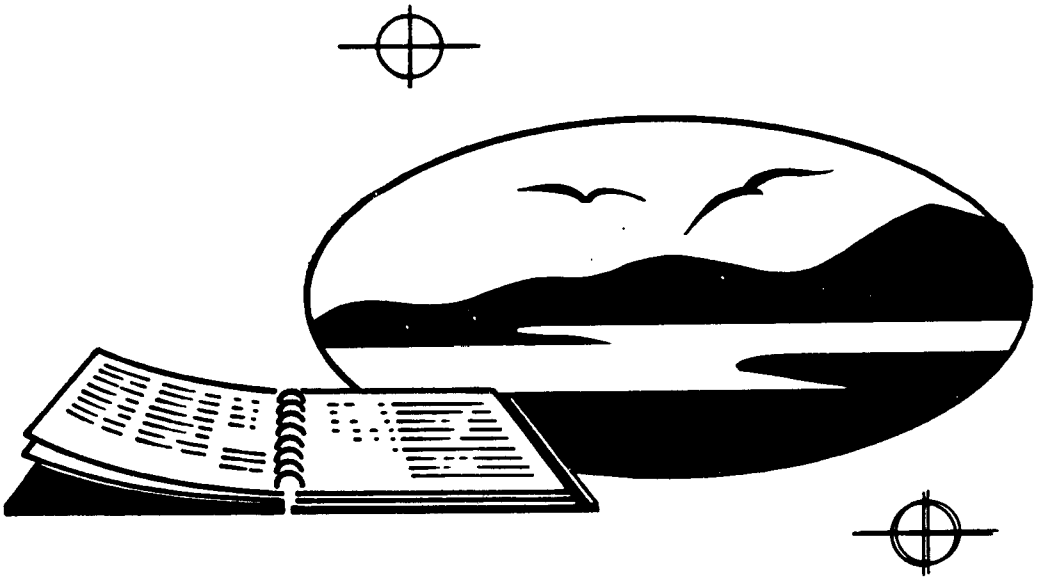
Seawater Intrusion Control In Coastal Washington Department Of Ecology And Practice



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Water Division
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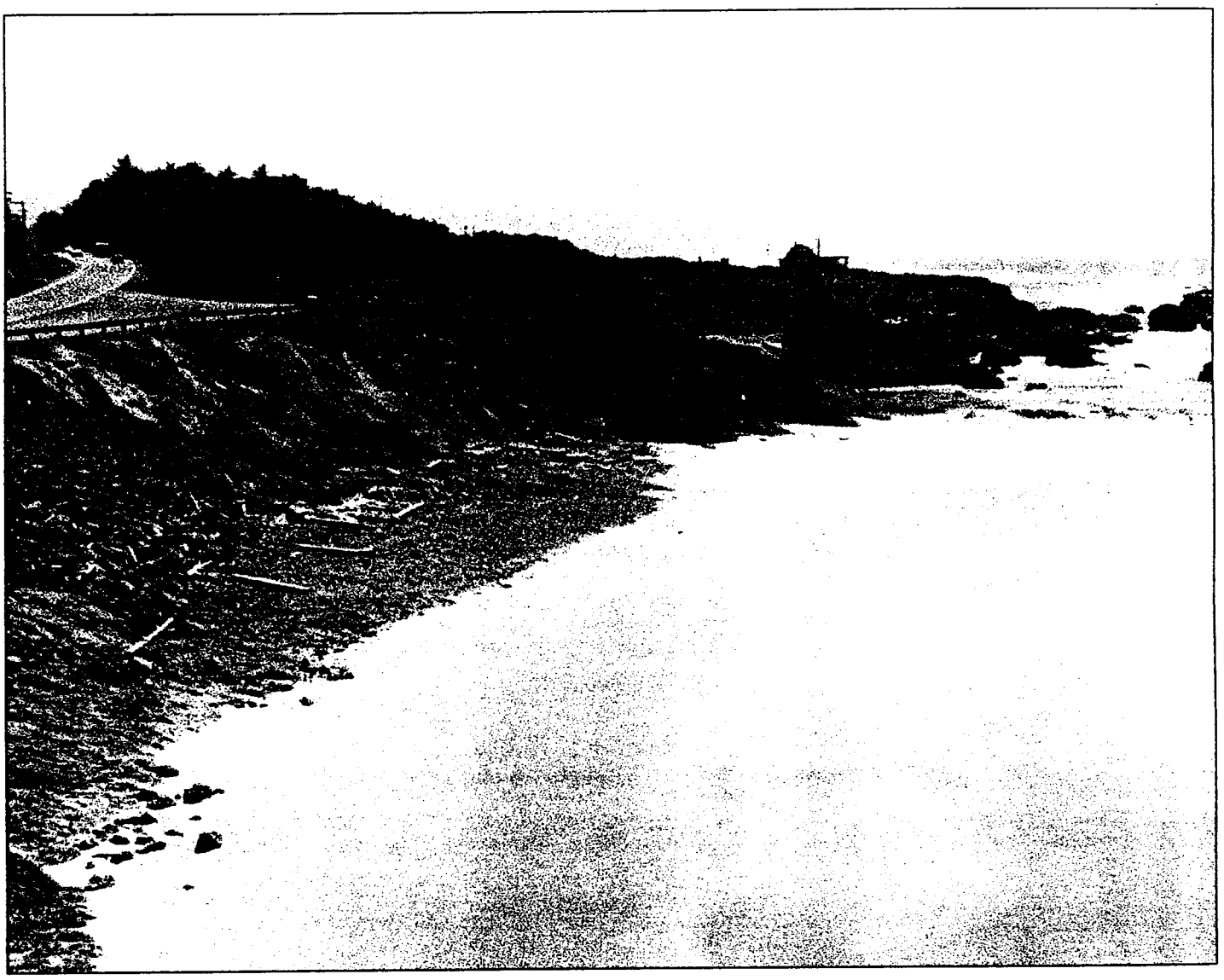

Seawater Intrusion Control in Coastal Washington: Department of Ecology Policy and Practice

By
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Prepared for the U.S. Environmental Protection Agency
Region 10, Office of Ground Water

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Disclaimer

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Abstract

Seawater intrusion into ground water has been identified by governmental and other entities as a growing environmental concern in coastal Washington. Many coastal communities depend primarily or exclusively on ground water as their source of fresh water. Massive population growth and development in many of these areas are depleting what was once imagined to be an abundant underground resource, frequently resulting in seawater contamination of this resource.

The Washington Department of Ecology (Ecology) was created in 1970 to manage the air and water resources of the State. As a result of increasing concern regarding seawater intrusion, efforts to control and reverse this problem have, over the last several years, become a Department focus. The Water Resources Program within Ecology is ultimately responsible for the control of seawater intrusion. Through its role in water rights administration, the Department decides whether to grant or deny water rights in seawater intrusion prone areas, thus controlling intrusion in these areas by regulating water allocation.

Following an explanation of the mechanics, causes, and effects of seawater intrusion, this report documents legal authority granted Ecology to control seawater intrusion as well as current Department policies and practices regarding water rights administration. The report concludes with an analysis of current policies and practices, considering both strengths and deficiencies, and suggests potential improvements in problem areas.

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Executive Summary

Seawater intrusion into ground water has been identified by governmental and other entities as a growing environmental concern in coastal Washington. Many coastal communities depend primarily or exclusively on ground water as their source of fresh water. Massive population growth and development in many of these areas are depleting what was once imagined to be an abundant underground resource, frequently resulting in seawater contamination of this resource.

Occurrences of seawater intrusion in the state were first reported in 1922 in King County, near the head of Elliott Bay. Much later, in the 1970's, localized severe cases of seawater intrusion were observed in several coastal counties, with widespread intrusion experienced in Island and San Juan Counties (U.S. Geological Survey, 1978, 1985). The Washington Department of Ecology (Ecology) was created in 1970 to manage the air and water resources of the state. As a result of increasing concern regarding seawater intrusion, efforts to control and reverse this problem have, over the last several years, become a Department focus.

The Water Resources Program within Ecology is ultimately responsible for the control of seawater intrusion, though its efforts must be coupled with those of local planning departments, utilities, and other groups to be successful. Through its role in water rights administration, the Department decides whether to grant or deny water rights in seawater intrusion prone areas, thus controlling intrusion in these areas by regulating water allocation. Following an explanation of the mechanics, causes, and effects of seawater intrusion, this report documents legal authority granted Ecology to control seawater intrusion as well as current Department policies and practices regarding water rights administration. Documentation was achieved through review of relevant legal code and Department policy, personal and telephone interviews, and examination of regional water right files. The report concludes with an analysis of current policy and practices, considering both strengths and deficiencies, and suggests potential improvements in problem areas.

This examination was motivated by the U.S. Environmental Protection Agency's (EPA) desire to more fully support the state's practices in the control of seawater intrusion. Through a thorough understanding of Ecology's practices in seawater intrusion control, the EPA hopes to identify specific ways in which relevant federal programs (e.g. Sole Source Aquifer and Wellhead Protection Programs) may support state efforts, and in turn, how the latter may support federal programs. The report is also intended as an educational tool for agency staff, legislators, citizen groups and others, as well as a mechanism for initiating necessary procedural and policy changes.

Chapter One. Introduction

Coastal regions of Washington are the most densely populated areas in the state. Approximately 70% of Washington residents live in the state's fourteen coastal counties (Department of Commerce, 1991). Some of these counties have experienced as much as a 30% population increase over the last ten years (Washington Department of Ecology, 1991). As growth in these counties continues, particularly along the coast, the demand for fresh water in some areas far exceeds surface supplies. Municipalities, industries, and families are increasingly looking towards ground water as a seemingly abundant source of fresh water. For many communities, especially in island settings, ground water is the only source of fresh water. However, unchecked exploitation of ground water in coastal aquifers has its costs; seawater contamination of these aquifers has become a growing concern and, in many areas, a reality.

Occurrences of seawater intrusion in the state were first reported in 1922 in King County, near the head of Elliott Bay. Much later, in the 1970's, localized though severe cases of seawater intrusion[1] were discovered in several coastal counties, with widespread intrusion experienced in Island and San Juan Counties (U.S. Geological Survey, 1978). The Department of Ecology (Ecology) was established in 1970 to manage the water and air resources of the state. Within Ecology, the Water Resources Program (Water Resources) was created in part to protect and manage the state's ground water resources. This Program focuses on water quantity rather than water quality concerns. Its purview includes control and prevention of seawater intrusion into coastal aquifers through responsible allocation of ground water. Water Resources' efforts in this regard have yielded mixed results. After an explanation of the hydrologic principles and human practices which control seawater intrusion, I will examine the legal authority granted Ecology for its control, as well as Water Resources' implementation procedures in light of this legal responsibility.

[1]For the purposes of this report, seawater intrusion is defined as saline water originating from any ocean, sound, or strait.

Chapter Two. An Explanation of Seawater Intrusion

Ground Water Characteristics

Aquifers are geologic formations which store and convey water rapidly enough to supply it in useful quantities. They are a critical component in the hydrologic cycle because of their ability to transmit and store water. Ground water flow operates on a different scale and time frame than surface water; the accumulation and movement of ground water may take thousands of years, and ground water aquifers sometimes span several states. Most ground water originates as surface water, entering aquifers by means of infiltration from soil or surface waters such as streams, lakes, and reservoirs. Ground water is stored and transmitted through ground water aquifers, and may eventually return to the surface through pumping, natural discharge to surface water bodies, or the transpirative and evaporative processes of plants. Natural sources of ground water recharge include infiltration from streams, lakes, reservoirs, and precipitation. Human-induced sources of recharge include excessive irrigation, seepage from canals, and water applied with the intent to replenish the ground water system. Figure One illustrates the hydrologic cycle.

Aquifers in western Washington are commonly composed of sand or gravel. Unconfined aquifers have direct contact with the atmosphere through porous material, while confined (or *artesian*) aquifers are separated from the atmosphere by a low permeability material. This low permeability material forms an *aquitard.* The *potentiometric surface* represents the height to which water will theoretically rise in a well completed in a confined aquifer. If this surface is above the well head, then the well is a *flowing artesian* well.

Darcy's Law, which describes the flow of water through a saturated medium, tells us that rate of flow through a unit aquifer area is directly proportional to the hydraulic gradient. (See Appendix A for equation). That is, there will be a higher rate of flow when there is greater change in hydraulic head[2] over a given distance. To apply the equation requires knowledge of the areal extent of the aquifer, the hydraulic gradient, and the hydraulic conductivity (the capacity of the aquifer to transmit water). Hydraulic conductivity depends not only on the porosity of the material (the amount of void space in the material), but also on the degree to which the pores are connected; geologic material with larger and well-connected pores is said to be permeable. Sand and gravel formations are materials with high hydraulic conductivity.

[2]Hydraulic head is the height of a column of water above a datum plane. In ground water systems, it is composed of pressure head and elevation head.

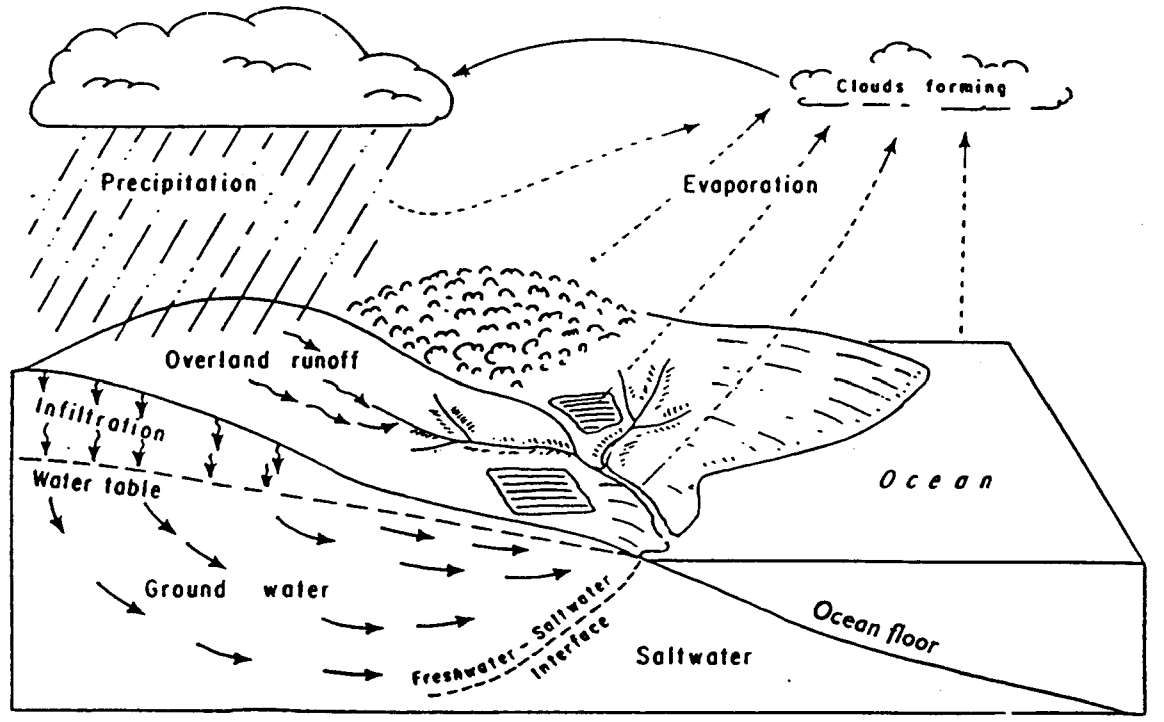


Figure One. The hydrologic cycle
Source: Heath, Ralph C.; Basic Ground-Water Hydrology. Water Supply Paper 2220, U.S. Geological Survey, 1983, p. 5

Seawater Intrusion

Saline water is the most common contaminant to fresh water aquifers (Todd, 1980). In very deep aquifers, it is often relict or old seawater which remains from some past era when sea level was higher. In shallow aquifers, its presence is generally the result of surface water pollutants which seep into the aquifer. In coastal aquifers, it occurs from infiltrating seawater. This latter case is the focus of this report.

Seawater intrusion arises when there is a change in ground water gradients. In a circumstance where there is a hydraulic connection between the aquifer and the sea, and when the aquifer is undisturbed, the lighter fresh water floats upon the denser salt water. The underlying salt water forms a *wedge* which thickens in the seaward direction. There is a salt water/fresh water *interface* formed at the top of this wedge which slopes downward in an inland

direction. When the process of ground water extraction through pumping upsets the hydrodynamic balance, fresh water is displaced by salt water, and seawater intrusion can occur.

In the early 1900's, two European researchers discovered that the intruding salt water occurs not at sea level, but at a depth of about forty times the height of the fresh water above sea level. The *Ghyben-Herzberg relation* determines the point of hydrostatic equilibrium at which salt and fresh water form an interface based on their different densities (See Appendix A for equation). This relationship does not consider flow variations, but rather assumes a hydrostatic condition where flow is almost horizontal. Unfortunately, static ground water conditions seldom occur in nature, especially adjacent to coastal areas where there is significant water mixing due to heightened vertical turbulence. In situations like this, the Ghyben-Herzberg relation underestimates the depth to the interface. In addition, the relation assumes that the fresh water level or potentiometric surface (depending on the type of aquifer) is above sea level and slopes seaward. Hubbert (1940) developed an equation in order to explain a hydrodynamic situation in which the top of the aquifer is above or below sea level (See Appendix A for equation).

