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ESTIMATED EXISTING AND POTENTIAL GROUND-WATER STORAGE IN MAJOR DRAINAGE BASINS IN OREGON

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C O N T E N T S

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PURPOSES AND OBJECTIVES

Because of expected greater needs for water and for better environmental control, the Oregon State Water Resources Board and others having an interest in water-resources development and management must have knowledge of the volume of ground water in storage as well as of the space available for additional storage underground. To provide these estimates, the U.S. Geological Survey has analyzed existing geologic and hydrologic data.

In estimating storage space available for ground water, little consideration was given to the possible sources of recharge water. Presumably some areas deficient in surface supplies would require water available only by interbasin transfer.

GENERAL COMMENTS ON BASINS

1. NORTH COAST:

This area is underlain mostly by marine sedimentary rocks and volcanic rocks of low porosity and permeability; consequently, winter runoff is high, recharge to ground water is small, and streams are low during the summer base-flow period. Ground-water withdrawals have been negligible, and the small yields of wells tend to restrict ground-water use to individual house supplies.

Moderate to large quantities of water can be obtained from wells in the dune lands. The high infiltration capacity of the sand allows precipitation to recharge large volumes of water into the dune-land ground-water reservoirs. Water tables in the dune areas could be raised or lowered to adapt to seasonal use and recharge conditions.

17. SOUTH COAST:

Same comments as (1).

18. MID COAST:

Same comments as (1).

2A. UPPER WILLAMETTE:

The Coast Fork and Willamette (Long Tom) subdivisions are similar to the coastal basins; they are underlain mostly by relatively impermeable rocks, and thus the streams have low base flows during the summer. Except for areas underlain by thin alluvial deposits adjacent to the Willamette River, ground-water withdrawals are small. Potential for ground-water management is limited.

The McKenzie River and Middle Fork of the Willamette drain the high part of the Cascade Range, which is underlain by porous permeable lava, tuff, and ash that readily accept water. Precipitation is abundant, but most of it falls as snow in the winter. Because the snow melts slowly in most years, infiltration capacity of the porous soils is seldom exceeded, and direct runoff is small. A high percentage of the total precipitation becomes ground-water recharge. The streams, which receive most of their flow from discharge of ground water, have a high, rather uniform base flow throughout the year.

Although the aquifers are permeable, ground-water resources have not been developed, mainly because regional water levels are deep. Reliable estimates of the average thicknesses of the saturated zones are difficult to make because the average depth of the water table is unknown. The few existing wells commonly draw water from perched zones; many of the lakes at high altitudes are perched above the regional water table.

The potential for additional storage in the Cascade areas is substantial because of the permeable nature of the rocks and the deep water levels. Artificial recharge might be practiced either by surface spreading or by injection through wells. An "on-call" recovery of this water at the recharge site might be difficult or impractical in some situations, but additional recharge would cause streamflow to become more uniform throughout the year--an asset for production of hydroelectric power, irrigation diversions, and other uses.

2B. MIDDLE WILLAMETTE:

The Upper Santiam and Pudding subdivisions lie partly in the Cascade Range. The same comments as made above about other Cascade areas apply. Most of the Coast Range subdivision is similar to the bedrock areas of the coastal basins.

Natural recharge in the alluvial areas at the lower altitudes of the basin is moderately high, and more water could be used for irrigation than is used at present. The water table beneath the valley plains is generally too high to permit additional storage.

2C. LOWER WILLAMETTE:

The hills and slopes of the Tualatin subdivision are underlain by basalt, whereas the valleys are underlain by alluvial gravel, sand, and silt. Recharge to alluvial aquifers is adequate to offset present and foreseeable future withdrawals. Water levels in aquifers within the basalt have declined near some sites of concentrated withdrawal, as at Bull Mountain, Beaverton, and Tigard, which indicates that large withdrawals need to be adequately regulated.

Ground-water-management potential may be limited to relatively small quantities of water. Additional withdrawals from the basalt aquifers can be replaced by artificial recharge. The containment of additional recharge water within the basalt of the hill areas would be limited because the unsaturated zones of the basalt lie in peaks and in rather narrow ranges.

The higher parts of the Clackamas and Sandy subdivisions have characteristics typical of the western part of the Cascade Range, being underlain by volcanic rocks of lower permeability and porosity than those of the high parts of the Cascade Range.

The lower parts of the Clackamas and Sandy and the higher part of the Columbia subdivision are underlain by young terrace sand and gravel, older mudstone and conglomerate, and basalt. Depths to water range from 50 to several hundred feet below land surface, and wells yield small to moderate quantities of water. Additional water could be withdrawn, and there is some room for additional storage. Because of impaired vertical permeability and perched water, artificial recharge would have to be limited to selected zones through use of injection wells.

