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Origen, potential and water quality of a perennial spring in Juárez city mountains, Chihuahua, México

Abstract

A Small Perched Perennial Spring has been used for Irrigation for 25 years. With an area of 23.3 ha its water potential basin varies from 90.7 to 979 m^3/day so water conductivity of (k=62 cm/day producing between 0.30 to 3.17 lt/sec for lowest to highest rain return period (PR1 to PR100). Water Quantity and Hydraulic conductivity already mentioned were evaluated: Firstly, RPS structure were formed for 100 m of thick impervious lowermost member Lagrima Formation (Kli) overloading for a medium porosity (Klm, Klu) as well as high porosity of Finlay and del Norte Formations (Kf, Kdn). Secondly, Rainfall-Runoff-Recession hydrology model with Recession constant of 0.6 and ratio to pick of 0.2 in the threshold were used trough the simulation. Thus, Base (underground) and Direct (surface) runoff were separated. Finally, water quality and its interaction with host rocks were performed so; two water samples were collected and studied. Both samples were qualified as: Calcic-Bicarbonated (6f-C2) with low salinization risk (C3-S2). Therefore, water could be used for irrigation. In addition, water interaction among Cretaceous rocks of Sierra de Juárez as Lagrima (Kl), Finlay (Kf) and del Norte (Kdn) formations suggests three cases; One; If Calcium reduces Sodium increases given a sodic shale-slate system as: Ca^{2}+HCO^{3}+shales+Na^{+}→Na^{+}+HCO^{3}+shales+Ca^{2}, this suggests that water have been confined by rock sourced Cretaceous Lagrima formation (Kli). Two, RPS overloaded recharge layers; Finlay (Kf) and (Kdn) with high karstification potential as high porosity is evident so: Three. If Na^{+} differ from Cl^{-} thus, the cationic exchange has more Na^{+} than Cl^{-} so more risk to karstification arises as mentioned before.

Keywords: water, perennial, spring, irrigation, rainfall

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Introduction

Tectonic[1] and Climate[2] are the main subjects to address a Perennial Spring. The present objective is the flow characterization of the Rayito Perennial Spring RPS. Therefore, emphasis will be placed on obtaining parameters such as: precipitation, abstractions, infiltration, surface and underground flow as well as the hydraulic and lithological association in the behavior of the flow through porous media. In this way, parameters such as Porosity, Hydraulic Conductivity, flow systems are essential. Furthermore, acidic water mineralizes the hydrogeological system causing variation in water quality.

Justification

The preservation of water resources for Juárez city depends on groundwater for domestic use, while for irrigation it uses water from the Rio Grande, the use of which is regulated by the Binational Treaty between Mexico and the United States of (1906, 1944)[2] but its adjustments were based on climatic conditions. These are related to periods of drought and prevailing flooding, that causes the amount of water delivered to Mexico to decrease in times of drought. Therefore, it is a priority to carry out studies of new water sources and preserve the existing ones. For example, in the aquifers of the region, especially in the mountains, where too much water came for springs.

Location

Ciudad Juárez is located at the East Longitude Coordinates: 351,000; 358,000 and North latitude: 3,503,000; 3,511,000 between altitudes above sea level of 1130 to 1810 meters. On the other hand, the RPS is located on the mountains: East Longitude; 356,630.91, 3’508,893.08 height: 1473 masl. To illustrate the location, the software known as Multiplans version 3.05[3] was used. Then, it was possible to geo-reference the geological map of the Ciudad Juárez mountain as well as to locate the geological structures indicated in (Figure 1).

Materials and methods

Introduction

The tectonic model of the study area resembles a multi-level structure where the upper level corresponds to the RPS water recharge. Due to the Alpine deformation style of brittle rocks thrusting over ductile ones folding systems like (S and Z) adjacent to the Las Flores Syncline (NW-SW) were developed. One to the North and other to the South as (Ap) forms topographic elevation ports of the order of 1600 masl (Figure 2, Tp) in the lower 100 m there are a saturated Lagrima stratum (Kli) (see profile Figure 3).

Geology of recharge area

Due to its Alpine- style with horsebacks and parasitic fragile folds rocks (S and Z) riding over ductile ones.[4–6] These two extreme folds of Flores Syncline are oriented (NW45-SW45) One, to the north and the other to the south forming a topographic port elevated nearly 1600 masl (Figure 3). In summary, the lowermost 100 m is a saturated stratum of (Aquitard RPS=Kli) (Figure 4). Reverse faults occurred during Laramide Orogeny[4–6] caused that Flores Syncline formed its geological structure as nappes; Juarez (F1), The Año (F3), The Indians (F11), were originated in the RPS aquitard (Figure 3 and 4). The RPS interconnection was due to Eocenic volcanism[4–6] Moreover, caverns, folds and fractures over formations formed the aquitard (RPS): named Del Norte (Kdn); Finlay (Kf); Upper Lagrima (Klu); and middle Lagrima (Klm) rode against ductile rocks forming metamorphic foliated shales and slates as well as schist which formed the floor of (RPS Kli). Benigno (Kb) and Cuchillo (Kc) cretaceous geological formations formed the lower floor of the multi-floor system at the bottom a large pit (Figure 4).