It is important to further define the fresh water/salt water interface referred to above. This interface is in reality not a sharp line, but a brackish zone in which fresh water is dispersed. The thickness of this zone is determined by the amount of pumping, tidal fluctuation, and area recharge. As these factors increase, the interface zone becomes thicker. This zone generally ranges in thickness from one meter to 100 meters. Thicker zones often happen in more permeable coastal aquifers which are heavily pumped (Todd, 1980). The salinity of the transition zone, as one moves from top to bottom, increases from that of fresh water to that of salt water (See Appendix A for relative salinity equation). Salinity may be measured as total dissolved solids, chloride, or electrical conductivity (Todd, 1980). The mid-level of a transition zone, or the line at which the salt water/fresh water interface would occur in a hydrostatic condition, has a relative salinity of 50%.

The relationship between seawater and fresh water in island situations is often more delicate. An island aquifer (typically composed of relatively permeable materials such as glacial outwash or fractured bedrock in western Washington (Williams, 1992)) can be surrounded on all sides by seawater (Todd, 1980). Given that the primary source of fresh water recharge of these aquifers is rainfall, the fresh water/ground water layer is relatively shallow, extending radially outward, creating a freshwater lens floating atop the underlying seawater. The depth of the latter is dependent upon the amount of rainwater recharge, the hydraulic conductivity of the aquifer, and island size. The transition zone is created by variations in tides, rainfall, and atmospheric fluctuations. Because of the sensitive nature of the fresh water layer in island conditions, island wells should be generally well-spaced and have low pumping rates to avoid over-stressing the aquifer, and should be fairly shallow in order to avoid tapping salt water (Todd, 1980). Some peninsulas in western Washington are practically islands. For instance, only a narrow isthmus attaches the Kitsap Peninsula to the mainland. Such peninsulas behave hydrologically almost as islands (Williams, 1992).

When seawater enters aquifers, a chemical reaction takes place such that the result is more than simply the mixing of salt and fresh water. Three processes are likely to occur (Todd, 1980): 1) a change in the chemical make-up of the salt water through its base exchange with aquifer minerals, 2) a reduction in sulfates and their substitution by weak acid radicals, and 3) the dissolution and precipitation of the salts in the water. These processes result in both changes in total dissolved solids (from 1 and 2) and salt concentration (from 3). Revelle (1941) proposed that measurement of chloride concentration was the best way to detect salt water intrusion. Chloride is the primary anion in seawater, and alternately occurs very minimally in ground water. Seawater includes approximately 35,000 mg/l dissolved solids, 19,000 mg/l of which is chloride. The Environmental Protection Agency (1977) requires that public drinking water supplies not contain more than 250 mg/l (milligrams per liter) chloride: water with higher concentrations will exhibit a distinctly salty taste.

Causes of Seawater Intrusion

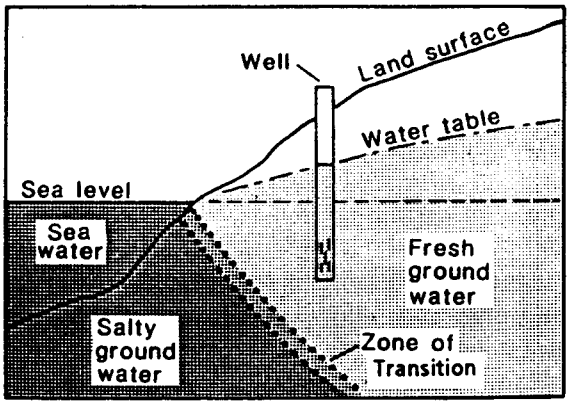
Ground Water Extraction

There are many causes of seawater intrusion; primary among them is ground water extraction, most typically caused by well pumping.[3] When excessive extraction occurs, the salt water/fresh water interface is disturbed and, as a result, the salt water wedge advances in an inland direction (Todd, 1980). When a well penetrates the fresh water layer of an aquifer which is underlain with salt water, a process called *upconing* results from excessive pumping whereby there is an upwelling of the salt water/fresh water interface locally below the well. This process is illustrated in Figure Two.

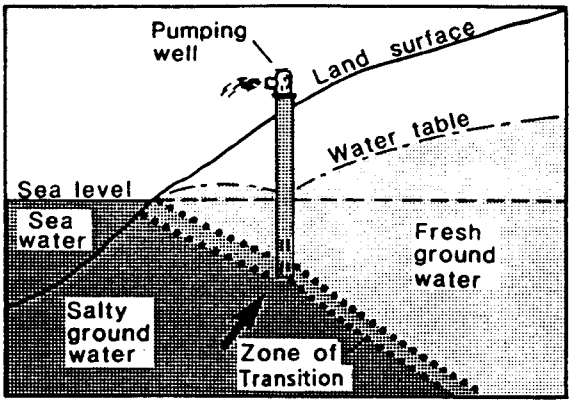
As pumping levels escalate, the situation worsens until the well must be abandoned due to contaminated, unusable water. After pumping ceases, the salt water recedes, and the salt water/fresh water interface assumes its pre-extraction position. Because of this occurrence, wells should be designed for shallow pumping in order to skim the fresh water from the top of the aquifer without penetrating the salt water layer. From a management standpoint, well location, spacing, depth, and pumping rates must be optimized to produce the greatest quantities of fresh ground water without exceeding recharge rates.

In the analysis of upconing, Schmorak and Mercado (1969) developed a mathematical relationship which links the salt water/fresh water interface directly to pumping rate using the Ghyben-Herzberg relation as its base (See Appendix A for equation). For the sake of simplicity, a sharp interface is assumed as was done for the Ghyben-Herzberg relation. There is a critical rise (See Appendix A) above which the interface will accelerate towards the well; this model works well only when rise is limited. However, a model has been developed to define the level at which water may be pumped without salt water entering the well, that is,

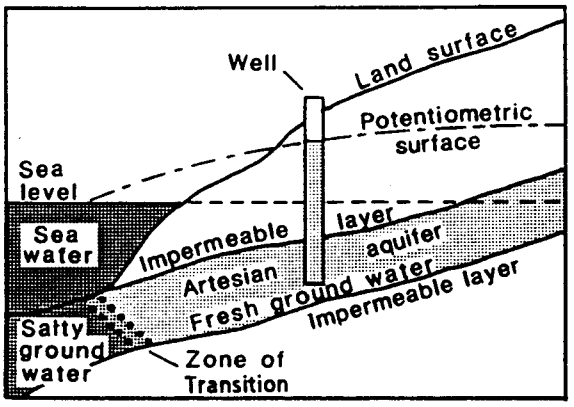
[3]For purposes of this report, the term ground water extraction will be used to signify well pumping.



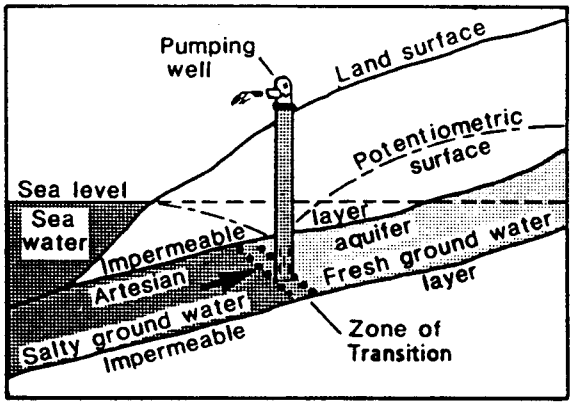
Well tapping an unconfined (water-table) aquifer under conditions of equilibrium--no intrusion has occurred.



The same well under conditions of intensive pumping--intrusion has reached the well.



Well tapping a confined (artesian) aquifer under conditions of equilibrium--no intrusion has occurred.



The same well under conditions of intensive pumping--intrusion has reached the well.

Figure Two. Schematic sections showing hydrologic conditions before and after intrusion in confined and unconfined aquifers

Source: Adapted with permission from Dion, N.P. and S.S. Sumioka; Seawater Intrusion Into Coastal Aquifers in Washington, 1978. Water Supply Bulletin 56, Washington Department of Ecology, 1984, p. 8.

the maximum pumping level (See Appendix A). It is important to note that, while these models present workable approximations, there is in reality no level above which salt water will not rise in a situation of continuous pumping when a well is drilled below sea level[4].

In considering the potential of seawater intrusion relative to well location, several distinctions have been made (Custodio, 1987). Wells that are drilled well inland, in conditions where the aquifer bottom is above sea level, experience little or no seawater intrusion although

[4]More than 90% of the wells in Island County are drilled to or below sea level (Abbott, 1992).

continued pumping acts to deplete well yields as well as the saturated thickness of the aquifer. In wells that are located inland, yet drilled into aquifers with bottom surfaces below sea level, seawater intrusion can occur when extraction exceeds recharge (a process called *mining*), though typically after a long period of time. Rates of intrusion are accelerated with deeper aquifers. High volume inland wells may cause or accelerate seawater intrusion in coastal areas without experiencing any intrusion themselves. In wells located near the coast, but in areas where the seawater wedge has not yet penetrated, seawater intrusion will occur when even a small fraction of ground water is extracted. Finally, in wells drilled in locations penetrated by the seawater wedge, there is imminent danger of seawater intrusion through upconing, even in shallower wells. Depending on a combination of factors including extraction rate and aquifer characteristics, the salt water wedge can take years or decades to work its way inland to aquifers; certainly, the more permeable the aquifer material, and the smaller the aquifer volume, the faster the salt water wedge will intrude.

Indirect Causes of Seawater Intrusion

There are other, more indirect activities which cause seawater intrusion, many of which are associated with population growth and urbanization (Custodio, 1987). When regions are urbanized, or as industrial sites increase, lands which were formally grassy or wooded are paved over. This process severely impedes infiltration of precipitation into the subsurface, instead creating surface runoff relatively useless for recharge. Even in areas which are not paved, vegetation is often disturbed or destroyed and soil is compacted, factors which decrease infiltration as well. A second activity which diminishes ground water recharge is the reduction in acreage of irrigated lands, or more efficient irrigation practices where surface water is used. The replacement of diffusion wells or other subterranean disposal facilities by more technically sophisticated sanitary networks also leads to a reduction in recharge. Forest management practices which result in deforestation or other reduction of vegetative cover decrease infiltration and increase runoff, thus negatively impacting recharge. Finally, a phenomenon over which humans have little direct control, and which encourages seawater intrusion, is drought. Certainly with a decrease in precipitation comes a decrease in recharge. All of these activities negatively impact quantity and rate of recharge; an aquifer which is being exploited, yet has little recharge, will be more immediately susceptible to seawater intrusion. These activities also serve to upset the salt water/fresh water equilibrium; the shift to a new equilibrium may take many years. At this point, the effects and their severity are not completely understood and further study and observation must be conducted to predict ensuing problems (Custodio, 1987).

Chapter Three. Seawater Intruded Areas in Washington

Independent studies by the United States Geological Survey (USGS), the Washington State Department of Health, and Ecology have identified coastal areas in which seawater contamination has occurred. Although all coastal and island areas are susceptible to seawater intrusion, the most widespread occurrences have been documented in San Juan and Island Counties (USGS, 1978, 1985; Department of Ecology, 1988). In many instances, chloride concentrations measured at wells in Island County have been greater than 100 mg/l (a somewhat arbitrary level used to indicate a seawater intrusion problem (USGS, 1978)), and in several instances, have exceeded the drinking water standard of 250 mg/l. The same is true in San Juan County. Both counties depend heavily (and in some areas, solely) on ground water for their fresh water supplies, and are experiencing rapid coastal development. Currently, the USGS is conducting a study of ground water quality on Guemes Island in Skagit County, a small island north of Anacortes which is beginning to experience rapid population growth (Kahle, 1992). A preliminary assessment suggests that there are a number of coastal wells with chloride levels exceeding 200 mg/l. In addition, Ecology is completing a seawater intrusion study on Marrowstone Island (Jefferson County), where suspicions of high chloride levels island-wide have been confirmed (Garrigues, Sinclair, in press). Figure Three illustrates areas in Washington which are sensitive to seawater intrusion.

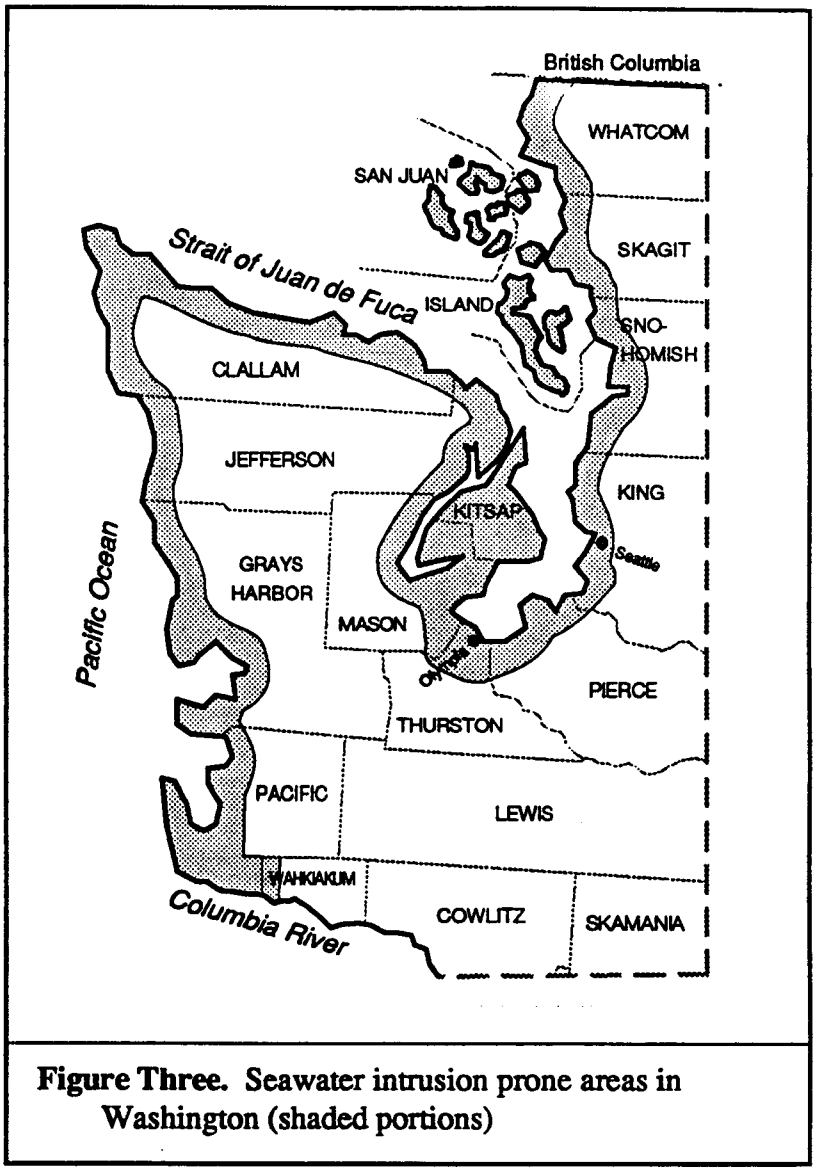


Figure Three. Seawater intrusion prone areas in Washington (shaded portions)

Chapter Four. State Policies and Regulations

The Department of Ecology, with its mission to protect and manage the ground and surface waters of the state for the public good, is the state agency authorized to prevent seawater intrusion. Outlined below are specific elements of the policies and accompanying regulations which grant it this authority. It is important to understand Ecology's legal responsibilities before considering its day-to-day practices in light of these responsibilities.

RCW 90.44: Regulation of Public Ground Waters (1945). In order to appropriate ground water in Washington in amounts greater than 5000 gpd (gallons per day) or to irrigate more than one-half acre, a water right must be acquired through Ecology's Water Resources Program. This policy was established in 1945 as an expansion of the 1917 water code addressing surface water appropriations (RCW 90.03). The granting of water rights in Washington is governed by the prior appropriation doctrine; those water right applications which are first in time are granted a superior right. *Section .050:* This section provides for an exemption from the application process for withdrawals of less than 5000 gpd or irrigation of less than one-half acre; in general, this applies to single or group domestic uses. These users are, however, entitled to the same rights as holders of water rights, and do have the option of undergoing the water right application process in the same manner as those desiring larger appropriations. Regardless of exemption status, Ecology may require, at its discretion, information about the nature, means and amount of the withdrawal. *Section .060:* This section stipulates the four criteria which must be satisfied for a water right to be granted: 1) the water desired for appropriation is available; 2) the water is intended for a beneficial use; 3) the desired water use will not impair existing water rights; 4) the public interest will not be negatively impacted. *Section .070:* Limitations on withdrawals may be imposed if the aquifer is incapable of yielding the desired amount of water under reasonable or feasible pumping conditions, or if the withdrawal would adversely affect an existing water right. In cases where the presence of either condition is suspected, Ecology may require additional evidence or proof of no harm from the applicant before a project may proceed; the burden of proof in this situation is placed on the applicant. *Section .250:* Ecology may, at its discretion, make investigations concerning location and extent of ground waters in the state, and, to this end, may require reports from ground water appropriators as to the amount and nature of use. *Section .400:* Ecology is authorized to identify and designate ground water management areas in order to most effectively protect and manage the ground water resource. These areas include aquifers that may be over-utilized or -appropriated, are primary or sole sources of drinking water for a community, or may be threatened by surface contamination due to land management practices; priority is given to aquifers which are imminently threatened. Ecology is to adopt these plans by January 1, 1986. *Section .450:* Ecology may require that withdrawals be metered as a condition of a new water right.