Artificial recharge is practiced in downtown Portland, in the sense that ground water pumped from basalt and alluvial aquifers is used for heating and air-conditioning systems and immediately returned to the aquifers.

Lower parts of the Columbia subdivision, adjacent to the Columbia River, are underlain by highly permeable gravel, and increased withdrawals of ground water would probably result in a corresponding increase in induced recharge from the streams.

4. HOOD:

Basalt is the principal aquifer in the Wasco subdivision. Yields of water to wells are moderate to large, but tectonic structures in the basalt have caused hydraulic compartmentation that restricts natural recharge. The covering tuff deposit of the Dalles Formation also restricts recharge.

Ground water in the higher part of the Wasco area is only partly developed, but in the vicinity of The Dalles, substantial pumpage has caused a critical decline in water levels within one structural compartment. Parts of the subdivision could be recharged artificially, with eventual benefit to the area. The declining ground-water reservoir at The Dalles could also be repressurized.

Young porous volcanic rocks of the Hood subdivision probably have good potential for ground-water withdrawal, artificial recharge, and storage of large volumes of water, although presently ground-water resources are almost untested except for the use of spring discharges. Regional water levels lie deep beneath the higher parts of the area.

5. DESCHUTES:

The Upper and Middle Deschutes subdivisions are underlain by rocks of good infiltration capacity, permeability, and specific yield that characterize the higher parts of the Cascade Range. Regional water levels are deep, and large quantities of additional water could be stored either by spreading or by point recharge of excess surface water.

6. JOHN DAY:

Mountainous portions of the North Fork and Upper John Day subdivisions are underlain by basalt and older crystalline and metamorphic rocks, but the basalt is commonly above the water table and overlies rocks of low yield and permeability. Springs emanating from perched zones are common, but additional storage of large quantities of water appears impractical in these rugged areas. A little additional water might be recharged into the upper parts of alluvial fans lying at the base of the mountains and also to some parts of the basalt.

Basalt in the Lower John Day is largely untested for water yields, but should contain moderate quantities of recoverable ground water. Precipitation is not so great as in the higher parts of the basin, but small dams in the Upper and North Fork might capture excess runoff for transport to artificial-recharge sites in the Lower John Day subdivision.

7. UMATILLA:

The Walla Walla subbasin is underlain by basalt and alluvium; both are permeable enough to yield moderate to large quantities of water to wells. The basalt aquifers are locally overdeveloped but can be easily recharged. Shallow water levels and the relatively steep slopes of the valley floors require that special techniques be used to obtain additional storage in the alluvium.

The Willow Creek subdivision and the northwestern part of the Umatilla subdivision are underlain by basalt aquifers in the upland to the south. The lowland to the north is underlain by alluvial and basaltic aquifers. Although precipitation is small, the alluvium appears to be adequately recharged for present withdrawals for irrigation. However, because the basalt is compartmented, water levels are declining rapidly near Ordnance and lower Butter Creek. If ground-water withdrawals are increased, similar declines in water levels in other areas can be expected, but adequate artificial recharge could prevent or nullify such declines.

8. GRANDE RONDE:

Parts of the Upper Grande Ronde and most of the Imnaha, Wallowa, and Lower Grande Ronde subdivisions lie in mountainous, uninhabited terrain. The area is underlain by igneous and metamorphic rocks of low permeability and specific yield. These rocks may be poor aquifers even for domestic needs. Where present and saturated, layered lavas yield moderate to large quantities of water to wells.

Parts of the upper and middle subdivisions are underlain by alluvium and lacustrine deposits and layered lavas that yield sufficient water for irrigation. Additional water might be put into upper parts of alluvial fans, but this could cause waterlogging in the valleys, where water levels in places are shallow.

9. POWDER:

The Burnt River area is underlain mostly by pre-Tertiary rocks of low specific yield. Basaltic rocks and sedimentary deposits of Tertiary age are limited in extent and lie above the regional water table in most places. The sedimentary deposits and the basalt might store a part of the small discharge of this river valley.

Baker Valley, in the Powder River subdivision, contains extensive and productive alluvial aquifers. Additional storage would have to be small and selective to prevent waterlogging of bottom lands. With the exception of several small areas underlain by permeable alluvial deposits or permeable lavas, the remaining parts of the Powder River subdivision are underlain by poorly permeable metamorphic and crystalline rocks or by lacustrine deposits.

10. MALHEUR:

Large areas of the basin are underlain by pre-Tertiary metamorphic rocks of low yield and permeability, but there are also some areas underlain by permeable Tertiary lavas. Some valleys in the basin contain permeable alluvium; however, recharge to ground water is negligible because precipitation is small, and therefore the aquifers are easily overpumped.

Total water needs of the basin are greater than the resources, and there is room for additional ground-water storage.

11. OWYHEE:

The basin is underlain by lavas and other volcanic rocks of moderate to good permeability. Water levels are deep, and thus few wells have been drilled.