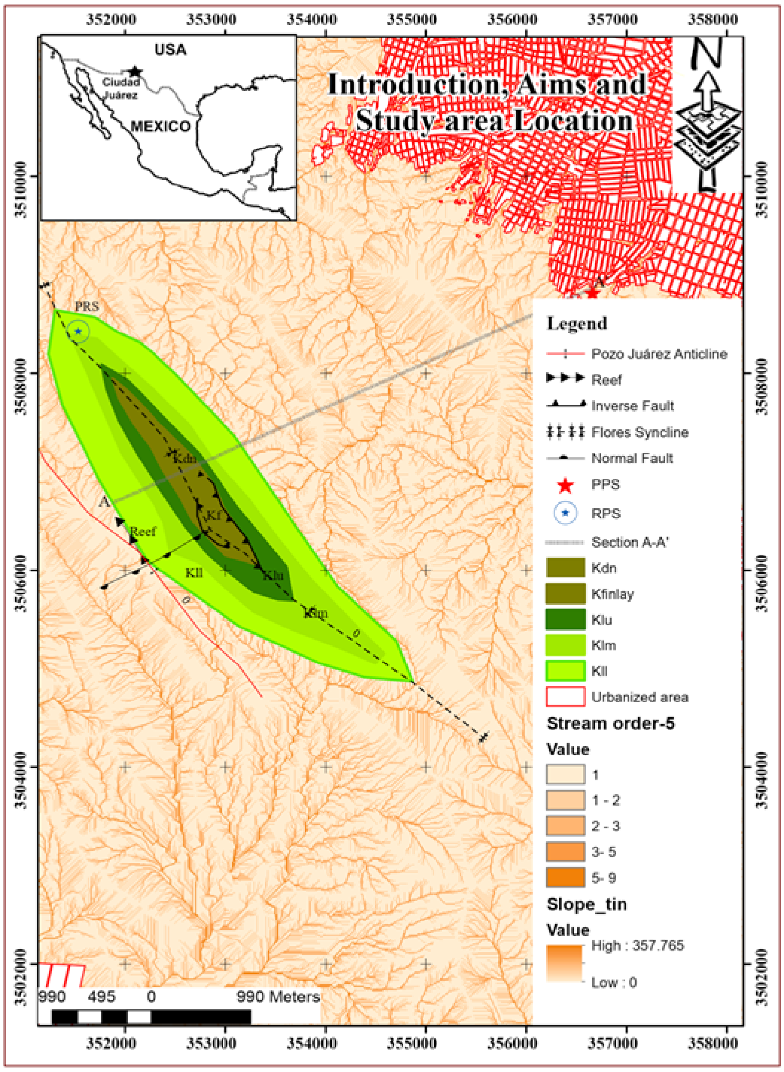

Figure 1 Section A-A'; Stream Order 5; Perennial Posito Spring=PPS=red star; RPS=blue star; (Ap) Topographic Port; Digital Slope Model DSM; (0-360^0); red grid=urban trace; (David Zúñiga, 2020 Arc-Map 10.2)[7], (Auto-Cad 2013).[8]

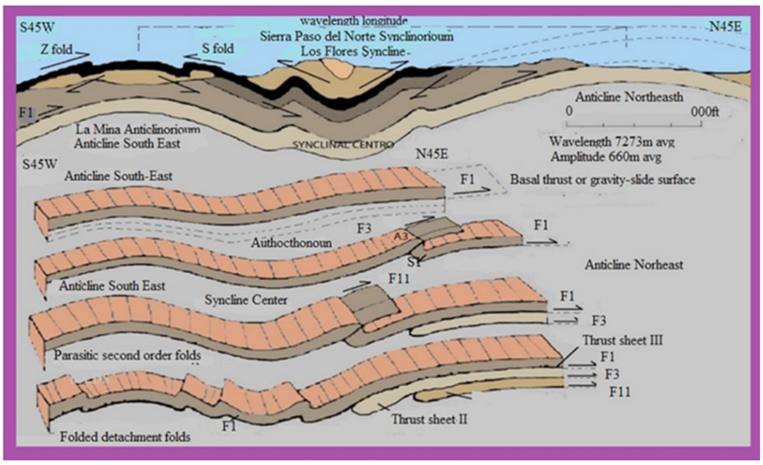

Figure 2 Colorado Anticline N45ºE connects with (F1-failure-floor F3); Topographic Port (Tp) near Pozo Juárez Anticline (Ap) and Flores Syncline. Progressive deformation of: (F1; F3 and F11 clearly show that the System developed bends (Z or S) in the S45oW Anticline. (Kb) where dissolution of calcite and Dolomite produce caverns and plastic faults that produced the multi-story hosted structure of RPS. (Source).[2-6]