WAC 173-150: Protection of Withdrawal Facilities Associated With Ground Water Rights (1985). This regulation is sanctioned by the Regulation of Public Ground Waters Act. *Section -110:* This section refers to seawater intrusion specifically, saying that Ecology may

control this condition through artificial recharge or water importation projects, or any other means it deems "reasonable, feasible, and appropriate."

RCW 90.48: Water Pollution Control Act (1944). This act designates Ecology as the state water pollution control agency under the Clean Water Act, and mandates that the Department maintain all waters of the state in their highest quality as well as protect these standards for the future. Though surface contamination (e.g. oil and sewage) is the focal concern of this Act, seawater also classifies as pollution according to Act definitions; thus, this Act serves to reinforce Ecology's role in aquifer protection.

RCW 90.54: Water Resources Act of 1971. The purpose of this Act is to establish basic water resource policy in the state--to insure that water is preserved for the highest benefit of the public as well as to direct Ecology in the management of state waters. *Section .050 (2):* If, in the process of making decisions regarding water resources, sound evidence or data is lacking to make these decisions, Ecology may prevent further withdrawal of certain waters until such data is available. *Section .140:* This section states that aquifers which are the only source of drinking water for a community are given highest priority in terms of protection. *Section .180 (4):* Ecology programs concerning strategies for efficient water use should focus initially on areas where water is (believed to be) over-appropriated.

WAC 173-200: Water Quality Standards for Ground Waters of the State of Washington (1990). This regulation serves to implement the Water Pollution Control Act and the Water Resources Act of 1971. The goal of these regulations is to maintain high quality ground water in an effort to protect present and future beneficial uses. *Section -030:* An anti-degradation policy is set forth which includes the following directives: *(2)(a)* ground water degradation which would interfere with current and future beneficial uses shall be prohibited; *(2)(c)* high quality ground waters should be maintained at their current level of purity, even if that level is higher than the stipulated quality criteria for those ground waters, unless an overriding public interest dictates otherwise. A maximum contaminant level for chloride is set at 250 mg/l (*Table 1*). *Section -050:* This section sets guidelines for establishing enforcement limits for contaminants (i.e. maximum acceptable levels assigned to contaminants for the purposes of protection), stating that, in the setting of these levels, an attempt should be made to set them as close to background levels as practical (*(3)(a)(ii)*), and that human and environmental health, as well as beneficial uses, should be considered (*(3)(a)(iii)* and *(v)*). *Section -070:* Guidelines for setting early warning levels for contaminants (i.e. levels at which contaminants may be detected and controlled before they become injurious and that represent a percentage of the ground water quality enforcement limit) are set forth. Subsection *(6)(a)* states that in cases where an early warning value is reached or exceeded, the holder of the water right must notify Ecology of this condition within ten calendar days of its occurrence. *Section -090:* Special protection areas may be designated by Ecology or other government agencies (or indian tribe) for ground water that requires special consideration. *Section -100(4):* Permits may only be issued if they do not cause violations of ground water quality standards set forth in this chapter.

RCW 90.14: Water Rights, Registration, Waiver, and Relinquishment Act (1967). This Act was intended to enable Ecology to gain greater control over the administration of state waters. It's passage was motivated largely by a stated uncertainty as to the volume of private water claims in the state. *Section .041 (2)(a).* The Act required individuals claiming surface water rights pre-dating 1917, or ground water rights pre-dating 1945, to file statements of these claims with Ecology by June 1974.

RCW 18.104: Water Well Construction Act (1971). This Act serves to regulate well construction and to regulate and license well contractors. *Section .040 (2):* Ecology is authorized to conduct well inspections at times it deems reasonable. *Section .040 (4)(f):* Ecology has the power to limit well construction for the purpose of sound water resources management.

WAC 173-160: Minimum Standards for Construction and Maintenance of Wells (1973). This Regulation, authorized by the Water Well Construction Act, dictates the minimum standards for construction of water supply and resource protection wells. *Section -020 (1):* In areas sensitive to seawater intrusion, construction requirements beyond the minimum standards are necessary. *Section -050 (1):* Within thirty days following well construction, a well driller must submit well drilling records to Ecology. *Section -055:* A contractor must submit a start card signalling an intention to start, alter, or abandon a well at least 72 hours prior to the start of construction. *Section -075:* Wells must be adequately sealed in order to prevent inter-aquifer contamination. *Section -205:* In areas of suspected contamination, wells must be cased with impermeable materials. All wells must not be located within a minimum distance from potential or known sources of contamination. *Section -415.* Abandoned wells must be properly decommissioned to prevent surface water and inter-aquifer contamination.

WAC 173-162: Regulation and Licensing of Well Contractors and Operators (1973). This Regulation, authorized by the Water Well Construction Act, provides guidelines for the licensing and regulation of well contractors and operators.

WAC 173-100: Ground Water Management Areas (1985). This law, authorized by the Regulation of Public Ground Waters Act, sets forth criteria for the designation and management of ground water management areas for the purpose of aquifer protection. Seawater intrusion is mentioned explicitly as a cause for developing a ground water management plan.

WAC 508-64: Measuring Devices for Water Diversion and Withdrawal Facilities (1969). This law was enacted due to the realization of increased competition for water resources. It regulates the installation and operation of water meters, as well as specifies the type to be used, in order to prevent both waste and over-appropriation of this limited resource.

Growth management language was codified into new and existing legislation in 1990. The following excerpts are relevant in the control of seawater intrusion:

RCW 36.70A: Growth Management--Planning by Selected Counties and Cities. Section .070: This section discusses the required elements of comprehensive management plans for cities or counties. Among these is a land use element, stipulating that land use plans be made with sensitivity to the protection of ground water used for public water systems.

RCW 58.17: Platting, Subdivision and Dedication of Land. Section .110: This section reinforces the connection between land use and water availability, saying that subdivision and dedication approvals are contingent upon sufficient water supplies.

RCW 19.27: State Building Code Act. Section .097 (1): This amendment to the state building code requires that applicants for building permits for structures needing potable water supplies must show that adequate supplies of such water are available. Proof of adequate supply may be shown by a water right permit, a letter from a certified water purveyor confirming the ability to deliver water, or some other acceptable form. A county or city may require, as a condition of a building permit, that the applicant hook up to an existing public water system where there is available water.

These rules and regulations facilitate, both directly and indirectly, Ecology's prevention of seawater intrusion.

Chapter Five. Agencies Involved in Seawater Intrusion Concerns

Department of Ecology

The Department of Ecology's Water Resources Program has principal responsibility in the control of seawater intrusion. Although seawater intrusion results in a water quality problem, it is caused by a depletion in the ground water resource, thus its control has been assigned to Water Resources. In 1989, a position was established within the Water Resources Program's Policy and Management Section to form and lead a Seawater Intrusion Team. The Team was created to develop and implement a strategy for seawater intrusion in Washington. This decision came from pressure, applied both externally and internally, that Ecology address this critical, unresolved water resource issue. Two other positions within the Section work on seawater intrusion more indirectly. These involve the coordination of Ground Water Area Management Plan development, as mandated in RCW 90.44.400 (see Chapter Four). Within the Coordination and Hydrology Section, a hydrogeologist was assigned to the Seawater Intrusion Team to serve as the technical lead.

On a regional level, Ecology's Northwest and Southwest Offices are responsible for evaluating and making decisions on water right applications in affected coastal counties. The Northwest Regional Office (NWRO), located in Bellevue, employs seven report writers (one representing each county in the region) and four hydrogeologists, one of whom is dedicated to coordinating well construction and operation. A report writer reviews water right applications, makes findings, and, based on these findings, advises what action to take on the permit (i.e. approval, conditional approval, or denial). Where information is lacking to make an informed decision, Water Resources may ask the applicant to provide it. When the factors in making a decision are more complex (e.g., if seawater intrusion is a potential or reality in the area), the report writer may seek the assistance of a hydrogeologist in the review of more technical aspects of the situation. Assistance is sought when the application is located in a seawater intrusion prone area, or when the report writer expects that the applicant will appeal his decision (Fritzen, 1992). The hydrogeologist's input adds technical support to the report writer's decision. His or her opinion may also be solicited in the review of a consultant's report or if an aquifer test is necessary (Sinclair, 1992). As well as assisting in technical review of applications, hydrogeologists perform aquifer studies and provide other technical support. The Southwest Regional Office (SWRO) employs five report writers, four divided evenly between the northern and southern parts of the region, and one specializing in applications from municipalities. In addition, there are three hydrogeologists, one of whom works as well drilling coordinator. Figure Four depicts an organizational chart of those individuals responsible for various aspects of seawater intrusion management.

Ecology's Water Quality Program is minimally involved in seawater intrusion management efforts. Seawater is just one of a host of contaminants it reviews, others considered more imminently serious to instream habitat and human life. The Water Quality Program's primary role is the issuance of waste discharge permits which stipulate allowable levels of industry-

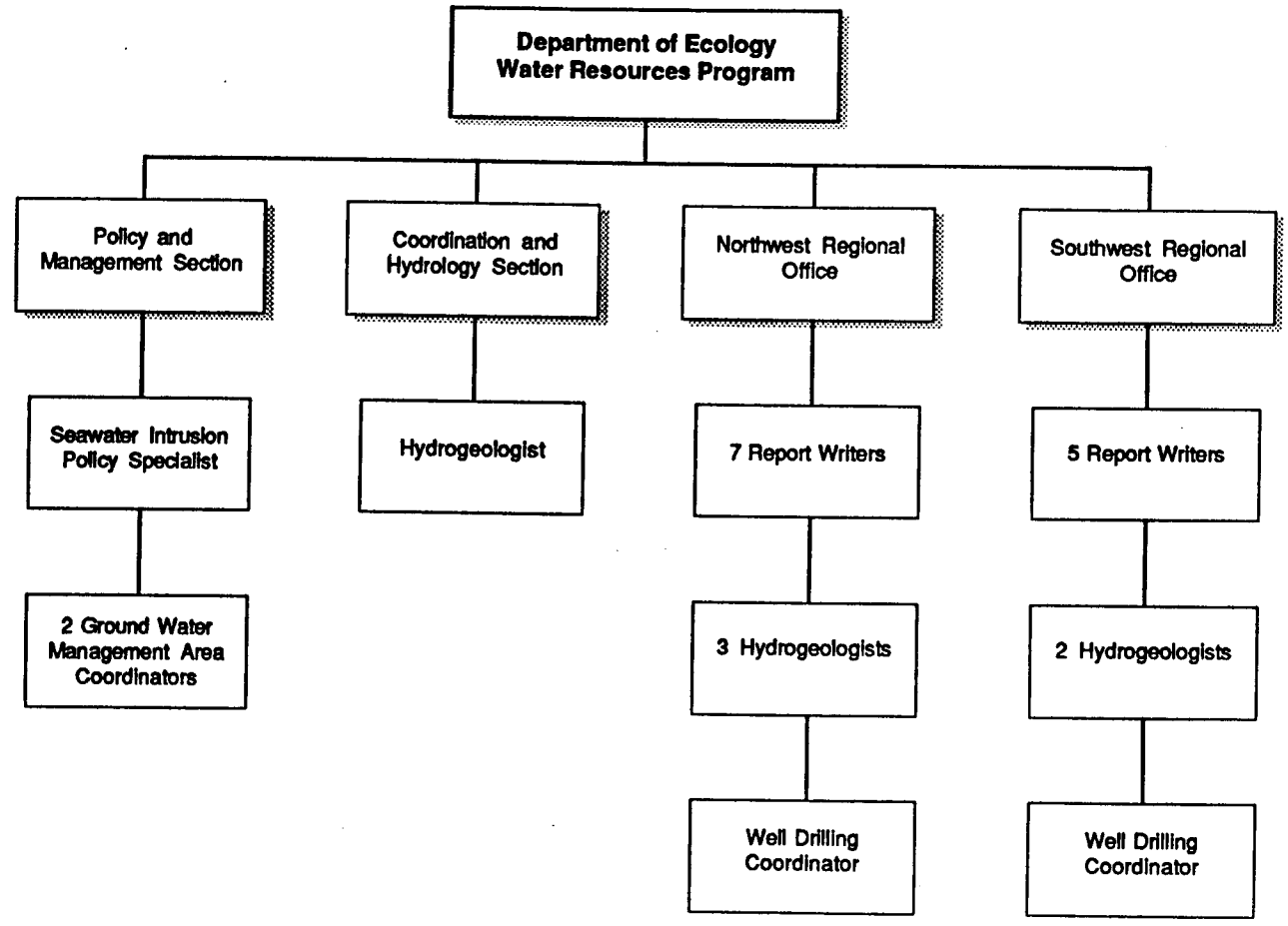


Figure Four. Water Resources organizational chart of positions involved in seawater intrusion control

and municipality-produced contaminants. More recently, the Program has begun monitoring ground water quality, on a selective basis, in areas of waste discharge. This data is potentially valuable to Water Resources, though no formal coordination efforts currently exist. There is general agreement within Ecology that greater information sharing and coordination is needed between the two programs as their functions are related, especially on the issue of seawater intrusion. A data management task force was formed in December 1990, one of its goals being data sharing between the two programs.

Other Agencies

Other agencies having concern and involvement in seawater intrusion management are the Washington Department of Health's (DOH) Northwest Drinking Water Program and the U.S. Environmental Protection Agency. Through its enforcement of drinking water standards (for which the maximum contaminant level for chloride is 250 mg/l), the DOH monitors approximately 13,000 wells statewide (Deem, 1992). This monitoring data has been shared with Ecology, which has no ongoing monitoring program, and has, to date, mostly monitored wells in crisis situations. The DOH, and its counterparts on the county level, perform well site inspections and review public water system plans, thus regulating the same applicants that Water Resources regulates. Additionally, the DOH and Island County Health Department co-authored a Salt Water Intrusion Policy (1989). This was in many ways a prototype for a later Ecology document. The DOH-Island County document sets similar risk categories to those in Ecology's document, requires more frequent chloride monitoring in higher risk areas, and mandates denial of new water systems or additional service connections to existing systems if chloride levels exceed 200 mg/l (DOH, 1989). Though it is not as stringent as Ecology's policy (discussed in Chapter Six), it was tremendously instrumental in the formation of that policy.

The EPA shares a role in seawater intrusion management through its Wellhead Protection and Sole Source Aquifer Programs. In areas designated as sole source aquifers,[5] the EPA reviews federal financially assisted projects to determine contamination potential and threat to public health. The EPA therefore has the authority to deny federal financial assistance for a project that could cause or aggravate seawater intrusion. The Agency can also require project modifications as a condition of receiving federal financial assistance. Through the Wellhead Protection Program, authorized through a 1986 amendment to the Safe Drinking Water Act, the EPA oversees states' efforts to protect ground water based public drinking water supplies from contamination. The Washington state program is currently being developed by the DOH. Wellhead Protection Programs are primarily implemented on the local level. There is

[5]Sole source aquifer designation is granted in cases where an aquifer provides at least 50% of a community's drinking water supply, and where there is no economically viable alternative. As a matter of policy, the EPA only makes Sole Source Aquifer designations in response to petitions by individuals and organizations. Of pertinence to this study, Whidbey and Camano Island Aquifers have received sole source designation.

no strict regulation of seawater intrusion through this Program; however, in workshops for counties developing wellhead protection plans, the DOH urges that seawater intrusion concerns be addressed in management plans (Jennings, 1992).

The U.S. Geological Survey and the Pollution Control Hearings Board (PCHB) have also performed roles in seawater intrusion concerns. The USGS has performed more extended hydrogeologic studies, occasionally at the behest of Ecology, some of which have focused on seawater intrusion (USGS, 1978, 1985). These have provided important regional data on which to make management decisions and build policy. Finally, the Pollution Control Hearings Board (PCHB) has issued opinions on seawater intrusion when water right application decisions have been appealed and brought for hearing before the Board (PCHB, 1981, 1983).

Chapter Six. History of Ecology's Management Efforts

Since the passage of RCW 90.44 (Regulation of Public Ground Water) in 1945, the state has required water rights for ground water withdrawals in excess of 5000 gallons per day or for irrigation of more than one-half acre. Until the last several years, ground water was perceived by top Ecology management as a fairly unlimited resource, and water rights were granted routinely. There was little or no concern that a right would be denied. The Department of Ecology was established in 1970 as the state agency responsible for water rights administration. Water Resources, and more directly, its regional offices, carry out this responsibility within the Department.

In the late 1960's, elevated chloride levels were found in wells on the southern end of Camano Island (Island County) (Department of Water Resources, 1968). Further studies by the USGS in the 1970's, including a major study on seawater intrusion in all coastal areas of Washington (USGS, 1978), revealed elevated chloride levels as both a localized yet severe problem in some areas, and a more widespread problem in others (Island and San Juan Counties being exemplary in the latter category). During the mid- to late 1970's, the NWRO began issuing ground water permits with the proviso that "wells within one mile of the shoreline must have the pump intake at/or above mean sea level" (Department of Ecology, 1985). This stipulation was later revoked as it was found that many coastal wells in Island County, for example, exhibited very low, if any, chloride. It was also nearly impossible for the NWRO to regulate the pump intake levels of individual wells. From 1979 to 1983, the NWRO issued water permits with a proviso requiring that, if chloride levels exceeded 250 mg/l, pumping cease or the pump intake be raised above sea level. Thus, chloride was considered a problem only when it reached recommended maximum contaminant levels for drinking water, and was controlled only at these levels. This resembled a crisis management strategy, with no opportunity for preventative efforts. More significantly, there was no well monitoring required, so no initial chloride readings or trends were known.