Precipitation is small, but there is substantial storage space available for artificially recharged ground water. All the runoff is now used for irrigation.

12. MALHEUR LAKE:

Basalt and pre-Tertiary rocks underlie the mountainous areas, and alluvium, lacustrine deposits, and volcanic rocks underlie the low areas. The basalt has low to moderate permeability and porosity. Some of the sedimentary deposits have moderate permeability, and there are some fine-grained deposits that yield small quantities of water of poor quality.

Precipitation is small in the lower areas and moderate but variable in the areas of higher altitude.

There is good potential for additional storage in the basin; the effective porosity factor is moderate, and water levels are deep in many places. Aquifers are practically untested and unused but have great potential in some subbasins, such as Bear Valley on the upper Silvies River.

13. GOOSE AND SUMMER LAKES:

The area comprises topographically closed basins underlain by Tertiary to Recent basalt and other volcanic rocks, and alluvial deposits, all of good permeability and porosity. The basins lie in the rain shadow of the Cascade Range; thus precipitation is low on the basin floors but greater on the upper parts of the watersheds.

Small to moderate yields can be obtained from wells in the alluvium, and moderate to large yields can be obtained from wells in the basalt and pyroclastic rocks. Presently these aquifers are not overpumped. The basaltic rocks are receptive to natural recharge and could serve as good reservoirs for imported water.

14. KLAMATH:

The very porous, permeable volcanic rocks that are typical of the high parts of the Cascade Range underlie much of the western half of the basin. Permeable basalt, pumice, and andesite, and less permeable sedimentary rocks underlie the eastern half of the basin.

Streamflow is largely discharge from ground water. Much of the streamflow evaporates from large lakes or is used for irrigation.

Where the depth to water is not great, moderate to large quantities of water are generally obtainable from wells drilled into volcanic rocks.

The possibilities for artificial recharge and additional storage are excellent in the western half of the basin and good in the eastern half.

15. ROGUE:

The higher part of the basin, which is drained by the main stem of the Rogue River, is similar in geologic and hydrologic characteristics to the western part of the Klamath Basin.

The lower part of the Rogue is underlain by early Tertiary tuff, lava, and sedimentary rocks, and by pre-Tertiary igneous and sedimentary rocks, all of low porosity and permeability. These rocks yield only small quantities of water to wells.

Even though precipitation is heavy, ground-water recharge is small, except in the volcanic rocks of the high part of the Cascade Range and in the sedimentary deposits beneath several small valley areas.

The rugged topography and the low permeability of the rocks throughout most of the area restrict the potential for ground-water management and additional storage.

16. UMPQUA:

The upper part of the North Umpqua subbasin is underlain by porous volcanic rocks of the high part of the Cascade Range; this part has geologic and hydrologic characteristics similar to the higher part of the Rogue Basin. Ground-water outflow from this part of the basin provides most of the base flow of the river system, and the area has potential for artificially increased ground-water storage.

The South and the Lower Umpqua subdivisions are underlain by marine sedimentary and metamorphic rocks of low permeability. These areas are similar to the coastal basin areas in that the generally impermeable rocks largely preclude artificial increase of ground-water storage.

EXPLANATION FOR TABLE

DRAINAGE BASINS AND SUBDIVISIONS:

The boundaries correspond in general to those on the map of the Water Resources Board. Exceptions are the three coastal basins, whose subdivisions are physiographic, and the Sandy River area, which is included as a subdivision of the Lower Willamette Basin rather than as a separate basin. Where necessary, basins were further divided for this report.

TOTAL AREA:

Areas, in square miles and acres, are those published by the Water Resources Board or determined from U.S. Geological Survey data. Only the parts of river basins actually within the State of Oregon are included.

GROUND-WATER CONDITIONS:

Natural recharge.--These quantities are estimated. For coastal areas, the average streamflow for the month of minimum flow (usually September) multiplied by 12 gives conservative, though reasonable, values for the annual discharge from ground water. This may be a reliable estimate of the annual ground-water recharge. For places where evapotranspiration rates are higher than in coastal areas, the sum of the flow of the 3 lowest months multiplied by four was used to obtain values that seem reasonable. However, in the driest parts of the State, where precipitation is low and evapotranspiration is excessive, this method also gives values for annual ground-water recharge that seem too low, even by conservative criteria.

If precise enough data were available, the following hydrologic equation could be used:

GROUND-WATER RECHARGE = PRECIPITATION - EVAPOTRANSPIRATION - DIRECT RUNOFF - SOIL UPTAKE

Runoff is commonly the only component of the equation known with satisfactory precision; values of precipitation obtained from isohyetal maps are very much generalized; and evapotranspiration and soil uptake must be estimated. The values of ground-water recharge can be in error by a large percentage where the recharge is small relative to the other components of the equation.

Recharge figures in the table have been obtained largely by the base-flow methods described above and probably represent conservative or minimum values.