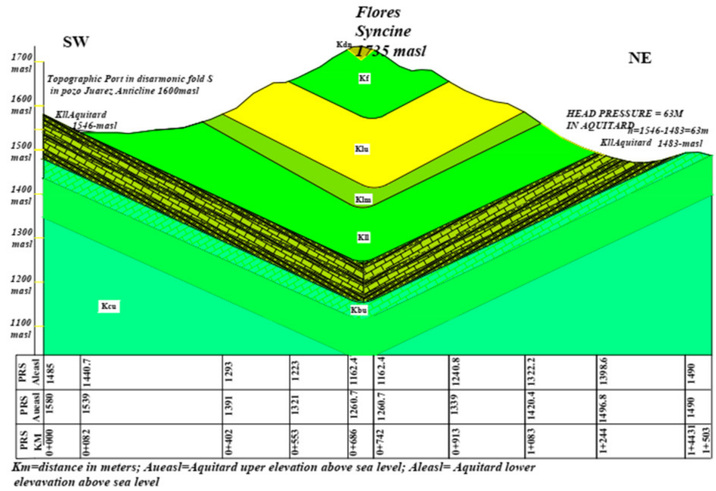

Figure 3 Section A-A' shows 1443 m of aquitard (RPS) porous competent Cretaceous rocks: (Kdn, Kf, Kls and Klm); on rocks of Lower Lagrima (Kli). Source (David Zúñiga, 2020 Arc-Map 10.2)[7], (Auto-Cad 2013).[8]

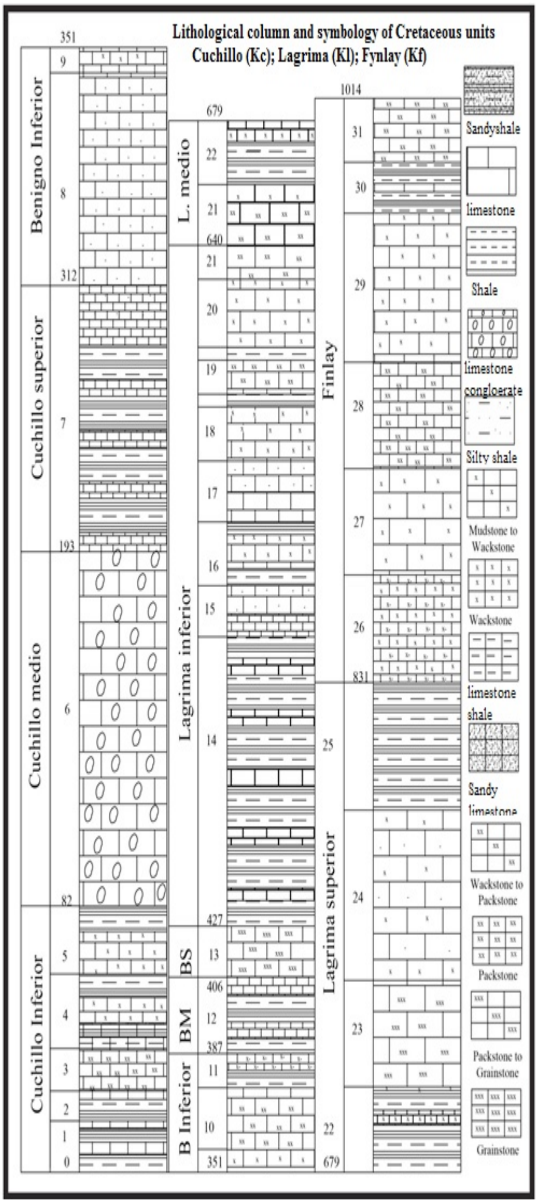

Figure 4 values were assigned for Cretaceous rocks: Cuchillo (Kc), Benigno (Kb), Finlay (Kf) and Lagrima (Kl). Porosity and thicknesses of lithological units are shown in (Table 1). Finally, information for study area Lithological column is given by (Wacker, 1972)[5] great information by: The recharge area and the RPS.

RPS litology

Rock units are shown in (Figure 4) and summarized in (Table 1) using graphic scale of (1cm = 15.25m). Therefore, Porosity (P) and Hydraulic Conductivity (K) illustrates the fracturing degree of fragile rocks as; Grainstones, Packstones, Wackstones, and Compressed limestones such as ductile rocks: Then, Shales and weakstones were taken a strength-deformation based on lithological units given in.[4–6]

Table 1 ID= Lithological unit identification or geological formation; Porosity (%); Thickness (m): Note: Lower member of the Kli-PRS-Aquitard Lagrima formation; thickness (100 m); (p=20%). Source: (González Vallejo, 2002)[9]

ID	Kdn	Kf	Kls	Klm	Kli(MPR)	Kbs	Kbm	Kbi	Kcs	Kcm	Kci
P(%)	18	20	16	16	20(unit14)	30	15	20	15	20	20
Thickness	21	183	152	39	213(100)	21	19	39	119	111	82

Porosity

Calcium and magnesium carbonate as well as calcium sulphated rocks are potentially vulnerable to karstification. Then, in contact with acidic rain deveops many caverns pathways along them. These pathways or caverns allowed that high amount of water would have retained. However, in the study area because there are not enough information related to field exploration, porosity values were taken from those recommended on page 128 of Table 3.2 of book Geological Engineering[9]. An average value is suggested for; volcanic rocks, continental and marine sedimentary rocks. In the case of RPS host layers are indicated in bold (Table 1), also regarded to RPS it would be influenced by Alluvial fans once captured during Plio-Pleistocence time or even during tertiary time,[10,11] their porosity is given in units 1 to 31 of the lithological column.

Hyetogram design

Nowadays, Intense and short rainfall is the best storm design suggested in arid zones like that prevailed in the study area. This is because hot and effective warm conditions is better than hot and dry or even cold and dry condition.[10,11,12] Values given in Table 2 corresponds to the day of the year with most intense historical (1 hour) rainfall occurred. Then, Intensity-Duration-Frequency (I-D-F)[12]; for 5; 10; 25; 50 and 100 years of Return Period were used (Table 2).