In the SWRO, a similar proviso was used, again setting the action level at 250 mg/l chloride. In cases where wells had not yet been drilled, a proviso was included that encouraged applicants to site wells as far inland as reasonable to minimize the potential for seawater intrusion. Some permits required that pump intakes be set above mean sea level.

Opinions rendered in two PCHB hearings have been formative in the evolution of Ecology's seawater intrusion policy. PCHB Hearing No. 80-193 (1981) considers an application for ground water withdrawal by Harbor Vista Association (Maury Island, King County). The Board decided that pumping must cease when chloride reached 150 mg/l, and that chloride monitoring results be sent to Water Resources. PCHB Hearing No. 82-193 (1983) considered a local citizen's appeal of a water right permit approval granted to Prairie Management, Inc. (Whidbey Island, Island County). In this situation, Water Resources had issued a permit with the proviso: "If the chloride concentration exceeds 250 mg/l, the withdrawal rate shall be reduced or the pump setting raised to reduce the chloride level to below 250 mg/l" (PCHB,

1983). The citizen, Harry Wilbert, appealed the permit on the basis that the proviso lacked stringency appropriate to the ground water conditions. The Board's opinion involved two conditions:

1. The permittee or its successor(s) shall report to Department of Ecology, in April or August of each year or at such times as the department determines to be appropriate, the chloride concentration and static water level[6] of the well(s) authorized by this permit.

2. The withdrawal of ground water under this permit may be limited, or other appropriate action may be required, by Washington Department of Ecology in order to prevent seawater intrusion notwithstanding whether chloride concentration exceeds 250 mg/l in the well(s) authorized by this permit. (PCHB 82-193, 1983, p. 7)

Urgency created by these cases, a growing awareness of widespread intrusion in select regions, as well as an increasingly aware and vocal public, compelled Ecology to develop formal seawater intrusion policy. The Seawater Intrusion Team, created in the late 1980's, was Ecology's first coordinated response to the problem. The Team is composed, on the primary level, of individuals representing the Policy and Management Section, the Coordination and Hydrology Section, the NWRO, the SWRO, the Shorelands and Coastal Zone Management Section (interested essentially in incidents of sea level rise), and the Water Quality Program. Playing an advisory role are individuals representing federal, local, and other state agencies and organizations. Tribes, consultants, the general public, and the environmental community were invited to participate.

The major product of the Seawater Intrusion Team, to date, is the Seawater Intrusion Policy, implemented in January 1992. Though this policy has not been codified, and faces further review and possible amendment, it has been completed for practical purposes, and is being applied in water rights administration in both the NWRO and the SWRO.

Seawater Intrusion Policy

The Seawater Intrusion Policy provides a guide for Water Resources in the administration of water rights in seawater intrusion prone areas, with the goal of preventing intrusion in regions where the risk exists, and controlling or reversing the situation in areas where it has occurred. It is a pivotal document in that it provides a standardized and conservative response to seawater intrusion, and requires Ecology to take a more proactive and coordinated role in minimizing aquifer degradation. As defined in the Policy, seawater intrusion is "the infiltration of marine salt water into fresh water aquifers, resulting in chloride concentrations

[6]Static water level refers to the water level in a well when it is not being pumped.

above background levels [i.e. greater than 15-25 mg/l]" (Ecology, 1992, p. 5). This Policy uses 100 mg/l as a level at and above which more stringent regulation must be enforced. The use of this somewhat arbitrary level as an indication of seawater intrusion is supported by USGS studies (1985), which suggests that chloride levels below 100 mg/l could be due to other sources of contamination (e.g. relict seawater or surface contamination). As may be surmised, there is some discrepancy in opinion as to what chloride level clearly indicates seawater intrusion, although 100 mg/l is generally used.

The Policy establishes risk categories as a basis for controlling intrusion, and sets forth action to be taken by Ecology as well as the water right applicant as defined by the existing risk level.

Risk categories:

- Low: 25 mg/l $\leq$ Chloride < 100 mg/l based on data from an existing well, a test well, or general ground water basin conditions (if the basin is not geologically delineated, a half-mile radius from a well with these chloride levels is used.)

- Medium: 100 mg/l $\leq$ Chloride < 200 mg/l based on data from sources outlined in low risk areas. In addition, an area with chloride levels classified as low risk, but where data show a trend towards increasing levels, falls in the medium risk category.

- High: Chloride $\geq$ 200 mg/l based on data from sources outlined in low risk areas. In addition, an area with chloride levels classified as medium risk, but where data show a trend towards increasing levels, falls in the high risk category.

Responses vary depending on the level of risk and whether it is defined in a new or existing well. In low risk areas, Ecology can require design, operation, and monitoring controls for new wells. Ecology *will deny* a water permit in a medium or high risk area unless the applicant can show that further intrusion would not result from the proposed withdrawal. Ecology may also advocate, though not legally require, that local governments deny or withhold building permits in medium and high risk areas (pursuant to growth management legislation) unless the applicant can show that the water use associated with the building would not increase the risk of intrusion. In medium and high risk areas, water permit holders must monitor well chloride levels in April and August of each year and submit these to Ecology, as well as report annually to Ecology on the amount of their water use. This is written as a condition of the water permit approval. It is critical to remember that many of these requirements are enforced through the water right application process; as withdrawals of less than 5000 gpd or for irrigation of less than one-half acre are exempt from the water right application process, many well users avoid these requirements. Drillers of exempt wells are required only to notify Ecology as to well location and type of water use intended, and to submit a well drilling log.

In addition, the Policy stresses the need to coordinate water rights administration with land use and water system decisions. To that end, Ecology has begun to work with the DOH, county health and planning departments, local building departments, and Indian tribes. Please see Appendix B for a complete copy of Ecology's Seawater Intrusion Policy.

Chapter Seven. The Water Right Process

Criteria for Evaluating Applications

Water Resources employs four criteria in making a water right determination; a right may only be granted when all conditions are met (RCW 90.44.060).

- **The water desired for appropriation is available.**
  Can the aquifer supply the water required at an acceptable rate?

- **The water is intended for a beneficial use.**
  Beneficial use, as defined in RCW 90.14.031 (2) "shall include, but not be limited to, use for domestic water, irrigation, fish, shellfish, game and other aquatic life, municipal, recreation, industrial water, generation of electric power, and navigation."

- **The desired water use will not impair existing water rights.**
  Those with existing rights in the area have seniority and must be protected.

- **The public interest will not be negatively impacted.**
  The public interest, in this case, refers to the need for sustainable and non-deteriorative development of ground water, so that future uses will not be impaired or prevented. Since water rights are issued in perpetuity, a long range perspective is crucial, as well as careful review of each application.

Application Process

In order to determine whether these four conditions will be met, Water Resources has developed an exhaustive application process. In obtaining a water right, an applicant must follow a prescribed set of steps outlined below. (See Figure Five for a generalized flow chart depicting this process.)

1) The individual requesting a water right should fill out an application provided by Water Resources, including source and point of withdrawal, the quantity requested, and the proposed beneficial use. Applications are required for new wells, change in amount or point of use, and increase in appropriation. There is a ten dollar minimum examination fee required with this application.

2) Water Resources reviews the application for completeness. If the application is accepted, an identification number is assigned to it, and the information included therein is entered on a computer database. If the application is rejected, it is returned to the applicant with an explanation.

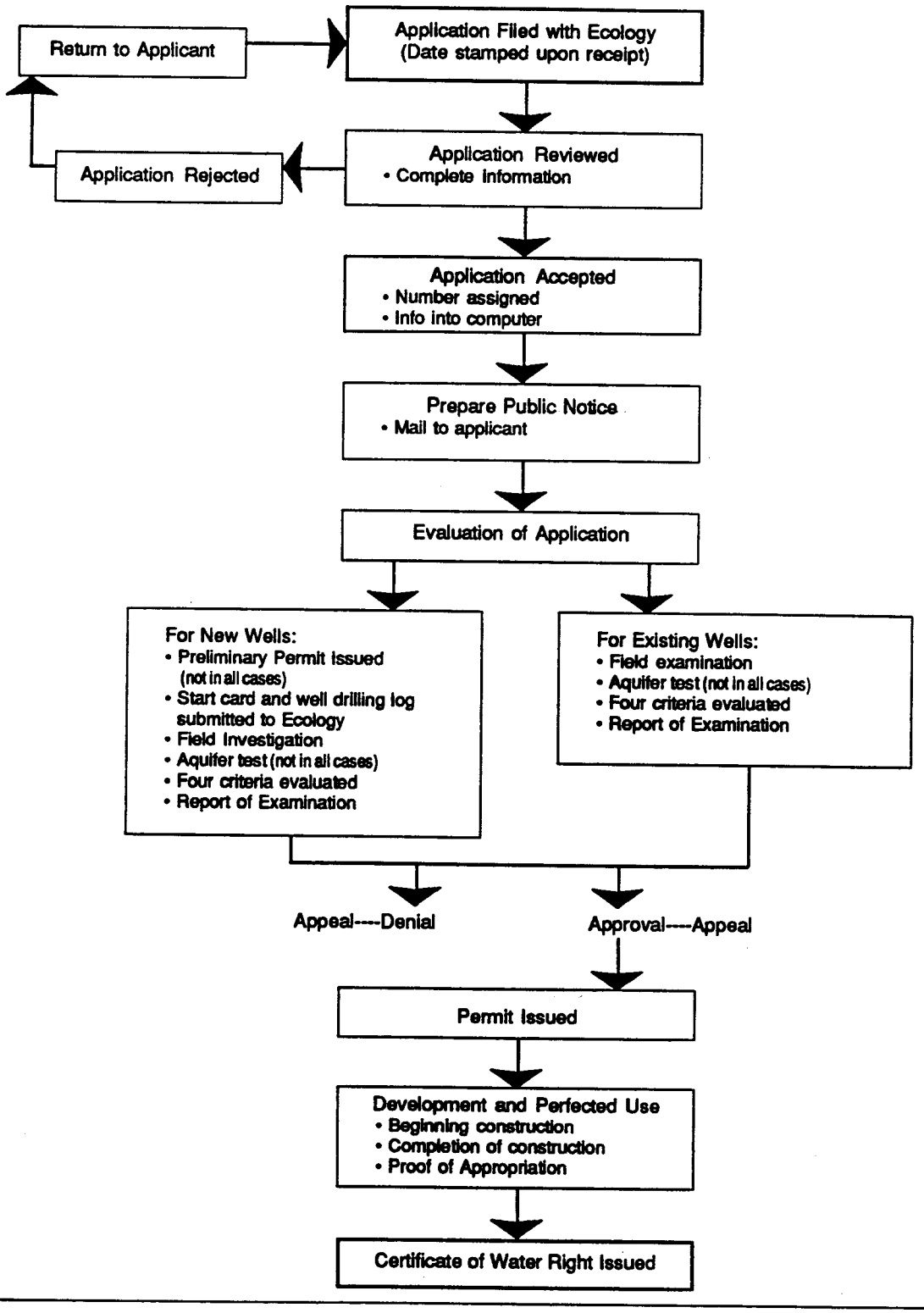


Figure Five. General steps in the water right application process

Source: Adapted with permission from Washington State Department of Ecology; Report on Water Right Administration: Assessment of Issues/Action Program. Department of Ecology, 1991.

3) Water Resources will then send the applicant a legal notice regarding the proposed withdrawal which must be published once a week for two consecutive weeks in a legal newspaper with circulation in the county where the withdrawal would occur. The notice contains information regarding the desired withdrawal, and grants citizens a 30 day period to protest the water use provided they feel it does not satisfy (any of) the four criteria.

4) After final publication of the notice, the applicant sends Water Resources an Affidavit of Publication as well as the original notice in order to confirm publication. Ecology will take no further action until the Affidavit is received (at which point the applicant's file is considered active), and the 30 day protest period has expired. If the proposed withdrawal is appealed, Water Resources factors these concerns in their decision regarding the water right. The appeals must be cited in the report of examination (discussed in Step 7).

5) After the protest period, Water Resources staff (often a Report Writer) will conduct a field examination to confirm the accuracy of application information and that the project is in the public interest. In seawater intrusion prone areas (as indicated in Figure Three), Water Resources staff will also examine existing ground water rights in the immediate vicinity, and chloride levels in those wells. Where the applicant is proposing a new well, a preliminary permit must usually be obtained in order to drill and test this well. In the SWRO, a preliminary permit is issued only if staff does not have enough information to approve or deny an application outright, and is used as a data collection mechanism only. As part of this permit, an aquifer test is performed during which the well is pumped at the maximum design rate[7] for which the well source would be used. The pump test must be performed for a minimum of 4 hours of stabilized draw down (this is a DOH requirement), though 24-72 hours is more standard in seawater intrusion prone areas. This longer test is designed to yield information about an aquifer's ability to transmit and store water. It is required by the SWRO only for larger projects or in critical supply areas. In seawater intrusion prone areas, Water Resources grants a standard preliminary permit subject to the following conditions beyond the normal requirements:

- Chloride and conductivity[8] analyses to be performed from samples taken at these intervals: one during 30 to 60 minutes after the start of pumping, one mid-way through the pumping, and one within the last 15 minutes of pumping.

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[7]Maximum design rate refers to the maximum withdrawal rate for which the pumping system is designed.

[8]Conductivity analysis refers to the electronic measurement of dissolved solids in the water. Chloride represents a significant portion of the dissolved solids; there is often a positive correlation between chloride concentrations and conductivity.

• Two chloride and conductivity analyses conducted on samples from an observation well preferably located between the tested well and the coast; one sample should be collected prior to the aquifer test and one within 30 minutes of completion of the test. This is generally not required from the SWRO. Staff in this office has found that only very rarely has this short term pumping of observation wells resulted in increased chloride levels, except in extreme conditions.

• A report submitted to Water Resources based on analysis of aquifer test data shall include these two elements: 1) data on tidal fluctuation and its effect on chloride levels and 2) a copy of all laboratory test results.

These elements are part of a standardized preliminary permit letter used in seawater intrusion prone areas in order to streamline the permit process.

6) Three days before drilling the test well, the well drilling specialist must submit a start card notifying Water Resources of his or her construction plans. This gives the well drilling coordinator at Water Resources the option of going to observe the drilling to ensure that construction regulations are fulfilled. Within 30 days following well drilling, the well drilling specialist is required to submit a well drilling log to Water Resources detailing drilling information and aquifer characteristics.

7) Based on the results of the aquifer test and the field examination, a Report Writer (with assistance from a hydrogeologist working in the same region if the case is technically complex) will issue a Report of Examination, recommending either approval or denial of a water right permit. A consideration of other ground water rights generally within a half-mile radius of the subject well will be included in the examination. The applicant and others have 30 days to appeal the Report Writer's decision to the Environmental Hearings Office of the state PCHB.

8) In instances where there are no protests to the proposed withdrawal, and where the proposed project satisfies the four criteria, Water Resources issues a Permit to Appropriate Public Waters which may include certain provisions or stipulations for use. While this is not a certificated water right, it allows the applicant to begin construction on the withdrawal facility and to use the water resource. It includes a construction timeline, and a date by which the water must be beneficially used.

If an application is denied, the applicant may either continue to withdraw within exemption limits, or abandon the project. The Report of Examination will include conditions for proper well abandonment according to WAC 173-160. It is the report writer's responsibility to ensure that the applicant has taken measures for proper abandonment.

9) When the water is put to beneficial use, the applicant must submit a Proof of Appropriation detailing the amount, purpose and location of use, equipment employed, and verifying that all permit conditions have been met.

10) Water Resources may examine the project to verify information provided in Step 9.

11) Provided all regulations have been complied with, and fees have been paid, Water Resources will issue a Certificate of Water Right to the applicant. The appropriation amount is based upon the extent to which the applicant's water use has been developed, and cannot exceed the amount requested in the application. Water Resources retains the authority to reduce permitted uses if necessary for resource protection.

While the initial four steps can be completed in several weeks, evaluation of applications and aquifer testing can take several months. Protested applications may take even longer, as they require additional evaluation regarding the elements protested. Though the goal is a six to nine month turn around time on applications, in practice it has ranged from six months to several years. This has been due in part to inefficiencies in Water Resources' review process, in part to resource limitations, and in part to applications being appealed. These issues will be explored further in Chapter Nine.

Water Permit Exemption

As mentioned earlier, a water permit is not needed for a ground water appropriation of less than 5000 gpd or for irrigation of less than one-half acre; this is commonly called a "domestic exemption" as it applies often to a single or group domestic water supply[9]. Though these users are exempt from the permit process outlined above, their water right is of equal value to one obtained through this permit process, and their priority of right dates to the time that they initially put the water to beneficial use. In addition, these users are *not* exempt from regulation in favor of senior rights. If a senior right were unable to be fulfilled, a junior exempt user's appropriation may be (temporarily) decreased. Exempt wells may also be monitored by Water Resources as deemed necessary. Except for the permit process (which exempt users may voluntarily undergo), exempt wells are *theoretically* subject to the same degree of regulation as non-exempt wells.

[9]As a rule of thumb developed by county planning and health departments, group domestic water supplies serving fewer than seven households do not require a water right unless the total lawn irrigation for the development exceeds one-half acre.