Artificial recharge.--These values are based on estimates and on published figures. Because of lack of current data, values are subject to adjustment. Many of the existing recharge operations are experimental and not continuous.

Ground-water withdrawals.--These values are based on published estimates, where available, or on assumed requirements for known industrial, municipal, domestic, and irrigation developments in each area.

Relative potential for additional withdrawals.--Qualitative estimates of potential for additional withdrawals of ground water were related to present rates and foreseen increased demands.

++ Most or all parts of the area show potential for substantial additional ground-water withdrawals

\+ Most or all parts of the area show potential for additional ground-water withdrawals

0 Overall ground-water withdrawals are near limit without "mining"

\- Substantial parts of the area are already developed beyond rate of natural ground-water recharge.

Where two symbols are given, the first applies to the subdivision as a whole, and the second applies to local but important areas that differ from the average for the whole subdivision. Because an area may be classified as underdeveloped does not necessarily mean that yields to conventionally constructed individual wells are satisfactory for all or even most purposes.

SATURATED ZONE:

Area of recoverable storage.--Where topographic relief is measured in thousands of feet and/or accessibility by road now is limited, the area of practical recovery of ground water is assumed to be less than the total area, at least for extensive use or management purposes. For present economic and technological conditions, the area of potential recovery of ground water for some areas would be less than is shown on the table.

Effective porosity factor.--The effective porosity factor, expressed in percentage of the thickness of the saturated zone, is used to determine the volume of water that would come out of or go into storage when an unconfined regional water table is lowered or raised. The effective-porosity-factor values are estimated composite averages of short-term specific yields of all materials in the saturated zone. The values are smaller than those for specific yield if drainage time were infinite, and are used to compute the volume of manageable stored ground water for a given area. For example, if a thousand-acre area has an average depth to water of 100 feet and an average depth to the base of the zone of recoverable water of 200 feet (thus a 100-foot-thick saturated zone) and an effective porosity factor of 20 percent, the volume of manageable storage in acre-feet would be computed:

.20 x 100 ft x 1,000 acres = 20,000 acre-ft.

Average depth to base of zone of recoverable water.--Figures in the table apply to the depth of the zone below land surface.

Average thickness above 500 feet.--This is the thickness of saturated materials in the zone 0-500 feet below land surface. It is dependent on the depth of the water table. Because water-table maps are available for few areas and spot information may be sparse or lacking for some areas, water levels are probably the least accurate factor used in computing saturated thicknesses and volumes. For example, a little-known area that was estimated to have an average depth to water of 300 feet would have a saturated thickness of 200 feet above a depth of 500 feet. If the average depth to water were actually 400 feet instead of 300, the thickness would be 100 feet--an error of 100 percent.

Ground water above 500 feet.--This is the volume of ground water in natural storage at a depth of less than 500 feet. The volume is obtained by multiplying Area of Recoverable Storage times the Effective Porosity Factor times Average Thickness Above 500 Feet.

Ground water below 500 feet.--This is the volume of usable ground water below a depth of 500 feet. It may be potentially recoverable. It is obtained from estimates of area, thickness, and yield, and is usually supported by inadequate data. The effective porosity factor is generally assumed to be less than that of the zone above 500 feet depth.

POTENTIAL ADDITIONAL STORAGE:

Estimated area.--This is the area, in acres, where hydrologic, geologic, and physiographic conditions indicate that the water table can be raised substantially above its natural conditions. The term does not apply to areas where recharge is used to restore water levels already lowered by artificial depletions.

No additional storage has been estimated for most areas where high precipitation is combined with shallow water levels; under natural conditions, these areas reject recharge during winter. More recharge would waterlog them. In the coastal dune lands the benefits of raising water levels artificially are presumed to outweigh any detrimental effects of waterlogging.

Average thickness of zone.--It is the thickness, in feet, averaged over the Estimated Area of Potential Additional Storage.

Effective porosity factor.--It is the same as was defined under Saturated Zone, except that it applies to unsaturated zones.

Volume of manageable storage.--The values are obtained by multiplying Estimated Area times Effective Porosity Factor times Average Thickness.

PRINCIPAL AQUIFER TYPES:

This column of the table identifies aquifer materials that are presently or potentially important. Because of such factors as different thicknesses of aquifers and/or the different specific yields of the aquifers, adjacent subdivisions with similar aquifer types may show dissimilar figures under Volume of Manageable Storage.