Table 2 One hour intense rainfall designed hietograms for different return periods[12]

Time in min	5	10	15	20	25	30	35	40	45	50	55	60	Precipitation in (mm)
RP1	0.35	0.5	1.5	2	3	5	3	2	1.5	1	0.5	0.35	20.7
RP5	0.64	1	2	3	4	6	5	3	2	1.5	1	0.5	29.64
RP10	0.5	1	3	4	5	7	5	4	3	2	1	0.25	35.75
RP25	1	2	3	5	6	8	6	5	4	2	1	0.75	43.75
RP50	0.5	2	3	5	7	11	7	5	4	3	2	0.25	49.75
RP100	1	3	4	6	8	11	8	5	4	3	2	1	56

Water quality

To address RPS water quality four points are presented: One, Water consumption of (RPS) will be at risk of disease if it does not acquire quality standards prescribed by International Institutions and Agencies responsible for water management as: Federal State and Municipal; National Water Commission (CNA)[13] International Commission on Limits and Water; (CILA)[14] and Municipal and State Water and Sanitation Boards. Other, two water samples (RPSIN and RPSOUT) will be discussed in chapter 3. Another, Chemical and physical study were conducted at the (IIT-UACJ) Environmental Engineering Laboratory of UACJ (Table 3)[15] The other, Gases derived from; volcanic and Forest fires and: industry, transport, irrigation and homes heating systems: (Carbon, Nitrogen, Phosphorus and Sulfur cycles (Chapters 1 and 2)[2] Before water infiltrates into rocks its Hydrogen Potential is nearly acidic (4 to 5) instead as a result of the physical reaction with rocks Hydrogen Potential were 7.88 and 8.17 (Table 3)[15] below.

Table 3 Physical-Chemical Analysis of two (RPS) water samples; NOM- C-A-I-Irrigation Water Quality; RAS-Sodium Absorption Ratio; S.D.T-Total Dissolved Solids C.E-Electrical Conductivity; (NOM-127)[16]; (WHO-2000)[17] Source: UACJ Environmental Engineering Laboratory

Units of the Parameter (%Meq/l)	RPSIN	RPSOUT	NOM-127
Alcalinity (mg/L $CaCO_3$)	226.55	211.78	
Electrical Conductivity (E.C) (µs/cm)	678	660	
Total Hardness (mg/L $CaCO_3$)	354.42	354.42	500
Totals Solids Dissolved (mg/L)	454	404	1000
Chlorides (mg/L)	12.63	14.08	250
Nitrates (mg/L)	8.91	12.21	10

Table Continued...

Units of the Parameter (%Meq/l)	RPSIN	RPSOUT	NOM-127
pH	7.88	8.17	6.5-8.5
Sulphates (mg/L)	101.52	106.53	400
Magnesium (mg/L)	14.91	29.83	
Calcium (mg/L)	117.45	117.45	
Potassium (mg/l)	4.78	4.78	
Sodium (mg/L)	11.35	12.41	200

Physical parameters

Electrical Conductivity (E.C); Hydrogen potential (pH) as well as: Alkalinity, hardness, Total Dissolved Solids (T.S.D), Chlorides, Nitrates, Sulphates, Magnesium, Potassium and Sodium were determined in the UACJ laboratory (Table 3) in Mg/L units and Miliequivalents in % by verifying water quality for domestic and Irrigation uses.

Methods

Programs like: Auto-Cad-2013[7] and Arc-GIS 10.2[8] were used to address Digital Elevation Model (DEM), Digital Slope Model (DSM) and Digital Basin Models (DBM). These models allow three-dimensional visualization of terrestrial relief. Their use is essential for; fault location as well mapping geological formations that show typical morphology (Figure 1). in this, DSM was chosen because their congruence with the terrestrial relief. So, they were done using Arc-Map 10.2[8] and terrain elevation curves in (dxf) format as well as conventional process to create DEM[8]. Also, the DSM spatially expresses geological faults; such as rifts and topographical accidents. This model was divided into seven offset intervals between 1100 to 1800 masl and assigned an appropriate color spectrum within a circumference arc of 0º to 360º. Finally, for reasons of stored memory capacity, images are converted from Triangular Irregular Network (TIN) to Raster format.[8]

Basin model

To address watershed a process method is needed then: Firstly, using the TIN (Triangular Irregular Network) model and through routines given in Spatial Analysis hydrology module, parameters as; basins, flow direction, flow accumulation, stream order, watershed and meeting point were performed. Then, the drained basins area were done[7,8]: micro-basins that feeds the (RPS). The lowest pour-point join pixel of the surface drainage system is chosen that drains the (RPS) and creates a dot shape file, then with the watershed tool the watershed is configured. Finally, this polygon is converted to vector format and the 2.33 ha RPS would be performed.

