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RESEARCH ARTICLE

Perspect and Assessment of Groundwater Resources using Remote Sensing Techniques in and around Choral River Basin, Indore and Khargone Districts, M.P.

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Abstract The study area around Choral river basin in the Narmada valley region, forms a part of Indore and Khargone districts of Madhya Pradesh. The geological, geomorphologic, lineament, hydro-geomorphic and groundwater potential zone maps of the study area have been prepared using IRS IC LISS III FCC imagery on 1:50,000 scale. Various litho-units, different land-forms, lineament fabric and hydro-geomorphic units have been worked out by visual interpretation methods and frequent field checks. The integrated hydro-geomorphological map of the study area reveals that the groundwater potential in denudation landforms such as buried pediplains, plateaus, denudational and residual hills is moderate-to-poor. On the other hand, the groundwater occurrence in structural landforms like structural hills, lineaments/faults and narrow gorges is likely to be good to moderate and the depositional landforms namely alluvial plains, valley-fills and meandering-channels favour the accumulation of sub-surface water and, therefore, may be considered as good recharge zones. From the point of view of groundwater occurrence, various hydro-geomorphic units have been classified as high, moderate and low potential zones.

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Introduction

The potential and scope of remote sensing techniques in various geological applications such as lithology, structure and tectonics, mineral exploration, engineering surveys, groundwater exploration, oil exploration,

etc. have been well recognized by the geological community. Of these, the study of groundwater resources is of utmost importance. Remotely-sensed data from satellite provides quick and useful baseline information on the factors controlling the occurrence, potential and movement of groundwater such as lithology, geological structure, geomorphology, soils, land use /land cover, etc. A systematic study and interpretation of this data can lead to better delineation of potential groundwater zone in any region.

The area under study is a part of Malwa plateau, consisting mainly of basaltic lava-flows of Deccan trap igneous activity. In this region, satellite data are useful in identifying linear features such as lineaments and fractures/faults which are usually the zone of localization of groundwater in hard rock areas and certain geomorphic features, such as alluvial fans, palaeo channels, buried channels etc., which often form good aquifers. SAC (1986); Sahai (1993); NRSA (1995); Reddy *et al*. (1996); Rao *et al*. (2003); Lokesha *et al*. (2005) and Khan *et al*. (2006) have discussed the application of remote sensing data in groundwater exploration including delineation of ground water potential zones in various parts of the country. Raghuwanshi and Thakur (2004) have recently discussed the water quality of the area under investigation.

Study Area

The area under study constitutes the drainage basin of the Choral river which is an important tributary of river Narmada and comprises a part of Indore and Khargone districts of M.P. It falls between the latitudes 22° 10′ and 22° 30′ N and longitudes 75° 45′ and 76° 10′ E on the Survey of India toposheet Nos. 55 B/3, B/4, 46 N/14 and 46 N/15, covering an area of about 370 km^2. Geologically, the area comprises various rock formations ranging in age from Archean to Recent. The drainage pattern of the Choral river is dendritic to sub-dendritic type and is sometimes controlled by joints and faults related to the Narmada rift. The Choral river originates near the village Ghodakhurd (22° 30′ to 75° 45′) at 630 m. A.S.L. and joins the Narmada river near Rupaberi village (22° 10′ to 76° 20′ 30) at 180 m. A.S.L. The average annual rainfall in the area is about 831.5 mm. This study deals with the hydrogeomorphological study of Choral river basin using essentially remote sensing techniques to understand the groundwater potentialities of the region, in general, and of the area around Choral river basin, in particular.

Data Utilized and Methodology

In order to establish an integrated picture of the hydrogeomorphology of the area, the groundwater prospect map has been prepared considering four major factors: geology/lithology, lineament/ structure, geomorphology (landforms) and hydro-geological recharge conditions. Survey of India topographic sheets (nos. 55 B/3, 55 B/4, 46 N/14 and 46 N/15 1: 50,000) were used to prepare base maps and drainage maps. Remotely sensed data from IRS IC (LISS 1II) and false colors composites (FCC) acquired at 1:50,000 scale were visually interpreted for tone, texture, size, shape relief, drainage pattern, vegetation, association and other factors. The data helped in the interpretation and delineation of lithology, landforms, geological structures and lineaments.