ESTIMATED EXISTING AND POTENTIAL GROUND-WATER STORAGE IN MAJOR DRAINAGE SUBDIVISIONS IN OREGON

Drainage Subdivision	Total area: Square miles	Total area: Millions of acres	Ground-water conditions: Natural recharge (millions of acre-ft per yr)	Ground-water conditions: Artificial recharge (millions of acre-ft per yr)	Ground-water conditions: Ground-water withdrawals (millions of acre-ft per yr)	Ground-water conditions: Relative potential for additional withdrawals	Saturated zone: Area of recoverable storage (millions of acres)	Saturated zone: Effective porosity factor	Saturated zone: Average depth to base of zone of recoverable water (feet)	Saturated zone: Average thickness above 500 feet (feet)	Saturated zone: Ground water above 500 feet (millions of acre-ft)	Saturated zone: Ground water below 500 feet (millions of acre-ft)	Potential additional storage: Estimated area (millions of acres)	Potential additional storage: Average thickness of zone (feet)	Potential additional storage: Effective porosity factor	Potential additional storage: Volume of manageable storage (millions of acre-ft)	Principal aquifer types
1. NORTH COAST	2,705	1.73	.54	--	0.004	--	--	--	--	--	1.1	--	--	--	--	0.01	
1. Dune lands	35	.02	.09	--	Little	++	0.02	25	100	75	.4	--	.008	5	25	.01	Sand
2. Alluvium	40	.02	.05	--	.004	+	.02	20	60	50	.2	--	None	--	--	--	Alluvial sand and gravel
3. Bedrock	2,630	1.68	.40	--	.0003	+	.35	½	--	300	.5	Little	None	--	--	--	Marine sedimentary rocks, Tertiary lavas
18. MID COAST	2,351	1.51	.58	--	.003	--	--	--	--	--	1.1	--	--	--	--	.01	
1. Dune lands	50	.03	.12	--	.002	++	.03	25	100	80	.6	--	.01	5	25	.01	Sand
2. Alluvium	50	.03	.06	--	.0005	+	.03	20	20	15	.1	--	None	--	--	--	Alluvial sand and gravel
3. Bedrock	2,260	1.5	.40	--	.0003	+	.30	½	--	300	.4	Little	None	--	--	--	Marine sedimentary rocks, Tertiary lavas
17. SOUTH COAST	2,984	1.91	.44	--	.003	--	--	--	--	--	.5	--	--	--	--	.01	
1. Dune lands	40	.02	.10	--	.001	++	.015	25	80	60	.2	--	.01	5	25	.01	Sand
2. Alluvium	30	.02	.04	--	.001	+	.02	20	20	15	.06	--	None	--	--	--	Alluvial sand and gravel
3. Bedrock	2,924	1.9	.30	--	.001	+	.30	.2	--	300	.2	Little	None	--	--	--	Marine sedimentary rocks, Tertiary lavas
2A. UPPER WILLAMETTE	3,887	2.49	3.7	--	.047	--	--	--	--	--	17.2	--	--	--	--	20.1	
1. Coast Fork	665	.43	.4	--	.003	+	.3	2	300	200	1.2	Little	.2	50	1	.1	Marine sedimentary rocks, Tertiary lavas
2. Middle Fork	1,354	.87	1.1	--	.004	+	.6	8	>1,000	200	10	20	.4	200	10	8	Middle and Late Tertiary pyroclastic and lava rocks
3. McKenzie	1,342	.86	2.0	--	.010	++	.5	8	2,000	100	4	40	.4	300	10	12	Middle and Late Tertiary lavas and pyroclastic rocks
4. Willamette (Long Tom)	526	.34	.2	.0002	.030	+	.3	5	120	130	2	Little	Little	--	--	--	Alluvium, Tertiary volcanic rocks
2B. MIDDLE WILLAMETTE	5,424	3.47	1.8	--	.110	--	--	--	--	--	21.4	--	--	--	--	6	
5. Santiam	2,443	1.56	1.0	--	.04	+	1.2	6	1,000	200	14.4	30	.6	100	10	6	Alluvium, terrace deposits
6. Coast Range	1,795	1.15	.3	--	.02	0	.2	15	30	20	.7	Little	Little	--	--	--	Marine sedimentary rocks
7. Pudding	1,186	.76	.5	--	.05	+	(.3	12	150	200	5.4	--	Little	--	--	--	Alluvium, terrace deposits)
							(.3	1	400	300	.9	Little	Little	--	--	--	Middle Tertiary basalt)