Flow simulation

RPS Flow model basin was done with HEC-HMS software[18,19,20,21] using the Curve Number (CN) and Recession models. These methods are preferred for arid zones to address Direct Flow (DF) and Base Flow (BF); Firstly, configuration of RPS components comprising two micro-basins (section 2.7); one to the south of Flores Syncline and the other to the north, also two streams joining with RPS. A cross section of upper snake stream were selected to measure; slope, hydraulic area and watered perimeter for 35.7 mm rain RP10 (Table 2). After that: runoff coefficient (NC=68), abstractions=0.20%, Waterproof Surface 2.33 ha (Figure 5), slope, length, lag time and concentration time were entered. Finally, the initial and subsequent infiltration rates were assigned by Recession method.[21] After that, weather components that include control specifications and design hyetograms (Table 2 section 2.4) were assigned. Simulation was done and results were obtained (see equations: 1, 2, 3, 4 y 5 as well Figure 4).

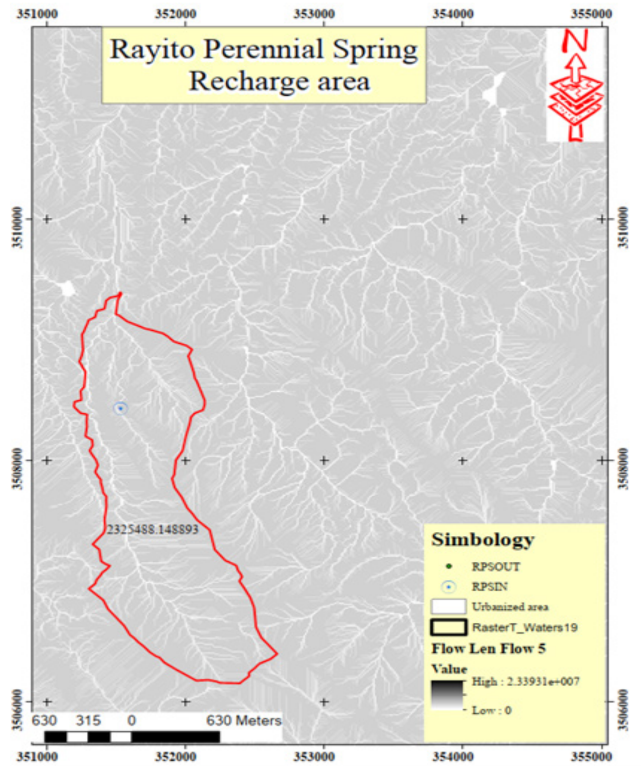

Figure 5 Basin area and drainage system: RPSIN-black polygon - Grey-tone basin watershed; Drainage System: Stream order=5. RPSIN-inner basin point: RPSOUT-Water tank in Rayito-RPSOUT ranch. Source: David Zuñiga de León, 2020 using ArcMap 10.2[8] and Auto-cad 2013.[7]

A) Basin Equations; Q=(P-0.2*S)2/(P+0.8*S)...........(1); S=(25400/NC-254).................(2)

Q= m3/s; P=Precipitation in mm (Table 2); S=Storage; NC=Curve Number=68.

B) Stream equations; Kirpich[18], Concentration Time; (Tc)=0.000325*(L0.77/S0.385).........(3)

Tr=0.6*Tc…(4); Channel length (m); S=slope in %; Tr=lag time (min) McCuen (2004)[19]….(5)

C) Infiltration. Base Flow were done for a rain event of PR-10 years with an initial discharge of (11.4 m3/s) physically recorded in the field along the Snakes stream which drained the **RPS**. A recession constant of 0.6 and a peak hydrogram ratio of 0.2 at the header threshold were used.

Results introduction

Two important features regarded to water quantity are the model used so to address water surface flow as well water underground flow. Therefore, This section is mainly concerned with: One, Direct flow better named as Surface water flow performed using the Curve Number (CN) Edited from The Service Conservation Soils of the United States of America SCS[22] (see section 3.1); Two; Base flow or underground water was addressed using also SCS[22] (See section 3.2); In addition, related to water Hydraulic Conductivity (K) which is water movility trough the porous media were addressed using Darcy Law and Continuity Equation (see section 3.3).[9,22] Finally, Based on results of water samples already done (see section 2.5 Table 3) then Water quality for irrigation as well Domestic use were performed[22] (See section 3.3.1 and 3.3.2).

Results direct flow (DF) and base flow (BF) for different rain return period

Direct and Base flow can be evaluated for different return periods (RP) by converting values in Table 4 which are given in millimeters or m^3/sec (Table 5) Note that in case of base runoff it lasted four hours rather than direct runoff which lasted one hour. Porosity influences in water base potential storage for several return periods (PR1 to PR100) and is evaluated in Table 5. Then, overloaded rocks are recharging over the PRS (Table 4, units 1,2,3 and unit 4=199m). In short, PRS is located in impervious rocks of the lowest member of Cretaceous Lagrima Formation (Kli).

Table 4 Peak Flow (Qp); effective and excess runoff, peak time=Flow (Tp=Qp); direct flow and Base Flow for return periods; PR (Q_{PR1})=0.00655*2325488/4*60*60)=(1.05 m^3/s.)