The geological, geomorphological (Fig. 1) and lineament maps of the area have been prepared using the above data on a scale 1:50,000. Extensive fieldwork was carried out for ground checks and verifications of the geological, structural and geomorphologic features interpreted by the remote sensing data.

The hydro-geomorphological map (Fig. 2) of the study area was finalized after field checks for verifying different units. This map highlights the results of study and assessment of groundwater prospects for future exploration and exploitation. Finally, the groundwater prospects of the delineated geomorphic units were evaluated using the available hydro-geologic characteristics and aquifer parameters (Fig. 3).

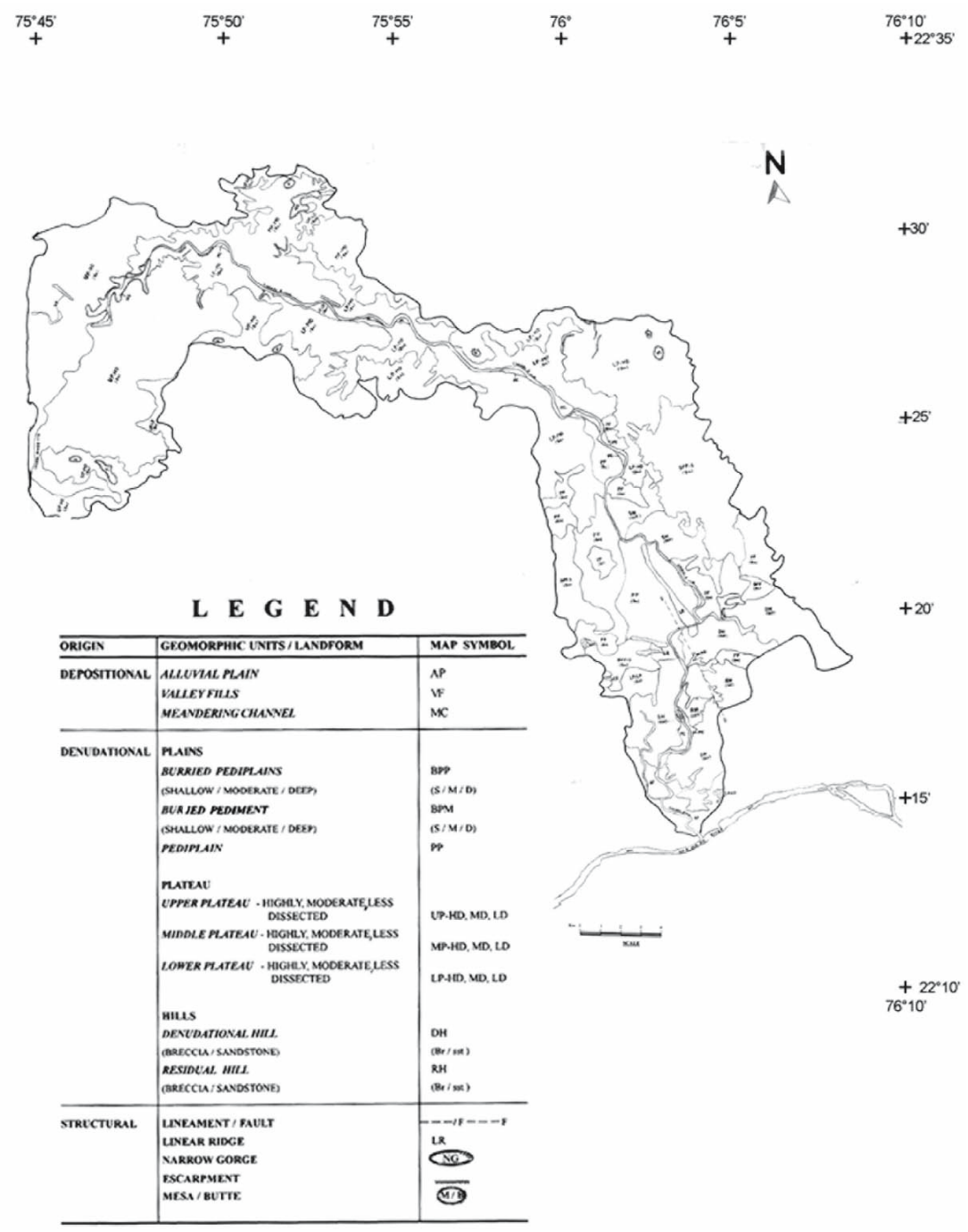

Fig. 1 Geomorphological map of the study area

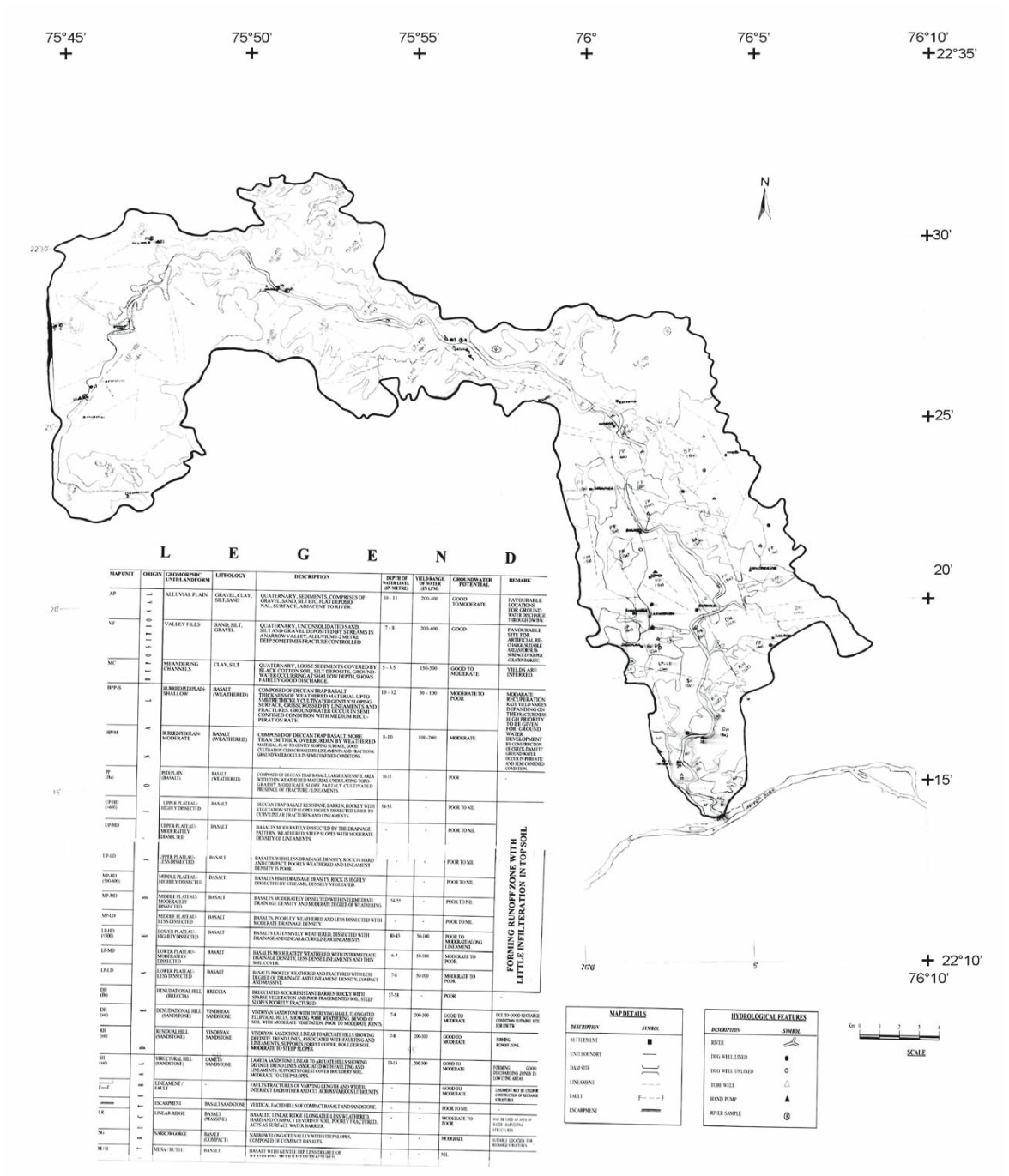

Fig. 2 Hydo-geomorphological map of the study area.

Fig. 3 Groundwater potential zone map of the study area.

Results and Discussion

Geological characteristics and lineaments

The geological formations exposed in the study area comprise basement gneissose granites and meta-sediments of Archaean age, dolomites and chert-breccia of Bijawars, sandstones and shales of Vindhyan Supergroup, conglomerates and sandstones of Lametas and basaltic lava flows of Deccan trap igneous activity with acidic and basic intrusives. The Archaean granite, quartzite, and phyllite form phreatic aquifer wherever weathered or jointed. In general, this aquifer has poor potential and very few dug-wells have been constructed into it. Breccia and dolomites which are hard and compact in nature, offer very restricted groundwater