2C. LOWER WILLAMETTE	2,757	1.39	2.2	--	.110	--	--	--	--	--	9.7	6	--	--	--	1	
8. Tualatin	721	.46	.4	--	.01	0	.13	10	400	400	4.2	--	.05	10	10	.05	Alluvium
9. Clackamas	1,019	.65	1.1	--	.01	+, 0	.4	3	>1,000	200	2.4	5	.3	20	10	.6	Alluvium, Middle Tertiary basalt
10. Columbia	431	.28	.2	.001	.07	+, -	.1	10	100	200	1.0	--	.1	25	10	.25	Alluvium and terrace deposits
11. Sandy	586	.38	.5	--	.02	+	(.2	10	100	100	2.0	--	.1	100	1	.1	Alluvium and terrace deposits)
							(.1	1	>1,000	100	.1	1	Little	--	--	--	Middle Tertiary basalt)
4. HOOD	1,022	.65	.5	--	.010	--	--	--	--	--	--	2	--	--	--	.06	
1. Hood	482	.31	.5	--	.002	++	.07	2	>1,500	300	.4	1	.05	5	2	.005	Tertiary, Recent pyroclastic rocks, lavas, alluvium
2. Wasco	540	.34	.03	--	.008	+, -	.1	1	>1,000	300	.3	1	.1	50	1	.05	Middle Tartiery basalt
5. DESCHUTES	10,390	6.6	5.4	--	.012	--	--	--	--	--	20.2	40	--	--	--	5.15	
1. Upper Deschutes	1,710	1.1	.6	--	.003	++	.4	5	>1,500	300	6	12	.4	50	10	2	Tertiary and Recent lavas, pyroclastic rocks
2. Middle Deschutes	1,850	1.2	1.3	--	.003	++	.6	5	>1,500	400	12	15	.6	50	10	3	Tertiary and Recent lavas, pyroclastic rocks
3. Lower Deschutes	2,690	1.7	.5	--	.002	+	.3	1	>1,500	400	1.2	3	.3	100	½	.15	Tertiary basalt
4. Upper Crooked	2,480	1.6	.1	--	.002	0	Little	--	--	--	--	--	Little	--	--	--	Tertiary volcanic rocks
5. Lower Crooked	1,660	1.1	2.9	--	.002	+	.4	5	>1,500	500	1	10	Little	--	--	--	Alluvium, Tertiary lava
6. JOHN DAY	8,010	5.1	.14	--	.002	--	--	--	--	--	2.6	5	--	--	--	--	
1. North Fork John Day	2,630	1.7	.08	--	Little	+	.15	1	200	200	.3	Little	Little	--	--	--	Tertiary volcanic rocks, alluvium
2. Upper John Day	2,120	1.4	.05	--	.001	0	.15	1	200	200	.3	Little	Little	--	--	--	Tertiary volcanic rocks, alluvium
3. Lower John Day	3,260	1.7	.01	--	.001	+	.7	1	>1,000	300	2	5	.5	50	½	.12	Middle Tertiary basalt
7. UMATILLA	4,554	2.9	.97	--	.090	--	--	--	--	--	6.5	16	--	--	--	.5	
1. Walla Walla	486	.3	.06	--	.050	0	.3	1	2,000	400	1.2	5	.1	50	1	.05	Middle Tertiary basalt, alluvium
2. Umatilla	2,666	1.7	.90	--	.030	0, -	(.15	20	30	30	.9	--	.03	20	10	.05	Alluvium)
							(.8	1	>1,500	400	3.2	8	.6	25	1	.16	Middle Tertiary basalt)
3. Willow	1,402	.9	.01	--	.010	0	.3	1	>1,500	400	1.2	3	(.05	30	10	.15	Alluvium)
													(.3	25	1	.08	Middle Tertiary basalt)
8. GRANDE RONDE	4,916	3.15	.75	--	.007	--	--	--	--	--	2.8	4	--	--	--	.11	
1. Upper Grande Ronde	680	.44	.18	--	Little	+	.1	1	400	400	.4	Little	.1	20	2	.04	Middle Tertiary basalt
2. Middle Grande Ronde	720	.46	.13	--	.005	+	.25	1	>1,500	450	1.1	3	.1	10	5	.05	Middle Tertiary basalt, alluvium, lacustrine deposits
3. Lower Grande Ronde	1,490	.95	.14	--	Little	+	.1	1	>1,500	400	.4	1	.05	10	2	.01	Middle Tertiary basalt, alluvium
4. Wallowa	928	.59	.12	--	.002	+	.2	1	450	450	.9	Little	.05	10	2	.01	Middle Tertiary basalt, alluvium
5. Imnaha	1,100	.70	.18		Little	0	Little	--	--	--		--	None	--	--	--	
9. POWDER	3,300	2.1	.19	--	.04	--	--	--	--	--	23.6	6	--	--	--	.1	
1. Powder	1,900	1.2	.10	--	.04	+	.4	10	800	500	20	6	Little	--	--	--	Alluvium, Tertiary lavas
2. Burnt	1,400	.9	.09	--	Little	+	.2	3	> 500	400	3.6	Little	.2	50	1	.1	Tertiary lavas, pre-Tertiary rocks
10. MALHEUR	4,850	3.1	.3	--	.04	--	--	--	--	--	12	9	--	--	--	1.3	