Chapter Eight. Regional Office Policy and Practice

Daily decisions are made on water right applications, many of which request ground water withdrawals in seawater intrusion prone areas. The Seawater Intrusion Policy is implemented on the regional level. The balance of this report will focus on decisions made on the regional level, as this focus provides the most valuable insight on seawater intrusion management practices.

The Northwest Regional Office

Many of the areas in which there is high risk or actual occurrence of seawater intrusion are under the NWRO's jurisdiction. The counties within this office's domain are: San Juan, Island, Whatcom, Skagit, Snohomish, King, and Kitsap. See Figure Six for regional definitions. Though all of these counties have documented incidents of elevated chloride levels in ground water, San Juan and Island Counties have the most widespread and chronic occurrences. It is no coincidence that both counties are comprised of islands whose residents depend almost solely on ground water as their water supply (75% of Island County residents depend exclusively on ground water (Island County Planning Department, 1991)). In addition, both counties are experiencing surges in population and concomitant development.

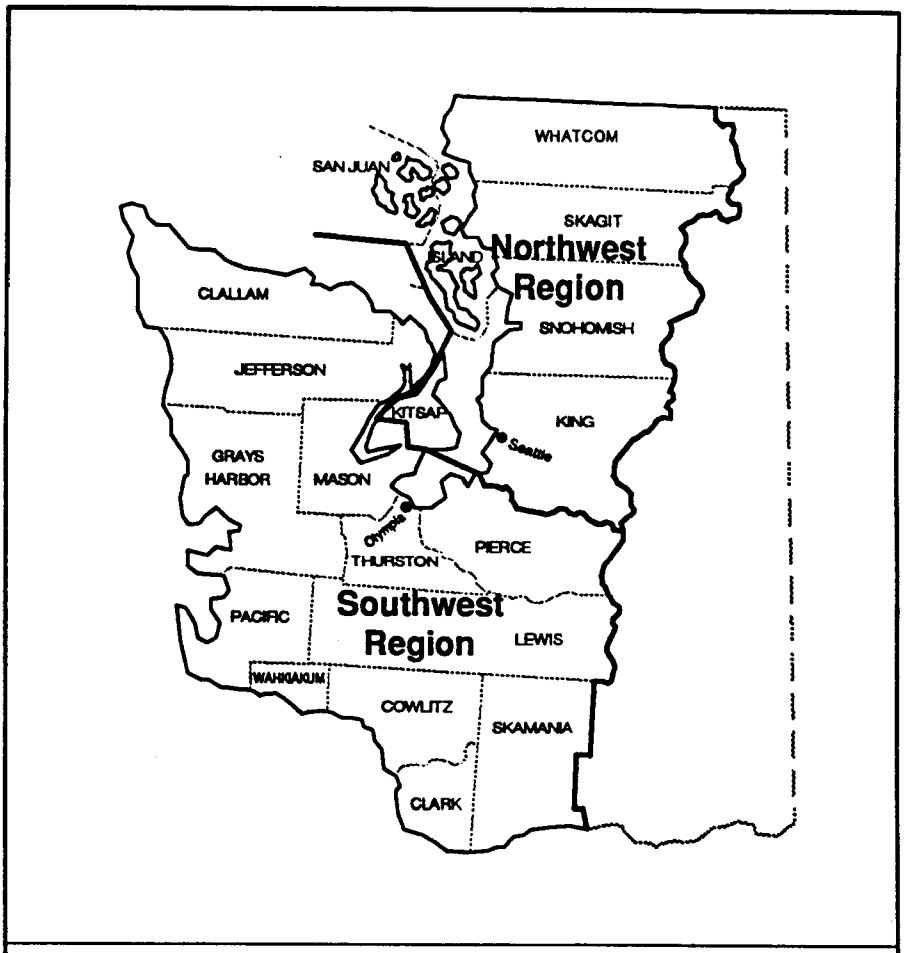

Figure Six. Washington Department of Ecology northwest and southwest regions

Water Resources' work with Island County towards the control of seawater intrusion has been prototypical. This is due to myriad factors, including the acknowledged widespread nature of the problem, extensive citizen awareness and pressure for corrective action, and a large and growing population (population is expected to grow by more than 20% between 1990 and 2000 (Island County Planning Department, 1991)). According to Island County's Ground Water Area Management Plan (the County was designated a Ground Water Management Area by Ecology pursuant to WAC 173-100), seawater intrusion is the most widely recognized ground water problem in Island County, with Whidbey and Camano Islands experiencing the highest impact. The balance of this section will examine Water Resources efforts in Island County, including a review of several case studies highlighting the water right application decisions in seawater intrusion prone areas.

Memorandum of Understanding

In December 1990, a Memorandum of Understanding (MOU) was signed by Water Resources and Island County Commissioners as an important step towards cooperative water resource management. It is Water Resources' hope that this agreement will eventually be modeled by other counties. A similar agreement is currently being designed in Kitsap County. The MOU represents an attempt by both state and local officials to adopt a proactive, preventative stance with regard to water resource problems in an effort to avoid crisis or remedial action. The MOU came about because of two problems: 1) delays in Water Resources permit decisions were confounding the local decision making process and 2), state and local decisions were often inconsistent (Walsh, 1992). For example, Water Resources would sometimes approve projects which conflicted with local land use plans, or conversely, counties would approve projects where adequate water supply was unavailable. Though the MOU does not address seawater intrusion specifically, it is directly supportive of prevention efforts. Agencies involved in implementation of this MOU are Water Resources and Island County Health and Planning Departments. Island County has nearly 700 public water systems (Marincic, 1992); this number does not include exempt wells. When the Seawater Intrusion Policy was implemented, there was a water permit application backlog of approximately 100 for Island County, over a third of which were more than four years old (Fritzen, 1992). Clearly, a coordinated plan was needed simply to deal with regulation of existing water systems, and current and incoming applications.

The goals of the MOU are as follows:

- Develop a water permit review process which is standardized, expedient, and clear to the public.
- Prevent overappropriation of water and aquifer degradation
- Accumulate technical information (hydrogeologic and well history data are lacking and are necessary for more confident and credible decisions)

- Develop a mechanism for dealing with application backlog

- Enhance education and conservation efforts

Ecology's focal strategies in fulfilling these goals include 1) analysis of applications on an areal basis, 2) implementation of the Seawater Intrusion Policy, 3) creation of a map of existing water rights (based on this and existing hydrogeologic data, water availability would be more quickly discernible), 4) requirement of flow meters for all new (and eventually, existing) permitted wells, 5) implementation of a well identification system for new (and eventually, existing) wells, and 6), ongoing well monitoring in problem areas. Action has been taken on all of these strategies, though most extensively on numbers 1 through 3.

Officials from Water Resources, state and county health, and county planning engage in monthly meetings to coordinate water management in Island County. These meetings have been a critical forum for sharing information on the status of water right applications, and for achieving consensus. Water Resources has gained a knowledge of local concerns and conditions which has enabled it to make more informed water right decisions.

Water Permit Decision Case Studies

Water permit decisions in seawater intrusion prone areas, while facilitated by the cooperative spirit of the MOU, are finally governed by the Seawater Intrusion Policy. Outlined below are cases representing three different applications for water rights and the decisions Water Resources made in light of the evidence provided. The process used in making these decisions is outlined in Chapter Seven.

Public Water Company A

In June 1981, a public water company submitted an application for additional water supply to an existing water system in Oak Harbor, Whidbey Island. The source was to be a well drilled 1150 feet from the coast, to a depth of nearly 100 feet below sea level. The absence of a seawater intrusion policy in the face of a potential problem led to inaction on the part of Water Resources. The company drilled and operated the well illegally for several years, exceeding the appropriation allowed in its water right for the prior three wells in the system. In 1991, exactly ten years following application submission, the application was readdressed by the Island County report writer. On the basis of multiple site inspections in which he tested chloride levels in the subject and neighboring wells, office research into case history and surrounding water rights, and a phone conversation with the applicant, the application was denied. Chloride readings taken in August 1991 indicated 140 mg/l in the subject well, and 120 mg/l and 65-70 mg/l on two other wells within a half-mile radius. The following statement fed the report writer's conclusion:

> The Department of Ecology's Seawater Intrusion Policy specifies that wells with greater than 99 mg/l of chloride are in medium to high risk areas. It also states that

preventive efforts will be approached from a regional perspective wherever possible and that, in the absence of hydrogeologic information to the contrary, a minimum half-mile radius around these elevated chloride wells will be used to delineate medium to high risk areas. The Policy specifically states that, "In medium to high risk areas, new water rights applications shall be denied, unless the applicant can show that additional withdrawal of ground water will not increase the risk of seawater intrusion." Well #4 [subject well] has been determined to be in a medium risk area at this time.

However, because of Water Resources' extreme delay in addressing the application, and the fact that the water served current uses and cutting it off posed health and safety risks, Water Resources granted a three year temporary authorization during which the company could use water at existing levels while attempting to decrease chloride levels. As part of this authorization, Water Resources required the installation of water meters and monthly reading reports, conservation efforts, and experimentation with altering pumping rates and/or raising pumping levels. Water Resources has also worked with Island County to prevent the issuance of further building permits to this company during this time.

This type of decision is unprecedented according to the Island County report writer. He is hoping that the company will make a concerted effort to bring chloride levels down during the three year authorization, at the end of which Water Resources can assess progress and either issue a permit if chloride concentrations have been brought into the low risk category, or grant an extension if a good faith effort towards this goal is being made.

Public Water Company B

In June 1990, a public water company submitted an application for nine service connections to be used in a community on south Camano Island. No protests were made to the application. The report writer investigated the application through a field examination, consideration of nearby water rights, and conversations with the applicant. Eight chloride readings on the subject well during the pump test ranged from 15 to 21 mg/l. However, several exempt coastal wells within a half-mile radius had exhibited chloride levels within the medium and high risk ranges, therefore placing the applicant's well within a high risk area. On the basis of the Seawater Intrusion Policy, it seemed that the application should be denied. The application is predicated on the abandonment of three intruded coastal exempt wells, however, and the cancellation of a planned coastal well; given this, Water Resources granted the permit on the premise that eliminating these seawater intruded exempt wells in exchange for the operation of an un-intruded well which they could more directly control through permit restrictions was the desirable option. The permit was conditioned on the following provisos:

1) Issuance of the [water right] certificate will be dependent upon the proper abandonment of the three existing coastal wells (WAC 173-160). The 'planned well' must also not be drilled. If these conditions cannot be met, the permit will become null and void.

2) An approved measuring device shall be installed and maintained.... Meter readings shall be recorded monthly and this data shall be maintained and be made available to the Department of Ecology upon request.

3) Static water level (SWL) shall be measured at least once each month. Measurements shall be taken after the pump has been shut off and the water level in the well has been stabilized. The data shall be maintained and made available to Ecology upon request. However, Ecology's Water Resources Section shall be notified if the SWL is determined to be below the level normally recorded at that time of year.

4) The permittee or its successor(s) shall provide data on chloride concentrations for the well authorized by this permit with analysis performed by a state certified laboratory. Sampling shall occur April and August of each year and permittee shall submit by October 15th of the same year written results for both sampling events to the Department of Ecology.... Depending on the results of this data collection, withdrawal of ground water under this permit may be limited or other action required.

5) If pumping of the well authorized by this permit causes chloride concentrations to exceed 99 mg/l, the permittee shall be required to take immediate action to prevent concentrations from increasing. If corrective measures fail to prevent chloride concentrations from exceeding said level in the future, permittee shall relinquish the option to perfect additional allocated quantities regardless of the stage of development.

6) A certificate of water right shall not be issued until a final investigation is made.

Public Water Company C

In July 1988, a public water company applied for ground water to supply a community development in south Whidbey Island. The production well is located 1700 feet from the coast, and is drilled to a depth of approximately 40 feet below sea level. The application was not addressed until February 1992 due to the fact that a Seawater Intrusion Policy was not in place until this time. Investigation of the application consisted of a field examination during which chloride levels were measured, office research including review of existing water rights within a half-mile radius of the production well, and information supplied by the applicant. Chloride levels measured in the well between 1984 and 1992 ranged from 110 mg/l to 140 mg/l. Wells within a half-mile radius, though not exhibiting high risk chloride levels, have shown readings of over 99 mg/l. The Seawater Intrusion Policy indicates that the subject well lies within a medium risk area; on this basis, the report writer recommended in April 1992 that the permit be denied.

In May, following a conversation with the applicant, the report writer agreed to an extension of time on an application decision during which the applicant had the opportunity to alleviate high chloride levels. Water Resources granted the extension on the basis that the applicant had not exceeded 5000 gpd during the application period, the maximum allowable withdrawal

without a permit. Water Resources staff also believed that the applicant's proposed appeal of the decision would result in an extension. The report writer allowed the applicant until October 1992 to re-sample the well and submit an August chloride reading to Water Resources, at which time an amended report of examination would be issued.

These cases are representative of the current challenges of and decisions made in the NWRO in handling water rights in seawater intrusion risk areas. In Island County, approximately 20% of the water right applications in seawater intrusion prone areas have been denied, though about half of the applicants in these cases have been granted opportunities to alleviate high chloride problems (as outlined in public water companies A and C, for example) (Fritzen, 1992). Most of these applications are several years old and were submitted before a seawater intrusion policy had been developed. As new applications are received, the Island County report writer is able to notify the applicant immediately as to whether the application is in a medium or high risk area based on other chloride readings in the area. The applicant knows from the outset of a probable denial, thereby avoiding unnecessary effort and aggravation.

Standardized Procedure

The NWRO uses the Seawater Intrusion Policy and standardized provisos (numbers 2 through 5 listed above) in water permits for intrusion prone areas. In addition, the NWRO developed other standard procedures for handling applications with greater fairness and expedience. In two cases where the report of examination recommends that the permit be denied and in which the applicant has been waiting a number of years for Water Resources to make a decision, the Island County report writer has granted an extension on application review until the following August when a new chloride reading can be taken. August, as the month of highest water use and lowest ground water recharge, is assumed to be the time of year when chloride levels peak. This gives the applicant a chance to lower chloride to allowable levels in the intervening time, renewing his or her prospects for application approval. A standard "August chloride" letter is sent in this case. During this time, the applicant must not pump in excess of water permit exemption limits.

A preliminary permit letter to be used for wells within seawater intruded basins in Island County has also been developed. In addition to fulfilling the conditions outlined in Step 5 of the application process, the applicant must also submit a report detailing information required in "Criteria for Establishing Lack of Influence of Proposed Withdrawals With Respect to Seawater Intrusion Within Island County." This document explains that, in attempting to prove that granting a water right to the applicant will not increase the risk of seawater intrusion in the basin, the applicant must supply the following (Department of Ecology, 1992):

1) Copies of available water well reports for wells located within a half-mile radius of both the proposed withdrawal point and the high chloride well. Information on surface

elevations and a map indicating well locations for wells within this half-mile radius should also be included.

2) Two geologic cross sections passing within relevant distance of the applicant's well, with section lines tending roughly 90 degrees to one another. These section lines should extend a minimum of one mile (or to the coast if this distance is less than a mile) from both the proposed withdrawal point and the high chloride well. These sections should depict subsurface geology at least as deep as the deepest well in the area and should also attempt to delineate the boundary between fresh and saline water (this is defined as water with 100 mg/l of chloride).

3) Chloride and static water level data compiled for at least two wells withdrawing water from the same aquifer as the proposed point of withdrawal. These wells should be located within a half-mile radius of both the proposed withdrawal point and the high chloride well. A trend analysis of the data should be performed in order to demonstrate that chloride levels have not increased and static water levels have not decreased significantly over time. The data should also be presented in hydrograph form.

4) A hydrogeologic interpretation including:

   a. A discussion of trends of both chloride and static water levels within the aquifer proposed for further withdrawal. Additionally, static water levels for the area should be analyzed in order to determine any ground water gradients.

   b. A water balance analysis indicating the relationship of recharge versus consumption in the area.

   c. Convincing arguments that granting of the water right will not lead to seawater intrusion. This might include a discussion of supporting evidence that indicates that the area is underlain by two or more discrete aquifers.

Standardization of procedures has made the NWRO's application process more rapid and efficient. Historically, there has been a tendency to handle each case independently; while this certainly allowed a tailored response to each applicant, it has proven ultimately infeasible given the number of applications received combined with limited staff resources.

The Southwest Regional Office

The Southwest Regional Office has jurisdiction over the following coastal counties: Clallam, Jefferson, Grays Harbor, Mason, Pacific, Thurston, and Pierce. (See Figure Six.) Evidence of seawater intrusion has been documented in areas such as Marrowstone Island (Jefferson County), Horsehead Bay and Gig Harbor (Pierce County), and Johnson Point (Thurston

County). This Office does not receive the volume of applications received in the NWRO. The population in these counties is less than half the population in the counties covered by the NWRO (Department of Commerce, 1991). As might be expected, the SWRO encounters fewer ground water applications in seawater intrusion prone areas. As of July 1992, the office had a backlog of approximately 70 applications in intrusion prone areas, which are two years old on average (Davidson, 1992). From receipt of application, it takes an average of fourteen months to make a water right decision; the evaluation of the application, including aquifer test, takes between six months and one year.

The following case study is fairly representative of the Office's response to applications in seawater intrusion risk areas. Though the Seawater Intrusion Policy is used, it is not cited as heavily as in the NWRO.