occurrence, that too in the bedding joints, fractures and sheared zones. The Vindhyan sandstones form a good groundwater potential zone in the study area. The basaltic lava-flows from the most predominant and widespread hydro-geological formations in the area. The top weathered mantle where thickness and presence of secondary porosity change according to geomorphic situation, the groundwater occurs under semi-confined to unconfined conditions.

The lineament map of the area reveals the presence of structural features such as faults, shear-zones, joints and lineaments. Two prominent sets of lineaments trend in ENE-WSW and NW-SE directions. The ENE-WSW trend is almost parallel to Narmada-Son geo-fracture, whereas the NW-SE trend is almost perpendicular to it. The presence of these two prominent sets of lineaments across the whole range of geological rock formations ranging from Archaean to Recent may probably be considered right from early Proterozoic time reactivation having taken place from time to time during various geological events.

Geomorphological characteristics

In the present study, various landforms have been delineated on the basis of their tone, texture, pattern, size, shape and association and categorised under three main types – denudational, structural and depositional (Table 1).

Denudational landforms include buried pediplains, plateau, Deccan trap terraces, knife-edge ridges, valleys and allied features, denudational hill complex and residual hills. The structural landforms include structural hills, linear ridges, escarpments, mesas and buttes and narrow gorges. Depositional landforms in the area include the valley-fills, alluvial-plains and river-terraces. In the area, Mehndikund and Patalpani water-falls have been observed along the course of Choral river and Nakheri nala respectively.

Slope analysis of the area reveals that the slope ranges from 1° to 35° in different rock formations. The variations of 4° to 35° are found over Deccan traps. The range varies from 1° to 14° over Bijawars and 2° to 4° over the Vindhyan formations.

Hydro-geomorphology and groundwater potential zones

The information pertaining to drainage, lithology, geomorphology, lineament etc. were obtained and by superimposition, a hydro-geomorphological map of the study area has been prepared. The hydro-geomorphological map gives a pictorial and spatial view of the groundwater conditions with respect to various geomorphic units (Table 2).

In buried pediplain, maximum over-burden thickness is up to 5 m while the density of lineament is limited and recuperation rate is also slow. Therefore, this unit has been considered as a moderate-to poor-potential zone for groundwater occurrence. The basaltic lava flows of Deccan trap activity form an almost horizontal plateau. These plateaus have been classified as highly, moderately and less dissected. Highly dissected plateau form run-off zone because of their less porous nature and high drainage density; lineament density is moderate, hence these plateaus constitute low groundwater potential zones because a large amount of water goes as run-off. On the other hand, in moderately dissected plateaus with regular shape, medium-to-fine texture and dendritic

Table 1. Image interpretation characteristics of various geomorphic units of the area.