1. Malheur	3,250	2.1	.2	--	.02	+	.5	4	1,000	400	8	6	.5	25	5	.6	Tertiary lavas, pyroclastic rocks, alluvium
2. Willow	1,600	1.0	.1	--	.02	0	.2	7	> 800	300	4	3	.2	50	7	.7	Alluvium and lacustrine deposits, Tertiary lavas
11. OWYHEE	5,400	3.5	.13	--	.01	--	--	--	--	--	12	20	--	--	--	7.0	
1. Upper Owyhee	2,000	1.3	.05	--	Little	+	1.0	1	1,000	200	2	8	1.0	200	1	2.0	Tertiary volcanic rocks
2. Crooked Creek	1,700	1.1	.05	--	Little	+	.8	2	>1,000	300	5	6	.8	100	3	2.5	Tertiary volcanic rocks
3. Lower Owyhee	1,700	1.1	.03	--	.01	+	.8	2	1,000	300	5	6	.5	100	5	2.5	Tertiary volcanic rocks
12. MALHEUR LAKE	10,000	6.4	.34	--	.03	--	--	--	--	--	24.8	41	--	--	--	5.3	
1. Alvord	2,000	1.3	.05	--	Little	+	.3	10	>1,300	300	9.0	15	.2	50	3	3	Alluvium, Tertiery volcanic rocks
2. Catlow	3,000	1.9	.03	--	Little	+	.2	2	1,000	200	.8	2	.2	150	2	.6	Alluvium, Tertiary volcanic rocks
3. Steens	1,000	.6	.10	--	Little	+	.2	2	2,000	200	.4	4	.1	100	5	.5	Lacustrine deposits, Middle Tertiary basalt
4. Harney	2,000	1.3	.06	--	Little	+	1.1	2	>1,000	300	6.6	8	.5	100	2	1	Alluvium, Tertiary volcanic rocks
5. Silvies	2,000	1.3	.10	--	.02	+	1.0	2	1,000	400	8.0	12	.2	50	2	.2	Middle Tertiary basalt, alluvium
13. GOOSE AND SUMMER LAKES	8,000	5.1	.44	--	.03	--	--	--	--	--	85	74	--	--	--	5.6	
1. Goose Lake	1,000	.6	.06	--	.01	+	.2	10	800	400	8	4	.2	25	10	.5	Alluvium
2. Warner Lakes	1,700	1.1	.03	--	Little	+	.9	5	1,000	200	9	18	.6	150	4	4	Alluvium, Tertiary lavas
3. Abert Lake	900	.6	.05	--	Little	+	.2	10	600	400	8	2	.1	25	5	.1	Alluvium, Tertiary lavas
4. Summer Lake	4,400	2.8	.30	--	.02	+	2	5	1,000	400	40	50	1.0	25	4	1	Alluvium, Tertiary volcanic rocks
14. KLAMATH	5,500	3.5	2.0	--	.07	--	--	--	--	--	26	47	--	--	--	3.0	
1. Williamson	1,400	.9	1.0	--	.01	++	.7	10	>1,500	200	14	35	.5	100	5	2.5	Tertiary, Recent lavas, pyroclastic rocks
2. Sprague	1,600	1.0	.4	--	.03	+	.3	5	>1,500	400	6	7	.2	50	3	.3	Tertiary lavas, pyroclastic rocks
3. Klamath	2,500	1.6	.6	.0001	.03	+	.4	5	>1,500	300	6	5	.2	30	3	.2	Tertiary lavas, pyroclastic rocks
15. ROGUE	5,160	3.3	1.66	--	.002	--	--	--	--	--	4.2	10	--	--	--	2.05	
1. Upper Rogue	1,250	.8	.94	--	.0003	++	.1	10	>1,500	300	3.0	8	.1	100	5	2	Tertiary, Recent lavas, pyroclastic rocks
2. Little Butte Creek	374	.2	.45	--	.0003	+	.03	10	>1,000	200	.6	2	.03	50	3	.05	Tertiary volcanic rocks
3. Bear Creek	341	.2	.02	.002	.0006	+	.2	1	200	200	.4	--	Little	--	--	--	Tertiary sedimentary and volcanic rocks
4. Applegate Valley	768	.5	.04	.001	Little	+	.04	5	200	200	.04	--	None	--	--	--	Tertiary volcanic and sedimentary rocks
5. Middle Rogue	943	.6	.10	--	.0003	+	.05	5	200	200	.05	--	None	--	--	--	Tertiary volcanic and sedimentary rocks
6. Illinois Valley	982	.6	.08	--	.0003	+	.05	5	200	200	.05	--	Little	--	--	--	Marine sedimentary rocks
7. Lower Rogue	503	.3	.03	--	Little	+	.01	5	200	200	.01	--	None	--	--	--	Marine sedimentary rocks
16. UMPQUA	4,560	--	--	--	.001	--	--	--	--	--	1.2	1	--	--	--	--	
1. South Umpqua	1,762	--	--	--	Little	+	.1	1	> 500	200	.2	.3	None	--	--	--	Marine sedimentary rocks
2. North Umpqua	1,308	--	--	--	Little	+	.05	5	> 500	200	.5	.4	None	--	--	--	Tertiary volcanic rocks
3. Lower Umpqua	1,490	--	--	--	Little	0	.05	5	> 500	200	.5	.4	None	--	--	--	Marine sedimentary rocks
TOTALS	96,000		22.6		.62						252	371				57	