Water Permit Decision Case Study

In October 1990, a public water company in Gig Harbor applied for a water right to withdraw more than 11,000,000 gpd from three wells for a community development. A preliminary permit was issued in March 1991 allowing construction of one of the wells with stipulations outlined in Step 5 in the application process. Field investigations were conducted in December 1991 and January 1992 and included a pump test of the subject well, during which chloride levels were measured at 5 mg/l, though a pre-existent well in the system has manifested chloride levels of 146 mg/l. In addition, monitoring of pre-, post- and during test water levels in nearby wells was performed. Given a number of neighboring wells and existing water rights, well interference was considered a potential (and in one case, actual) problem. Because of the potential for elevated chloride levels as well as interference with other wells, strict monitoring of the subject and planned wells was recommended in the report of examination as a condition of approval. The application was approved in May 1992 with the following seawater intrusion-related provisos:

1) Installation and maintenance of an access port...is required.... Water levels shall be measured and recorded using a consistent methodology, in accordance with accepted industry standards. Such measurements shall be made at least monthly. The length of the pumping period or recovery period prior to each measurement shall be constant, and shall be included in the record.

2) An approved metering device shall be installed and maintained.... Meter readings shall be recorded at least monthly.

3) A certificate of water right will not be issued until a final investigation is made.

4) Testing will be required of both Well #1 and Well #2, and withdrawal quantities may be reduced commensurate with testing results, prior to certification of this permit.

5) Quarterly monitoring is required as a provision of this permit; any increases from the current chloride of 5 mg/l...will be considered significant and management of the production rate through reduction of pumping rate, or raising of the pump intake, will be required.

6) The applicant is reminded of the responsibility towards other water users in this area, and advised that regulation of the withdrawal and pumping rate will be required if existing rights are injuriously affected.

With regard to pending applications for ground water withdrawals in high risk areas, staff indicated that many would be denied on the basis of the Seawater Intrusion Policy.

Other Standard Provisos

In the SWRO's list of standard provisos, there are two which deal specifically with intrusion prone areas, one called the "Chloride Concentration" proviso and the other called the "Seawater Intrusion" proviso. They are both modifications on Proviso 5 listed immediately above. Both require quarterly monitoring in conjunction with DOH sampling by a lab accredited by Ecology. Interestingly, one proviso lists 50 mg/l as a corrective action level, and the other lists 125 mg/l as an action level. Staff in the office was unable to explain the reason for this, though suggested it might be due to a disparity in opinion as to what constitutes a problem level, or perhaps to the fact that the provisos have not be reviewed and amended recently.

One other directly relevant proviso used in the SWRO is the "Water Resources Act" proviso:

> The Water Resources Act of 1971 specifies certain criteria regarding utilization and management of the waters of the State in the best public interest. Favorable consideration of this application has been based on sufficient waters available, at least during portions of the year. However, it is pointed out to the applicant that this use of water may be subject to regulation at certain times, based on the necessity to maintain water quantities sufficient for preservation of the natural environment.

Because of the low volume of applications for public water supply in seawater intrusion prone areas relative to that of the NWRO, and the comparatively low backlog, the SWRO has not developed as many standardized procedures for handling these applications, though the Office did provide the model for the standard preliminary permit letter (Step 5 of the application process). The Seawater Intrusion Policy, the preliminary permit letter, and provisos provide the basis for response to applications in intrusion prone areas.

Chapter Nine. Analysis and Recommendations

The foregoing chapters have attempted an objective description of Water Resources' historic and current seawater intrusion prevention efforts as well as supportive legislation. This chapter presents a more critical look at those efforts in light of resource, organizational, policy, and political considerations. Specifically, while Water Resources has made large strides in intrusion control efforts, its Seawater Intrusion Policy not least among them, there are well-defined obstacles to its continued and ultimate success in this area.

Resource Constraints

Primary among the resource constraints is a lack of dedicated or consistent funding. In the 1991 legislative session, for example, Water Resources received a 30% increase in funding, which was spent primarily to salary additional report writers and hydrogeologists in the regional offices. Soon after, Ecology as a whole experienced a 2.5% funding decrease, also determined by the legislature. While the new staff was retained, temporary help, interns, and the Washington Conservation Corps (six individuals in the SWRO) were lost; these people had provided invaluable assistance in examining water right applications and, due to their departure, many of these functions returned to the report writers and hydrogeologists. A similar number of temporary positions and interns was lost in the NWRO. Thus, the financial assistance provided initially was undermined by a later contrary decision. This deficiency in dedicated, consistent funding has been a chronic problem in Ecology historically, and has resulted in projects which are not fully realized, and staff with unrealistic workloads. This leads to inefficiency and incomplete efforts.

Because of inadequate staffing support, staff involved in reviewing and deciding on water right applications have had scarce time for follow-up on regulatory practices with regard to water permit approvals. Though staff issues provisos which provide appropriate and critical guidelines which applicants are to fulfill in developing and perfecting their ground water withdrawal, the goals of which are sustainable development and protection of the aquifer, staff is unable to monitor compliance with these provisos. The report writer for Island County is only able to perform the minimum necessary level of field work for project examinations during the application process, and is not able to perform follow-up monitoring. The applicant is like a speeding motorist who, on seeing the roadside police car, slows down, but speeds up again when out of sight. Though state and (in some cases) county health departments perform monitoring, these agencies are monitoring for public health concerns (at which an action level for chloride concentration is 250 mg/l), not for aquifer degradation concerns (at which action levels are considerably sooner, as set forth in the Seawater Intrusion Policy). More significantly, these efforts are not comprehensive: the DOH monitors approximately 13,000 public water systems with two or more service connections in the state (Deem, 1992). Island County Health Department monitors only ten wells for seawater intrusion on a routine basis, and these through a grant from Ecology (Deem, 1992). While Island County attempts to monitor its public water systems in a fairly consistent way, it

does not have the staff resources to enter and track this data. Most county health departments have no on-going well-monitoring program. One potential solution is to have dedicated citizen volunteers perform monitoring activities, as well as computer entry of the results. This raises a host of issues such as training, equipment, scientific viability of the results, and bias in testing. There are citizens willing to do this testing (Abbott, Sinclair, 1992), and it may be preferable to insufficient monitoring.

Data management also suffers due to lack of staff. While many appropriators submit quarterly or semi-annual chloride readings and monthly static water levels, many of these data are never entered on Water Resources' database. This database was created in 1989 with information provided from the USGS, the DOH, Island County Health Department, and Water Resources and provides the basis for a data management system. Unfortunately, there is little time to actually enter the data, so that as a tracking tool, the database is not particularly useful. Tangentially, a Water Resources Data Management Task Force was created in 1990 to evolve a strategy for successful data management; progress towards this goal has been fairly consistent since the Task Force's inception. A major weakness in Water Resources' approach to seawater intrusion is that the Program has not made a sustained commitment to developing a water quality, water level, or water use monitoring program for seawater intrusion prone areas. Without consistent and reliable data, it is very difficult, if not impossible, to forge a defensible and proactive water management and allocation program.

It is also not uncommon for appropriators to use more water than was granted them (as in the case of "Public Water Company A"); alternately, Water Resources has little knowledge of relinquished rights, cases where appropriators are no longer using the amount originally granted. (If allocated water has not been put to a beneficial use, the state has the authority to rescind the water right.)

In another example of staffing inadequacy, there is only one well drilling coordinator in each of the Northwest and Southwest Regional Offices. In the SWRO, that translates to one person monitoring well construction (for permitted *and* exempt wells) for twelve counties, in which there are approximately 120 well drillers. The well drilling coordinator in the NWRO indicated that he receives approximately 400 start cards per month, and is able to observe construction on about 3% of these wells (Thompson, 1992). Because of this glaring lack of staff in well construction compliance monitoring, the effort has lost public credibility (Thompson, 1992). Wells are at times drilled illegally or their locations are inaccurately reported on the well drilling reports. It is difficult to know how often this occurs, but a 20% incidence rate is estimated (Thompson, 1992). Most of the well drilling coordinators' site visits are motivated by complaints or "tattling" by other well drillers. In addition, there is no enforcement of well construction standards in seawater intrusion prone areas; WAC 173-160-020(1) stipulates additional construction standards in these areas. For example, non-corrodible casing should be used, yet this is not enforced.

To make matters worse, both the NWRO and the SWRO are experiencing an increase in applications submitted. This is due to a number of factors, the most obvious of which is

increased population growth in many coastal and island regions. Additionally, two thirds of the growth occurring in Washington in the last decade is situated in rural settings (Ecology, 1991). These settings offer few municipal suppliers, the result being more applications for smaller systems. The current drought has also motivated more applications, as well as the need for report writers to perform more enforcement activities. Finally, growth management legislation has increased the number of applications filed. The combined effect of these factors has been an increase of approximately 50% in ground water applications from 1985 to 1991 (Ecology, 1991), an irritated public, and an overwhelmed staff.

It is obvious that resources for staffing must be increased, because workload certainly is increasing. The laudable goals and policies of Water Resources mean very little if practice does not reinforce them. One solution is to increase application processing fees, which are abysmally low compared to the Water Quality Program's wastewater discharge permit fees, or the DOH system approval fees, for example. Water Resources application fees currently shoulder less than one percent of administrative costs (Walsh, 1992).

Organizational Constraints

Internal Organization

The internal organization of Ecology should be improved in order to support Water Resources' efficiency and administrative success. In making a water right decision, there are potentially (too) many reviews which the application must undergo; the application may get stalled at one of these reviews, thus increasing decision time. A shift should be made towards greater decentralized control, vesting the report writer with more decision making authority. Certainly this individual should not operate in a vacuum, though over-control should be avoided. One might consider the regional offices at the DOH as an example of a more decentralized operation.

Secondly, there is very little information sharing between the NWRO and the SWRO. Both offices are in the process of implementing the Seawater Intrusion Policy. It makes infinite sense that they share information and methods in a more continual way in order to develop greater efficiency, consistency of response, and agency camaraderie and morale. The standardized preliminary permit letter is an example of the NWRO building on something developed in the SWRO. This type of sharing should be the norm, not the exception.

Seawater intrusion is an issue which, though its cause is a resource shortage, has as its effect a water quality problem. Because of this, seawater intrusion is a concern of both the Water Resources and the Water Quality Programs in Ecology. Unfortunately, Water Resources' staff attempts to involve Water Quality in an ongoing way have met with no real success. As mentioned in Chapter Five, Water Quality's purview is in large part to issue waste discharge permits for industries and municipalities, and chloride is one of the water quality elements the Program reviews. Recently, Water Quality has begun to monitor ground water in wastewater

discharge areas. This information could be shared with Water Resources to augment its knowledge of regional aquifers, and to notify Water Resources as to discharge sites and quality issues within these areas. This overlap in Program responsibility touches on a more formidable question: Should Water Resources be issuing ground water permits and therefore implying a clean source of water, yet with no actual knowledge of ground water quality? This is a potentially very dangerous situation for Ecology, though has not yet proven problematic. For example, what if a permit was issued for a seemingly pure source of ground water, yet the source contained toxic contaminants? Greater coordination between the two Programs would at least mitigate the potential for this very serious problem.

Inter-Agency Coordination

The DOH's Drinking Water Division is responsible for public water system approval in the state. As such, its role fits snugly with Water Resources' water permit approval role. Until recently, there was little coordination of efforts between the two agencies. What occasionally happened was that the DOH would issue a system approval, the development would be built, and the developers would apply for a water right only to find that there was no water available. In late 1991, the DOH reinforced existing policy by stating that it would not consider a public water system approval until the applicant had been granted a water permit, thus water availability and water system approval are now more closely coordinated. While Water Resources has an *ideal* turn around time of six to nine months (as mentioned, it has historically been quite a bit longer), the DOH's Northwest Drinking Water Division has an *actual* turn around time of six to eight weeks (Deem, 1992). This causes frustration among applicants, and greater pressure for Water Resources.

Additionally, the two agencies have recently agreed on a unified aquifer test. According to this agreement, the applicant would only need to do one aquifer test to satisfy both departments' requirements. When Water Resources sends its preliminary permit letter, the elements required by the DOH are also included. If the period between the time of the aquifer test and the time that the applicant applies for system approval is great (i.e. if water right application review is lengthy), water quality conditions may change and the aquifer may have to be re-sampled. This has not yet been a problem, and hopefully, with Water Resources attempt to expedite the water right decision process, will not be.

This progress in Water Resources-DOH coordination is quite positive, however, due to a different agency mission, the DOH has chosen not to help directly with seawater intrusion control. In practice, the DOH will only deny a public water system approval if chloride levels exceed 250 mg/l, the point at which they cause an aesthetic (i.e. taste) problem; the Department will not typically deny project approval at levels at which Water Resources has determined as medium to high risk (i.e. 100 mg/l and above).

The EPA has a role in regulating seawater intrusion through its Wellhead Protection and Sole Source Aquifer programs, as explained in Chapter Five. However, this control is fairly minimal. Through its Sole Source Aquifer Program, the Agency has the power to deny

federal financial assistance for a project in EPA designated Sole Source Aquifer areas. The preponderance of private funding, few Sole Source Aquifers, and the probability that many projects are not sent to the EPA for review limits the Agency's role in preventing seawater intrusion. The EPA has even less regulatory control through its Wellhead Protection Program. In this instance, localities are encouraged to address seawater intrusion concerns in their wellhead protection plans, though there are no strict requirements or parameters set forth. It is also important to recognize that both of these programs are intended to protect public health. Natural resource protection in and of itself is not the primary concern. In areas threatened by seawater intrusion, aquifer protection is tied to appropriate resource allocation; since allocation is expressly a state responsibility, the EPA cannot be directly involved at the most useful level.

Primary responsibility for seawater intrusion control, in as much as it finds its cause in over-allocation of ground water, rests with Ecology. Other state, federal, and local agency support is, however, absolutely necessary to the success of this effort.

Policy Constraints

Water Permit Exemption

RCW 90.44.050 provides for an exemption from the permitting process for ground water withdrawals of less than 5000 gpd or for irrigation of less than one-half acre. In areas where increased aquifer protection is necessary (e.g. seawater intrusion risk areas), this exemption has proven particularly troublesome and is sometimes referred to as the "5000 gpd loophole." In practice, Water Resources has much less regulatory control over these wells; for instance, no ongoing monitoring or report submission is required of the well user in these cases. Though RCW 90.44.250 grants Ecology the authority to make periodic investigations concerning these wells, in practice, it typically only happens when these wells lie within a half-mile radius from a water right applicant's well. In addition, Water Resources sometimes has inaccurate or no records regarding these wells. According to one report writer, there are "zillions" of exempt wells of which Water Resources has no knowledge. WAC 173-160-205(2) stipulates that wells not be located within certain distances of contaminants, yet Water Resources has little control over this in many cases. In short, Water Resources' charge to properly allocate and manage the ground water resource is undermined by this exemption.

To complicate matters, county health departments (which approve smaller water systems) have a coincident exemption whereby, in most counties, single and double unit wells are exempt from monitoring practices, and, in some cases, exempt from the well site approval process. No county or state agency has an organized plan to monitor these wells at this point in time. While one may argue that county health departments should amend their policies to include regulation of these wells, because the motivation is aquifer protection, it is really more appropriate for Ecology's policy to be revised.

A number of responses have been developed to this problem as follows:

- **Lower or eliminate the exemption**
  Given the large number of exempt wells coupled with the already large number of applications, this change would increase workload and counteract Water Resources' current efforts towards efficiency.

- **Eliminate the exemption in island settings**
  This again would be an unrealistic workload increase given Water Resources' limited staffing levels.

- **Close certain areas to further ground water development through regulation**
  This has actually been done in certain sub-basins of the Methow Valley and in two basins within Kitsap County, however the processes were quite lengthy and cumbersome.

- **Close areas with certain characteristics to further ground water development through the Seawater Intrusion Policy**
  It has been suggested that the Policy be amended to prevent new wells from being allowed within half-mile radii of certain critical risk intrusion areas (to be defined based on current development in area, chloride levels, etc.), or that only in-house or septic uses be allowed. This would give Water Resources direct and continuing control in these decisions; this is preferable to applying to the state legislature on a repeated basis.

Seawater Intrusion Policy

While creation and implementation of the Seawater Intrusion Policy was certainly a progressive step, the Policy has shortcomings. Although it provides a regulatory mechanism for seawater intruded areas, and a half-mile sphere of influence radius, it lacks a comprehensive focus. For example, at the same time that it may prevent operation of a coastal well, the Policy never directly addresses or provides guidelines to control the potential causes for the coastal contamination such as inland development and the paving of ground water recharge areas. In the Johnson Point area of Thurston County, high chloride levels have been observed around the peninsula concurrent with inland development (Sinclair, 1992). To the extent that the Policy deals with an effect (i.e. elevated chloride levels) and does not specifically address the potential causes, it is a band aid solution, or, at best, an initial step.

Along similar lines, the Policy sets forth no plan for distinguishing among different types and volumes of use in its guidelines. In a case where an industry and a municipality are both applying for a limited supply of ground water, who has precedence? In short, there is no prioritization of beneficial uses. Perhaps an industry and a smaller domestic user are competing for ground water; who has precedence in this situation? A water right denial made without consideration of this imbalance may constitute an inequitable denial. These questions

pertain not only to cases of seawater intrusion, but to water right decisions in general. With increasing hydrogeologic data, the perception of ground water as an "unlimited" resource is shifting, and questions of prioritization must be addressed. Washington water law does provide a means for prioritizing uses through a "maximum net benefits" test (RCW 90.54.020); however, Ecology has not exercised this authority (Walsh, 1992).