CUENCA	Qp (M3/SEG)	PRETOTAL	PERDIDAS	PRE-EX	TP-Qp	ESC-DIR	ESC-BASE	Qp (mm)	PR
CUENCA NTE	13.9	56 mm	38.24 mm	17.7 mm	04:40	17.76 mm	34.51 mm	52.27 mm	100
CUENCA SUR	13.5	56 mm	38.24 mm	17.7 mm	04:40	17.76 mm	35.70 mm	52.94 mm	100
TOTAL	27.4					35.52 mm	70.21 mm	105.21 mm	
CUENCA	Qp (M3/SEG)	PRETOTAL	PERDIDAS	PRE-EX	TP-Qp	ESC-DIR	ESC-BASE	Qp (mm)	PR
CUENCA NTE	10.5	49.75 mm	35.23 mm	14.52 mm	04:40	14.52 mm	22.05 mm	36.57 mm	50
CUENCA SUR	10.2	49.75 mm	35.23 mm	14.52 mm	04:40	14.52 mm	17.85 mm	32.37 mm	50
TOTAL	20.7					29.04 mm	39.90 mm	68.94 mm	
CUENCA	Qp (M3/SEG)	PRETOTAL	PERDIDAS	PRE-EX	TP-Qp	ESC-DIR	ESC-BASE	Qp (mm)	PR
CUENCA NTE	8.1	43.75 mm	32.12 mm	11.63 mm	04:45	11.63 mm	15.64 mm	27.27 mm	25
CUENCA SUR	7.8	43.75 mm	32.12 mm	11.63 mm	04:45	11.63 mm	9.62 mm	21.15 mm	25
TOTAL	15.9					23.26 mm	25.26 mm	48.42 mm	
CUENCA	Qp (M3/SEG)	PRETOTAL	PERDIDAS	PRE-EX	TP-Qp	ESC-DIR	ESC-BASE	Qp (mm)	PR
CUENCA NTE	5.6	35.75 mm	27.60 mm	8.15 mm	04:45	8.15 mm	10.69 mm	18.84 mm	10
CUENCA SUR	5.4	35.75 mm	27.60 mm	8.15 mm	04:45	8.15 mm	10.69 mm	14.10 mm	10
Total	11					16.30 mm	21.38 mm	32.94 mm	
CUENCA	Qp (M3/SEG)	PRETOTAL	PERDIDAS	PRE-EX	TP-Qp	ESC-DIR	ESC-BASE	Qp (mm)	PR
CUENCA NTE	4	29.64 mm	23.82 mm	5.82 mm	04:40	5.82 mm	7.41 mm	13.22 mm	5
CUENCA SUR	3.9	29.64 mm	23.82 mm	5.82 mm	04:40	5.82 mm	3.57 mm	9.39 mm	5
TOTAL	7.9					11.64 mm	10.98 mm	22.61 mm	
CUENCA	Qp (M3/SEG)	PRETOTAL	PERDIDAS	PRE-EX	TP-Qp	ESC-DIR	ESC-BASE	Qp (mm)	PR
CUENCA NTE	2.1	20.7 mm	17.70 mm	3	04:40	3	4.12 mm	7.12 mm	1
CUENCA SUR	2.1	20.7 mm	17.70 mm	3	04:40	3	2.43 mm	5.43 mm	1
Total	4.2					6 mm	6.55 mm	12.55 mm	

Table 5 RPS Recharge Origen. Note: It is a value of BF for RP100 (last column and fourth row) and thikness of 199 m second column and 4 row. Therefore, 0.003175 m^3/s for PR100 unit 4

Unit	Thickness (m)	Porosity (%)	BF RP1 (m)	BF RP5 (m)	BF RP10 (m)	BF RP25 (m)	BF RP50 (m)	BF RP100(m)
1	183	0.2	0.370216	0.620606	1.20843	1.427733	2.255208	3.968375
2	152	0.2	0.30675	0.514216	1.00127	1.182979	1.868601	3.288082
3	39	0.15	0.063466	0.10639	0.207159	0.244754	0.386607	0.680293
4	199	0.15	0.296173	0.496485	0.966744	1.142186	1.804166	3.1747
5	14	0.1	0.021155	0.035463	0.069053	0.081585	0.128869	0.226764
Base Flow	587	0.8	0.00655	0.01098	0.02138	0.02526	0.0399	0.07021
Runoff (l/s)			1.057774	1.773185	3.452704	4.079294	6.44354	11.33837

Results base flow

RPS water potential. Base flow (BFs) for different PRs are expressed in l/s and were taken for lithological units depending on thickness and porosity (Table 5).

Results hydraulic conductivity

Hydraulic Conductivity (K) and PRS BF given by: Qmm=(Nf/Ne)*K*Δh... (5): where:(Ne)=Equipotential lines; Nf=flow lines (Gonzáles Vallejo 2002;pags. 33 to 36)[9].In addition in Table 5 row 4, the last column registered BF of 0.003175 m^3/s. On the other hand Δh=63 m pressure (Figure 6) In the next parragraphs is evaluated PRS Hidraulic Conductivity (K).[22]

In Equation 5 Hydraulic Conductivity[28]; Qeff.=Recharge=0.00655mm (Table 5); Nf=Flow Squares=14; Δh=pressure load=63m; ax=distance=100m; bx=height=100m. Replacing in equation 5 (K)=(0.003175)/(7*63)=0.0000072*86400 then K=62.2 cm/day.