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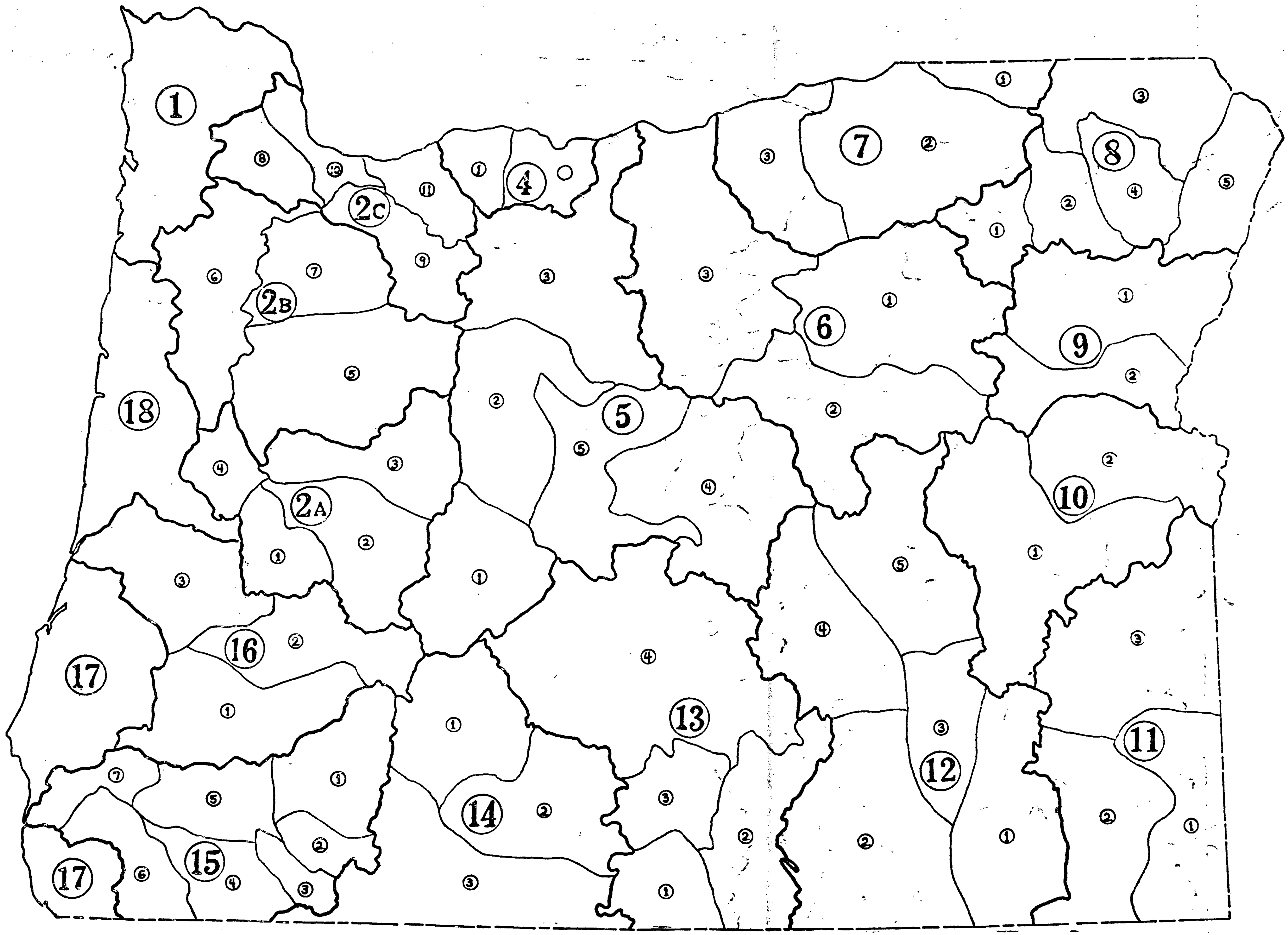

BASINS

1	North Coast
2	Willamette
2A	Upper Willamette
2B	Middle Willamette
2C	Lower Willamette
4	Hood
5	Deschutes
6	John Day
7	Umatilla
8	Grande Ronde
9	Powder
10	Malheur
11	Owyhee
12	Malheur Lake
13	Goose and Summer Lakes
14	Klamath
15	Rogue
16	Umpqua
17	South Coast
18	Mid Coast

3 Subdivisions (See table)

OREGON DRAINAGE BASINS