A third concern is that, as applicants are denied permits based on the Seawater Intrusion Policy, they will increasingly turn to exempt wells, building the number of exempt wells needed to fulfill the demands of their project (as long as the connections to these wells are not intertied, this is legally permissible). This response counteracts the purpose of water rights, which are used to properly allocate the ground water resource. Also, if a denied applicant opts to build a number of exempt wells, then Water Resources loses ongoing and programmatic control over these wells. This is a good argument for either eliminating exemptions in certain areas, or closing areas to further ground water development. Otherwise, or until this happens, granting a permit in an effort to maintain more direct control is perhaps the preferable option. Finally, the building of exempt wells undermines the coordinated water supply plan of several counties (including Island County) to have larger, more centralized water systems.

Growth Management Legislation

Growth management legislation, the intent of which is to coordinate land use and water availability, is welcome and overdue. RCW 19.27.097 stipulates that "each applicant for a building permit of a building necessitating potable water shall provide evidence of an adequate water supply for the intended use of the building." This is good as far as it goes, however there is no seawater intrusion provision. In determining potability, at least regarding chloride levels, concentrations below 250 mg/l typically fulfill this requirement. While Ecology's Seawater Intrusion Policy may preempt this guideline in uses requiring a permit (a permit is deemed one method of showing adequate water supply), it does not apply when the permit applicant's water needs fall into the exempt category. Some mechanism is needed for employing the Policy in exempt situations.

One possible vehicle is the implementation of the Seawater Intrusion Policy on the county level. This could be applied either in the planning department, where building permits for smaller developments are issued, or in the health department, where well site review for single unit domestic needs is conducted.[10] As part of growth management legislation, Water Resources may currently notify counties of problem ground water areas and advise zoning limits in these areas. There is no enforcement clout behind this, however. A second option, at least in Island County, is to implement the Seawater Intrusion Policy in the Ecology-Island County Memorandum of Understanding.

[10]Not all counties perform this function. Island County is a notable exception and, hopefully, a model.

Political Context

The political environment ultimately determines which policies are enacted and the success of their implementation. Seawater intrusion prevention or control is, in practice, a politically difficult policy, for its implementation may curb growth in tremendously desirable areas. It is particularly difficult for a county to enforce this type of policy, especially if (and this is not unusual), a majority of its commissioners have land development or real estate interests (Abbott, 1992). Additionally, counties are caught directly in the cross-fire between no growth and development advocates. On the state level, Ecology is in a sensitive position; implementation of the Seawater Intrusion Policy (synonymous for some with denying growth) will cause some undeveloped properties to have significantly higher costs for securing alternative water supplies, whereas existing properties will be protected. However, not implementing the Policy would negatively impact every piece of property eventually. Ecology is charged with overregulation by one faction, and with not doing enough, by another. Though this has not (yet) happened, the Department could be charged with "wrongful taking" of land, in the same way that "wise use" groups are charging that the Endangered Species Act restricts their private land use. Ecology walks a thin tightrope, and must be sensitive and deliberate in its seawater intrusion policy.

General Recommendations

Coupled with the recommendations implicit in the foregoing analysis, more general recommendations deserve mention. Though this may seem obvious, education and conservation efforts should be increased. Statements such as "we don't need to ration, we're on ground water" are particularly troublesome, though not uncommon, especially in the current drought. In addition, newspaper articles speculating a potential enormous (as to imply unlimited) ground water source in an, as yet, untested aquifer are misleading at best (Seattle Post-Intelligencer, 1992).

Water Resources' current educational efforts with regard to seawater intrusion includes a staff-presented slide show, and a brochure entitled "Seawater Intrusion - What Does it Mean to us?" Solicitation of other agencies' assistance in this effort is a natural next step; the EPA, for example, could sponsor a regional seawater intrusion educational conference or provide printed educational materials (Mullen, 1992). On a local level, concerned citizen groups could hold informal workshops. As a conservation measure, water meters should be required for all existing wells (though they have recently been required for new wells, a plan for retrofitting existing wells has not been implemented). Monthly water use charges might also be considered as an effective method for inducing conservation practices among users (Bowen, 1992). Water Resources' current conservation projects (such as water reuse) could be enhanced through coordination with other state and federal water conservation programs. For example, the EPA has a section working on water use efficiency and reuse which could assist in Water Resources' efforts. This type of cooperation on every level, from land use planners to water system reviewers to public utilities to concerned citizens, is crucial; without this cooperation, the most well-meaning policy will fall on its face.

Chapter Ten. The Importance of Seawater Intrusion Prevention

It is critical that Ecology, with the assistance of appropriate agencies and other groups, works to overcome the obstacles discussed in the foregoing chapter in order to adequately prevent or control seawater intrusion. Otherwise, there may be serious consequences. Once an aquifer has been contaminated by seawater, a vast water supply has been compromised and the clean-up process is incredibly costly, as well as lengthy. On a human time scale, aquifer contamination by seawater is an irreversible condition (Custodio, 1987). The aquifer must first be flushed of salt water. Then, any salts trapped in half shut pores must be extracted. Large quantities of fresh water and sophisticated equipment are required for this process.

Planning

The best time to engage seawater intrusion prevention efforts is before intrusion occurs. This may seem obvious, yet historically, aquifer development plans have often been implemented with little thought to this potential problem. It is critical that knowledge of aquifer geology is obtained before the aquifer is exploited. From this, a plan for preventing salinization and seawater intrusion should be created as well for maximum exploitation of the aquifer without promoting intrusion. Several guidelines should be observed in developing these plans (Custodio, 1987):

- Concentrated withdrawals should be avoided in coastal aquifers.
- In all cases, aquifer mining should be avoided.
- In cases where a shallow fresh water layer or lens floats atop underlying salt water, withdrawals should be minimal.
- For aquifers below sea level, avoid localized and consistent depletion of the aquifer.
- Where there is considerable tidal fluctuation, a "pump and rest" schedule should be implemented.
- When semipervious or impervious layering protects the aquifer, this should be maintained to the extent possible.
- Well construction should be conducted with a minimum of damage to protective layering, and wells should not allow vertical leakage from one aquifer to another. Well casing should be made of materials resistant to salt water corrosion.
- Leaky wells should be repaired immediately; cement or some other impermeable material should be used to plug the holes.

- When a well is abandoned, it should be plugged with bentonite clay or cement to avoid salt water upwelling.

- Chloride should be monitored during the life of the well.

- In all cases, recharge sources must be protected.

Corrective Actions

Artificial Recharge

Corrective actions taken once seawater intrusion has become a widespread problem can be tremendously costly and, in some cases, infeasible. One method that is used to mitigate seawater intrusion is the recharge of the aquifer by artificial means. Possible sources of recharge include wells, flood and river water, flood control structures, imported water, and treated sewage water. In considering this method, an immediate question arises: Should the new water be applied for recharge or go directly to fill demand? The answer to this depends on several factors such as duration of need, location of water source, water quality, and means of transportation and storage.

If it is feasible, artificial recharge by surface spreading is preferable to well injection (Custodio, 1987). As the surface water filters through the unsaturated zone towards the aquifer, soil and underlying material attenuate some contaminants, protecting the aquifer from certain pollutants. Surface spreading is also generally an easier method. It becomes problematic when the aquifer surface area is small, or when there are semi-pervious layers between the ground surface and the top of the aquifer. In considering aquifer recharge, data on the specific characteristics of the aquifer must be obtained; information from one aquifer cannot necessarily be transferred to another.

Barrier Walls

Creating underground barriers is a more direct method for correcting seawater intrusion. This option allows the maintenance of existing exploitation levels while at the same time alleviating intrusion. This barrier extends the vertical length of the aquifer on the coastal side, and can be made from clay, cement, sheet piles, concrete, or asphalt. It can also be made by pressure injection of these materials into existing consolidated or unconsolidated material. In either case, the process is quite expensive. Maintenance costs must also be weighed, especially when the area is subject to earthquake shock. There are no existing examples of these types of barriers; all such proposals have been abandoned following a benefit-cost analysis and feasibility study (Custodio, 1987). Additionally, barriers are not feasible in island settings given that seawater intrusion can be omni-directional (Walsh, 1992).

The injection hydraulic barrier is a second type of corrective device. A series of wells is established along the coast, and these are injected with fresh water to maintain a sufficiently high fresh water head to alleviate intrusion. A procedure of withdrawing salt water is often used in combination with fresh water injection. In confined aquifers, or those with semi-pervious layering, hydraulic injection barriers may be the only method available. This too can be a costly method given the expense of wells and accessories, as well as the fact that water for injection must be clean since any impurities will clog the wells.

There are several critical factors to review before choosing an injection hydraulic barrier (Custodio, 1987). The quantity and quality of water needed for the project must first be determined; the amount of water needed to create and maintain this barrier must be established as well as the adequacy of the water quality for the method chosen. Assuming that the water needed is available, one must decide whether to apply this water to directly meet existing uses and consequently reduce ground water withdrawals, or whether it should be injected into the aquifer. It is then important to consider the operational life of the facility and potential maintenance problems. Finally, benefit-cost and feasibility analyses should be performed. A pilot field test is helpful to understand and anticipate the complexity of the system.

A third option is the pumping hydraulic barrier. This is somewhat similar to an injection hydraulic barrier, though without an injection of fresh water; the purpose of the wells in this case is to withdraw seawater as it approaches land. In this scenario some fresh water is lost as it mixes with the extracted salt water, and the aquifer becomes completely salty between the pumps and the ocean. This is best as a temporary solution in aquifers where intrusion has occurred; the wells are normally drilled in the intruded area. Once the situation is somewhat ameliorated, it is best to switch to another method such as artificial recharge or reductions in extraction. Possible violation of coastal water rights must be considered in reviewing this option.

One last method addresses prevention of upconing. In this case, a second well is created at the site of the fresh water well for the purpose of pumping salt water, thus creating a delicate balance of the salt water/fresh water interface. There are few existing examples of this, the main drawbacks being the cost of the second well, the energy required, the great amount of salt water extracted and dealing with its safe disposal. In addition, small pumping irregularities can lead to the contamination of the fresh water. The costs and high risks make this option undesirable.

Costs of Remedial Efforts

There are also powerful economic effects of seawater intrusion. For example, the abandonment of a current project generates the need to access other water sources. This may involve the building of new and possibly longer canals and pipes to carry the water. In addition, there is a higher energy cost involved because the new sources are often at deeper

levels, thus pumping costs are greater. Developing new sources, wherever they may be, is an expensive business. A development of approximately 175 lots on Center Island in San Juan County, for example, had a reverse osmosis unit for its contaminated water system installed several years ago (Bankson, 1992). The unit pumps seawater directly, then removes the salts to make it potable. The installation costs of the reverse osmosis unit, pump, and filter were roughly $40,000 (Bankson, 1992). Each lot owner of the approximately 40 lots currently served by the system has agreed to pay $100 extra per year towards the capital and operating costs of this system. In addition, every lot owner in the development dedicates $35 per year of his or her yearly dues to a water fund for eventual expansion of the reverse osmosis unit, or development of other water sources (Bankson, 1992). Because of the costs associated with this unit, these individuals are paying $.01 per gallon for water which would normally cost them $.00001 per gallon. A number of families are installing reverse osmosis units in San Juan and Island Counties. Given the associated costs, it is clear that these are affordable to only a small segment of the population in these areas. An important philosophical question is raised: should clean water be the privilege of only those who can afford it, and at the expense of the less fortunate?

On a larger scale, Whidbey Island (Island County) has for several years considered extending to the central island the pipeline currently providing water to Oak Harbor from Anacortes. According to a 1990 study regarding a pipeline extension, the capital costs alone on such a project would be over $3,000,000 (Economic and Engineering Services, Inc., 1990). Given current population estimates of the area to be serviced by such an extension, the cost per person would be more than $700. Certainly the question of cost justification arises. A second, and possibly more central, issue also needs to be addressed. The water carried by the pipeline comes from the Skagit River, the majority of which is already appropriated; would there be enough water if the pipeline were extended, and how long would it last? Further, Island County's potential dependence on a resource outside of its jurisdiction would carry a relatively low reliability factor given the many competitors for the Skagit River resource.

In Orange County, California, the Orange County Water District manages an injection hydraulic barrier supplied by a combination of reclaimed wastewater, demineralized wastewater, and deep well water. The capital costs alone for this system, in 1973-74 dollars, were nearly $21,000,000 (Orange County Water District, 1987). In a county of this size, in a consistently arid environment, this cost is perhaps justified; a project of this scope in coastal Washington is not economically viable.

In extreme cases of seawater intrusion, actions such as those outlined above may become necessary. The high cost of such remedial actions underscores the need for immediate and sustained preventative action. It is critical that Ecology manage ground water resources in order to minimize, and hopefully prevent, the need for such remedial actions.

Chapter Eleven. Conclusions

The Department of Ecology has made great strides over the last decade in addressing an issue which has become a major environmental concern. Ecology has developed and adopted a seawater intrusion policy, and its regional offices have standardized and expedited their response to this problem as well as initiated coordination efforts with local counties. This is just a beginning; the policy must be refined through practice at the same time as broadened to adopt a more comprehensive scope. Through careful examination of this problem in policy and political contexts, one realizes that there are no easy solutions to seawater intrusion, though abundant possibilities. This report, in laying out Ecology's policies and practices in this area, has hopefully made this clear. One caution: however difficult seawater intrusion policy implementation is, non-implementation is far worse. In island contexts especially, the costs of remediation may be astronomic and economically infeasible; pumping hydraulic barriers, water importation, or other remedial measures may be economically unworkable. More importantly, a region which is experiencing chronic and extreme seawater intrusion has ceased to live sustainably with its available resources. Once this happens, it becomes dependent on unreliable external resources and loses direct control of its own viability. And, as we have seen in countless national and global situations, this is serious indeed.

Appendix A: Ground Water Equations

Darcy's Law:

$$Q = KA(dh/dx)$$

where Q = aquifer discharge, A = cross-section of aquifer area through which water flows, K = hydraulic conductivity of aquifer material, and dh/dx = hydraulic gradient

Ghyben-Herzberg Relation:

$$z = [p_f/(p_s-p_f)]h_f$$

where p_f = density of fresh water, p_s = density of salt water, h_f = elevation of fresh water above sea level (or potentiometric surface in confined aquifers), and z = the depth of the fresh-saline interface below sea level. Given that the density of salt water is 1.025 g/cm^3 and the density of fresh water is 1.000 g/cm^3, the relation can be simplified as

$$z = 40h_f$$

Hubbert's Equation:

$$z = [p_f/(p_s-p_f)]h_f - [p_f/(p_s-p_f)]h_s$$

where h_f = height of water level in a fresh water well of density p_f and terminated at point z, h_s = height of water level in a sea water well of density p_s and terminated at point z

Relative salinity (S_R) of an aquifer:

$$S_R(\%) = 100[(c-c_f)/(c_s-c_f)]$$

where c = salinity at a specific depth in the transition zone, c_f = salinity of fresh water, and c_s = salinity of salt water

Schmorak and Mercado equation:

$$z = Q/2\pi dk(\Delta p/p_f)$$

where z = rise of salt water-fresh water interface, Q = pumping rate, $\Delta p = p_s-p_f$, k = hydraulic conductivity, and d = distance from the well bottom to the sea water-fresh water interface

Critical rise above which the interface will accelerate towards well:

$$(.3 < z/d < .5)$$

Model developed to define maximum pumping level (the level at which water may be pumped without salt water entering the well, adapted from Schmorak and Mercado equation):

$$Q_{max} \leq \pi d^2 k(\Delta p/p_f)$$

Appendix B: Washington Department of Ecology Seawater Intrusion Policy

Preamble

- Groundwater is a finite and precious resource; in many coastal areas of Washington State, it is a critical source of water which cannot be readily replaced.

- Seawater intrusion is both a water resource and a water quality management issue, potentially affecting coastal aquifers throughout Puget Sound, the Strait of Juan de Fuca and the outer coast of Washington. Seawater intrusion poses aesthetic, public health, and environmental risks, as well as economic impact to public resources.

- The technical and economic feasibility of reversing seawater intrusion is uncertain, at best. Therefore, this policy calls for prudent management of the state's water resources via *prevention* of seawater intrusion for areas currently unaffected and *control* (i.e. stabilization and reversal) for areas where the problem has occurred.

- Ecology shall uphold the principles of resource conservation and sustained yield through its administration of water rights (Chapters 90.03 and 90.44 RCW). If a determination cannot be made with available information, Ecology shall direct the applicant to obtain the necessary data in order for the water right application to receive further consideration.

- Seawater intrusion is a complex problem to diagnose and resolve due to the fact that, in many cases, baseline data is lacking or not organized. Furthermore, the effects of seawater intrusion may not be evident where it is caused. Through this policy, Ecology seeks to improve the information base upon which water right decisions are based. In addition, Ecology will evaluate water right applications, to the extent possible, from the perspective of the overall hydrogeologic system.

- Water resource decisions need to be made in coordination with local governments and tribes, especially in consideration of water availability and land use provisions of the Growth Management Act.

I. Policy Purpose

The objectives of this policy are as follows:

1. To provide the Department of Ecology with a common definition of seawater intrusion.

2. To clarify Ecology's authority/role with regard to the seawater intrusion issue (including Chapter 173-150 WAC).

3. To prevent seawater intrusion in areas which are at risk.

4. To stabilize or reverse seawater intrusion in areas where the problem already exists.

5. To guide Ecology's administration of water rights vis-a-vis seawater intrusion.

6. To provide a technically sound and informed basis for decision making.

7. To ensure state/local government consistency with regards to implementation of water availability and planning provisions of the Growth Management Act.