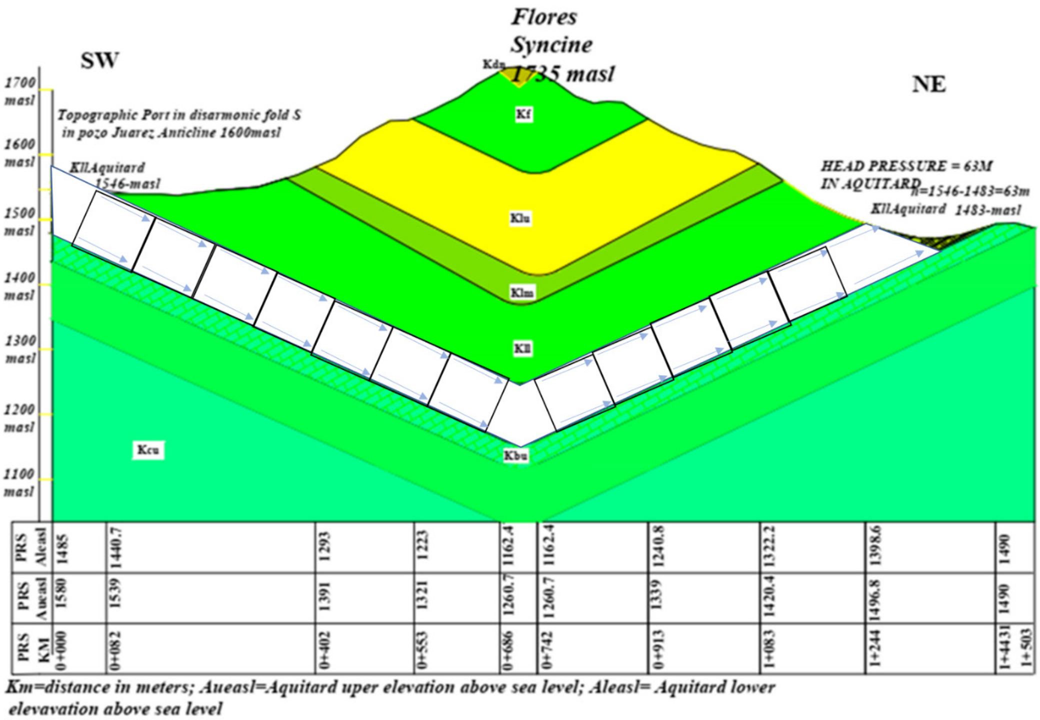

Figure 6 RPS Aquitard Flow System (blue arrows=confined flow aquitard and equipotential=black lines. The profile was exported from the DEM to (Arc-Map 10.2)[8] to an excel sheet then from it to the word program. Source: DEM Arc-Map 10.2[8]; David Zúñiga, 2020.

Results water quality for domestic use

Water composition was adjusted to Piper's model; Anions, (Group1-6); Cations, (Group a-f) according to their predominarIy as well as molecular composition (Figure 7): RPSIN (6f-C2) and RPSOUT (6f-C2).[22]

Results irrigation use

(E.C) at 25°C (Risk of Salinization) and Sodium Absorption Ratio (SAR) (Figure 8). That is, RPS (SAR) equation 5. (Custodio and LLammas, 2001)[22]: According to Figure 8, Table 3, it is permissible to use for Irrigation in terms of SAR and EC.

rNa ((rCa±rMg)/2)$^{0.5}$ It is clear that: RPSIN=RPSOUT

RAS = ---------------------= 5.07 = C3-S1…. (5)

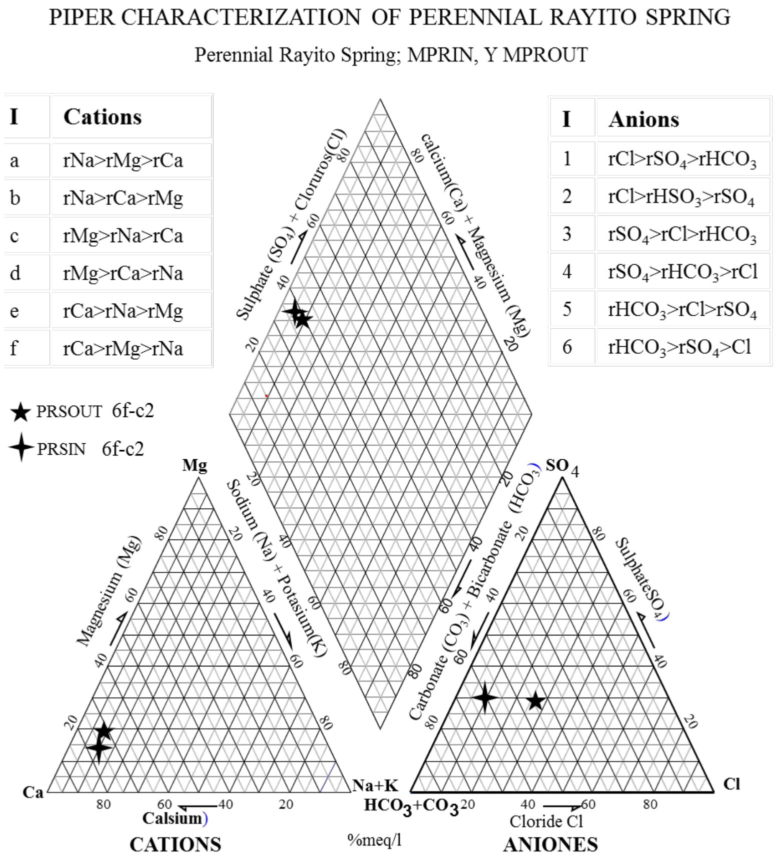

Figure 7 Water characterization for domestic use according to Piper[22]: Anions and Cations for four-sided star RPSIN and for five-sided star RPSOUT. Source UACJ Laboratory, David Zúñiga, 2020 using Auto-cad, 2013.[7,8]