II. Legal and Administrative Authority

The Department of Ecology has clear statutory authority to prevent and control seawater intrusion under the following codes:

- **Water Well Construction Act - Chapter 18.104 RCW**

  Provides the Department of Ecology with authority to establish and enforce well construction and maintenance standards, license well drillers, require reporting of well construction, and restrict well drilling in sensitive areas to protect the groundwater resource.

  Associated regulations:

  Minimum Standards for Construction and Maintenance of Wells - Chapter 173-160 WAC

- **Regulation of Public Ground Waters - Chapter 90.44 RCW**

  Extends prior appropriation doctrine to groundwater withdrawals. Requires a permit for groundwater withdrawals. Stock-watering, lawn or noncommercial garden, and single or group domestic uses (in an amount not to exceed 5,000 gallons per day) are exempt. Establishes Ground Water Management Area Program.

  Associated regulations:

  Ground Water Management Areas and Programs - Chapter 173-100 WAC

Protection of Withdrawal Facilities Associated with Ground Water Rights - Chapter 173-150 WAC

- **Water Pollution Control - Chapter 90.48 RCW**

  Establishes state policy with regards to groundwater quality, i.e. to retain and secure high quality for all waters of the state. Regulations (173-200 WAC) adopted pursuant to this statute define secondary maximum contaminant level (MCL) for chloride at 250 mg/l and provide for the establishment of an early warning value. The groundwater quality standards also articulate an antidegradation policy.

  Associated regulations:

  Water Quality Standards for Ground Waters - Chapter 173-200 WAC

  Water Quality Standards for Surface Waters - Chapter 173-201 WAC

- **Water Resources Act of 1971 - Chapter 90.54 RCW**

  Sets forth fundamentals of water policy to ensure that state waters are protected and fully utilized for the greatest benefit of the people. Broadly defines beneficial uses of water. Prescribes maximum net benefit test to be applied to allocation of water among potential uses and users. Emphasizes water use efficiency and conservation in the management of the state's water resources, recognizing potential to meet future needs.

The purpose of this policy is to supplement, not supersede, these authorities.

In addition to the aforementioned laws and regulations, Ecology has responsibilities or plays an advisory role under the following:

- **State Building Code - Chapter 19.27.097 RCW**

  Requires applicants for a building permit to provide evidence of an "adequate water supply". The county or city may impose conditions on building permits requiring connection to an existing public water system where the existing system is willing and able to provide safe and reliable potable water to the applicant with reasonable economy and efficiency. Under this statute, an application for a water right does not constitute sufficient proof of an adequate water supply. (Note: This amendment to the State Building Code has origins in the Growth Management Act)

Associated regulations:

Ecology may adopt rules to implement this section of the State Building Code.

- **Growth Management Act - Chapter 36.70A RCW**

  Requires state agency actions to be in compliance with local government plans prepared pursuant to the Growth Management Act. In terms of water right administration, Ecology must review and make permit decisions consistent with local government plans which establish urban growth boundaries and capital facilities.

Although Ecology has extensive authority, prevention and control of seawater intrusion will require a concerted effort with other state and local agencies, (especially the Washington Department of Health, local health departments, and planning departments) which have additional statutory and regulatory authorities. Ecology staff shall work in cooperation with these entities.

III. Application of Policy

This policy applies to withdrawals of groundwater in areas where a seawater-intrusion problem has been documented (e.g. through the Ground Water Management Area Program or through studies by the U.S. Geological Survey, Ecology or consultants) or in areas where natural conditions are such that groundwater withdrawals may create or aggravate seawater intrusion. This includes all groundwater systems which interconnected with saltwater bodies. This policy may be applied to coastal aquifers or groundwater supplies within any of the state's 15 coastal counties, especially those counties which are experiencing population increases and development.

This policy is intended to address seawater intrusion which is suspected to be or is caused by human activity only. In some cases, wells have been drilled in such proximity to saline groundwater that intrusion is unavoidable, regardless of steps taken to mitigate the problem. In other cases, seawater intrusion caused by natural processes, such as daily tidal or seasonal climactic changes, is cyclical and/or uncontrollable by human endeavors. In these situations, the only solution is relocation of the well or substitution of another water source.

Ecology's Water Resources Program regional staff shall refer to this policy for guidance in administration and regulation of water rights whenever a seawater intrusion risk has been identified.

IV. Definition of Related Terms

For purposes of this policy, a number of terms have been so defined:

Adaptive Management - A flexible management system which is applicable in situations where there is a lack of information or certainty about the causes or effects of a particular action or process. Essentially, hypotheses are tested and results evaluated. Management techniques are then adjusted to achieve the desired result.

Aquifer - Geologic materials capable of yielding a sufficient amount of groundwater to wells or springs for commercial or domestic purposes.

Ground Water Basin - a ground water reservoir that is more or less separate from neighboring ground water reservoirs. The ground water reservoir consists of an aquifer or system of aquifers that has reasonably well-defined geologic and/or hydrologic boundaries and more or less definite areas of recharge and discharge.

Public-Water System - Any water-supply system intended to provide water for human consumption or other domestic uses, including source, treatment, storage, transmission, and distribution facilities where water is furnished to more than one single-family residence or facilities, or is made available to the public for human consumption or domestic use. [1]

Saline Contamination - Occurrence of chloride in groundwater supplies at concentrations which exceed the specified maximum contaminant levels set forth by the U.S. Environmental Protection Agency.

Seawater Intrusion - Also known as "salt-water intrusion" is the infiltration of marine salt water into fresh water aquifers, resulting in chloride concentrations above background levels.

Single-Domestic Wells - Wells which are used to withdraw less than 5,000 gallons of water per day for single domestic use, including irrigation of up to 1/2 acre of non-commercial garden and/or lawn.

V. Problem Definition

Seawater intrusion, also known as "salt-water intrusion" is the movement of marine seawater into freshwater aquifers or other geologic formations capable of yielding groundwater. If

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[1] Source: State Board of Health - *Drinking Water Regulations* (September, 1989).

unchecked, seawater intrusion can lead to saline contamination of coastal groundwater supplies.

Seawater intrusion can be caused or exacerbated by human activity, i.e. via increased consumption of groundwater or a reduction of aquifer recharge. In coastal areas, growing consumption of groundwater associated with economic development and increasing population are increasing the risk of contamination of groundwater by seawater. Global warming and associated sea level rise are expected to compound the problem.

Increasing levels of chloride and specific conductivity are indicators of seawater intrusion. The Department of Ecology's Ground Water Quality Standards establish chloride as a secondary chemical contaminant at levels of 250 mg/l or more.

VI. Establishment of Risk Categories

For purposes of this policy, seawater intrusion risk shall be defined by water quality and hydrogeologic factors which are intended to guide the Department of Ecology's administration of water rights.

Since all wells within an island or coastal setting generally contribute to seawater intrusion to some degree, seawater intrusion risk is hereby approached from an areal perspective wherever possible. Where the ground water basin cannot be defined due to lack of hydrogeologic information, a minimum 1/2-mile radius will be used to delineate the ground water basin. These areas will be categorized as low, medium or high risk areas according to the following criteria. (Note: Where two or more risk areas overlap, the higher risk will take precedence. In island settings, all water wells will be assumed to be included in one of the risk categories.)

The risk categories and criteria for each are as follows:

Low-Risk Areas

a. A history of chloride analyses from the water well showing concentrations $\geq$25 mg/l and $<$100 mg/l (existing systems); or

b. Chloride concentrations from a test well $\geq$25 mg/l and $<$100 mg/l based upon a state certified lab test; or

c. Located within a ground water basin[2] where chloride concentrations are ≥25 mg/l and <100 mg/l.

Medium-Risk Areas

a. A history of chloride analyses from a water well showing concentrations ≥100 mg/l but <200 mg/l (existing systems); or

b. State certified lab tests from test well showing chloride concentrations ≥100 mg/l but <200 mg/l; or

c. Located within a ground water basin[3] with chloride concentrations ≥100 mg/l but <200 mg/l; or

d. Chloride concentration levels which are ≥25 mg/l but <100 mg/l, yet show evidence of an increasing trend as indicated through yearly monitoring or an aquifer test.

High Risk Areas

a. A history of chloride analyses showing concentrations ≥200 mg/l (existing systems); or

b. State certified lab tests from test well showing chloride concentrations ≥200 mg/l; or

c. Located within a ground water basin[4] with chloride concentrations ≥200 mg/l; or

d. Chloride concentration levels which are ≥100 mg/l but <200 mg/l, yet show evidence of increasing trend as indicated through yearly monitoring or an aquifer test.

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[2] Where a ground water basin has not been delineated, within a minimum 1/2-mile radius of a water well with a known chloride concentration ≥25 mg/l and <100 mg/l.

[3] Where a ground water basin has not been delineated, within a minimum 1/2-mile radius of a water well with a known chloride concentration ≥100 mg/l but <200 mg/l.

[4] Where a ground water basin has not been delineated, within a minimum 1/2-mile radius of a water well with a known chloride concentration ≥200 mg/l.

VII. Policy Coordination

Through this policy, Ecology shall strive for consistency with ongoing planning processes to be accomplished through participation in planning efforts, consultation, and review and comment on proposed policies and plans. Ecology actions shall be consistent with approved Ground Water Management Area and Growth Management Plans.

Ecology shall strive to coordinate its water right decisions with land use, water right and water system decisions with other governmental entities via memoranda of agreement, data collection, and information sharing. Under this provision, Ecology shall work in cooperation with the Washington Department of Health, affected Indian tribes, county health departments, county planning departments, and local building departments.

VIII. Education

Ecology shall educate the public about the causes and effects of seawater intrusion and inform the public about what steps can and are being taken. In addition, Ecology shall educate purveyors, potential water purveyors, well drillers, local governments, legislative committees, and citizens about the risk categories and requirements for each as established under this policy. Ecology will provide technical assistance and guidelines to local governments for review of single-domestic wells.

IX. Conservation

Since water conservation is recognized as one of the best defenses against seawater intrusion, Ecology shall require conservation plans and implementation measures for new or expanding developments within groundwater areas that are at risk. For instance, low-flow fixtures, lawn watering schedules, artificial recharge basins, and in-house use only restrictions are among the options to be considered. In addition, retrofitting existing facilities to offset new withdrawals or redesign of proposed system shall be considered as possible mitigation measures for new developments.

In order to improve our understanding of the human impact on the hydrologic cycle, to identify potentially wasteful practices, and to determine the effectiveness of conservation, metering shall be recommended for all wells within a seawater intrusion risk area.

Ecology shall provide technical assistance on water conservation to well owners and water users and work in cooperation with local government to develop innovative approaches for voluntary participation by the public. In order to curb wasteful practices, Ecology shall advise local government on water efficiency standards for building codes and encourage the use of progressive rate structures.

X. Water Right Administration - Policy Directive

The Department of Ecology shall seek to make informed decisions about seawater intrusion through its administration of the water right program. When hydrogeologic information is lacking, however, this policy defers to risk categories and requirements as specified under each. The unequivocal goals of this policy are to prevent seawater intrusion in areas where it has not occurred and to control seawater intrusion in areas where the problem already exists. Mitigation is appropriate provided that these goals are not compromised.

In areas where a seawater intrusion risk has been identified, data collection shall be required to determine the risk and to monitor changes in the hydrologic system. The onus shall be on the water right applicant or water right holder to provide this information. In recognition of the cumulative effects of groundwater withdrawals, Ecology shall evaluate water right applications from a hydrologic system perspective.

Ecology has a variety of options available to prevent and control seawater intrusion. Conservation plans and standards can be sanctioned. Innovative approaches such as requiring new applicants to retrofit existing facilities to offset the impact of additional withdrawals will also be considered.

Since our understanding of how to effectively control seawater intrusion is evolving, and given the variability of hydrogeologic conditions and the lack of groundwater information in many areas, this policy encourages the use of adaptive management techniques for controlling the problem in known seawater intrusion areas. Participants in adaptive management shall include, but not be limited to: Washington Department of Health, local health departments, Washington Department of Ecology (Water Resources and Water Quality Programs), Washington Department of Wildlife, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, environmental and citizen groups, consultants, water right holders, and purveyors.

For existing wells in areas where the risk of seawater intrusion has been identified, Ecology shall provide technical assistance, require monitoring, and review water plans as required by the Department of Health.

For new water right applications in low-risk areas, Ecology shall require stringent monitoring, operation, and design controls. In medium and high risk areas, new water right applications shall be denied unless the applicant can show that additional withdrawal of groundwater will not increase the risk of seawater intrusion.

Pursuant to the Growth Management Act, Ecology may also recommend to local government that building permits be withheld or denied in medium and high risk areas for any new or expanding developments which propose to increase ground water withdrawals above their existing water right unless the applicant can show that additional withdrawal of ground water

will not increase the risk of seawater intrusion.

XI. Water Right Administration - Policy Requirements

Based upon the risk categories defined in Section VI, this policy establishes the following requirements:

A. NEW WELLS - LOW RISK AREAS
1. Public Water Supply, Irrigation, and Industrial Wells
o monitor water use (via source meter)[5]
o chloride and conductivity test for each water well required at least once each year during August and analysis by a state certified laboratory - annual reporting to Washington Department of Health
o water conservation practices are required to be incorporated into the operation and maintenance agreement
o minimum aquifer test, as needed
2. Exempt Wells
o report to Ecology well location, status, type of use, and number of households served (at time of construction)
o water conservation fixtures and measures encouraged

B. NEW WELLS - MEDIUM RISK AREAS
1. Public Water Supply, Irrigation, and Industrial Wells
o a current hydrogeologic report, including a hydrogeologic evaluation of the potential for seawater intrusion, is required

[5] As specified in publication prepared by Washington Department of Ecology, Washington Department of Health, and Washington Water Utilities Council - *Interim Guidelines for Public Water Systems Regarding Water Use Reporting, Demand Forecasting Methodology, and Conservation Programs*.

o minimum 24-hour aquifer test
o sampling for chlorides and conductivity in April and August of each year and analysis by a state certified laboratory - annual reporting to Washington Department of Health
o water conservation practices are required to be incorporated into the operation and maintenance agreement
o source and individual meters required - annual reporting to Ecology of water use
o appropriate design modifications are likely to be required (e.g., raising pump intake or reducing pumping rate and increasing storage)
o phased development is likely to be required
o future degradation of water quality or elevation of chloride concentrations in water well may halt development at current levels, even if system is approved for additional connections
o mitigating measures are required and defined in approval
2. Exempt Wells
o report to Ecology well location, status, type of use, and number of households served (at time of construction)
o request local government to require installation of water conservation fixtures
o advise well owner of possible water use restrictions

C. NEW WELLS - HIGH RISK AREAS
1. Public Water Supply, Irrigation, and Industrial Wells
o a current hydrogeologic report, including a hydrogeologic evaluation of the potential for intrusion, shall be required
o aquifer test protocol
o sampling for chlorides and conductivity in April and August of each year and analysis by a state certified laboratory - annual reporting to Washington Department of Health
o water conservation practices are required to be incorporated into the operation and maintenance agreement
o source and individual meters required - annual reporting to Ecology of water use

o appropriate design modifications are likely to be required (e.g., raising pump intake or reducing pumping rate and increasing storage)
o phased development is likely to be required
o future degradation of water quality or increasing chloride concentrations in water well may halt development at current levels; water right permittee shall relinquish the option to perfect additional allocated quantities regardless of the state of construction
o retrofitting existing facilities to offset new withdrawals shall be considered
2. Exempt Wells
o report to Ecology well location, status, type of use, and number of households served (at time of construction)
o advise owner that water system is subject to water use restrictions including in-house use only

D. EXISTING WELLS - LOW RISK AREAS
1. Public Water Supply, Irrigation, and Industrial Wells
o monitor water use (via source meter) - annual reporting to Ecology of water use
o chloride and conductivity test for each water well required once each year during August - annual reporting to Washington Department of Health
2. Exempt Wells
o report to Ecology well location, status, type of use, and number of households served (at time of construction)

E. EXISTING WELLS - MEDIUM RISK AREAS
1. Public Water Supply, Irrigation, and Industrial Wells
o monitor water use (via source meter) - annual reporting to Ecology of water use
o sampling in April and August of each year and analysis for chlorides and conductivity by a state certified laboratory - annual reporting to Washington Department of Health
o recommend analysis of problem and investigation of solutions - Ecology is available for technical assistance

o institute rigorous water conservation measures
2. Exempt Wells
o report to Ecology well location, status, type of use, and number of households served (at time of construction)

F. EXISTING WELLS - HIGH RISK AREAS
1. Public Water Supply, Irrigation, and Industrial Wells
o monitor water use (via source meter)
o sampling for chlorides in April and August of each year and analysis for chlorides and conductivity by a state certified laboratory - annual reporting to Washington Department of Health
o annual reporting to Ecology of monthly source meter readings required
o require investigation and implementation of possible mitigation measures
o moratorium placed on new hook-ups for systems with chloride concentrations greater than 250 mg/l
o institute rigorous water conservation measures (e.g., in-house water use only)
o relinquishment of unused water right
2. Exempt Wells
o report to Ecology well location, status, type of use, and number of households served (at time of construction)
o advise well owner of possible water use restrictions

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