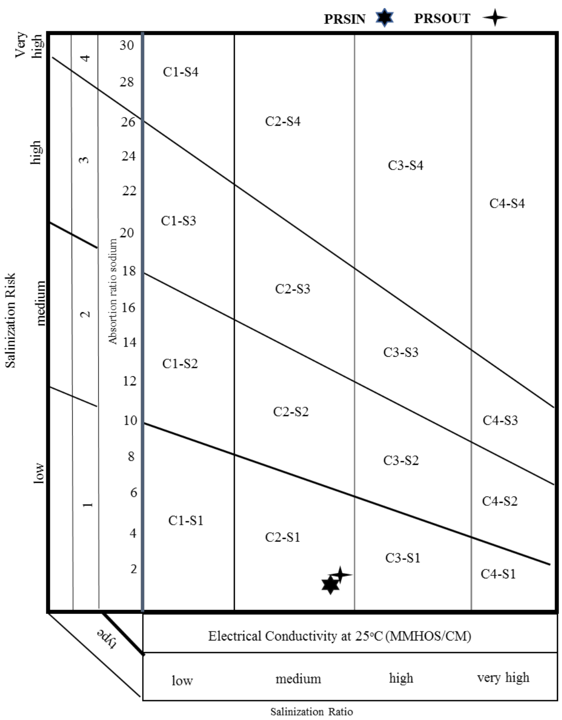

Figure 8 Water Characterization for Irrigation: Star 6 Tips=RPSIN, Star 4 Tips-RPSOUT. Domestic use and Irrigation pass the Standards: NOM EEC 2000[23] Source: (Custodio y Llamas, 2001).[22] (David Zúñiga, using, Auto-cad 2013).[7,8]

Table 6 With Sodium Absorption Ratio (SAR) Electric Conductivity (E.C) Water was classified: (Custodio y Llamas, 2001)[22]. Likewise; using Table 3 for the 2 samples and Fig. 8 ; It is clear that: To RPSIN>RPSOUT; 5.07>4

Spring ID	ASR	Electical Conductivity	Clasification
RPSIN	5.07	830	C3-S1
RPSOUT	4.18	619	C2-S1

Discussion

When acidic rain infiltrates into rocks three main reaction occur. One, When calcium decreases but sodium increases cation exchange passes through limestones to shales as: (Ca^2+HCO^3+shales+Na^+→Na^++HCO^3 +shales with Ca^2). Two; in current groundwater, the concentration of Na^{+1} does not correspond to that of CL^{-1} because water with cation exchange has excess of Na^{+1} over Cl^{-1} chlorine, i.e. HCO^3 predominates over Ca^{+2}. Finally, in the RPS Aquitard, acidic water reacts with 335 meters of predominantly high porosity limestone rocks such as: Del Norte (Kdn); Finlay (Kf) as well as middle and upper members of Lagrima Formation (Klm and Klu) produces Calcium-Bicarbonated water. Then water infiltrates approximately 100 m of partially saturated sodium shales rocks of lower unit of Lagrima Formation (Kll) RPS Aquitard. On the other hand, water captured in the RPSIN Aquitard is transported by (RPSOUT) to Rayito Ranch using 2-inch pipes. diameter. From the tectonic viewpoint the Aquitard is part of the lower unit of Lagrima Formation (100 m) thick. It is formed for evaporitic and very foliated metamorphic shales such as slates and dense silts which are part of the structure that produces supply of perennial water to the RPS. Hydraulic Conductivity (K) was 62.2 cm per day with a conservative porosity of (20%). Thus, the K value is under-estimated because K depends on the degree of rock saturation. In conclusion, well piezometric pressure will increase K values higher than that of dry condition

Conclusion

Continuous rain-runoff models such as Amount of Soil Humidity (SMA) are recommended when multilayer systems are available. However, a two-layer model was applied named a Recession method that separates both direct and base flow according to the amount of initial runoff measured during an intense rain of 35.75 mm/hour occurred along a segment of Snake stream. There were possible to evaluate the Hydraulic area; wetted perimeter and stream slope; so surface runoff were defined as 11 m3/sec. In this model The formations of the North, Finlay and Lagrima formed the ceiling of the RPS and have good porosity and karstification that allows an effective recharge derived from the underground flow above the Aquitard. It receives between 1.06 and 11.33 lt/s for heavy rain hyetograms of one hour PR11 and PR1100 respectively. This value represents the RPS's Water Potential. This is concluded in the following paragraphs. Two potential water recharge for RPSIN associated with intense historical rains occurring in the study area. Tables 4 and 5 show Base and Direct flow for PR; 1, 5, 10, 25, 50 and 100 years. These tables express flow in mm. Then, the flow last 1 hour while the BF last 4 hours, its conversion allows to rate these in m^3/s. The CN curve number method was used with abstractions as losses given by the National Resource Conservation Service of the United States of America (USA NRCS).

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Conflicts of interest

The author declares there is no conflict of interest.

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