Geomorphic Units	Tone	Texture	Pattern	Drainage	Landuse / Cover	Association	Relief	Remarks
Escarpment	Dark reddish brown	Coarse to moderate	Straight or curvilinear with steep steps	Absent		Dissected plateau and butte	High	Some of these escarpments were identified as fault scarps.
Dissected plateau	Yellowish brown	Moderate to fine	Irregular	Structurally controlled sub-dendritic	Sparse deciduous forest at the top	Steep scarp in all sides and plateau top	High	Deccan trap basalts are the main constituents of these plateaus.
Linear ridges	Light brown	Smooth	Linear, rectilinear or curvilinear	Not developed coarse parallel	Barren but sparse bushes at places	Pediplains and pediments	High	Linearly arranged discontinuous hillocks of basaltic rocks trending E-W.
Mesa / Butte	Light yellowish brown	Smooth	Nearly circular but sometimes elliptical, smaller extent	Not developed	Sparse busehs		Moderate to high	Isolated flat-topped table lands of Deccan traps.
Denudational hill complex	Light brown	Coarse to rough	Short rectilinear hills with oval crest	Not developed	Rocky, barren with shrubs	Plateau and pediments	High	Group of hillocks of brecciated composition formed due to differential erosion.
Structure hills	Light brown	Coarse to uneven	Often undulating to gentle slope	Fine dendritic	Dry, cultivation at lower parts	Dissected structural plateaus and pediplains	High	Covered with thin black cotton soil at the lower parts.
Buried pediplains	Medium to dark grey, sometimes reddish due to cultivation	Fine and even	Rectangular and field pattern	Well-developed dendritic pattern	Intensive cultivation	Denudational hills, buttes, linear ridges, pediments etc.	Low	Covered with a thick mantle of black cotton soil.
Plateau top with thick soil cover	Dark-greyish tone	Fine	Irregular, but at places rectangular and field pattern	Dendritic	Cultivation	Dissected structural plateaus	High	Thick soil cover over the dissected structural plateaus.
Valley fills	Dark reddish tone	Fine	Linear, curvilinear and elongated	Coarse dendritic	Intensive cultivation and dense vegetation	Dissected structural plateaus	Low	Comprises of unconsolidated material brought down by streams from adjacent hills.
Older alluvial	Light yellowish grey	Fine to medium	Elongated and present in narrow belts along the river further from the younger alluvium	Dendritic	Extensively cultivated	Pediplains and younger alluvium	Low	Light yellowish tone due to low moisture content. Sandy material deposited by the river.
Recent alluvial	Dark yellowish grey	Fine to smooth	Elongated and present as narrow belts along the river	Internal	Extensively cultivated	Older alluvium	Low	Fine silty oxidized soil with high moisture content giving rise to a comparatively darker tone.

Table 2. Lithology and groundwater prospects of the hydro-geomorphic units.

Sl. No.	Geomorphic unit	Lithology	Depth of water level (in metres)	Yield (in LPM)	Groundwater prospects
1.	Alluvial plain	Gravel, Clay, Silt, Sand	10–11	200–400	Good to moderate
2.	Valley fills	Sand, Silt, Gravel	7–8	200–400	Good
3.	Meandering channels	Clay, Silt	5–5.5	150–300	Good to moderate
4.	Burried pediplain	Basalt (weathered)	8–12	50–200	Moderate to poor
5.	Pediplain	Basalt (weathered)	10–15	–	Poor
6.	Upper plateau	Basalt	54–55	–	Poor to nil
7.	Middle plateau	Basalt	54–55	–	Poor to nil
8.	Lower plateau	Basalt	6–7 and 40–45	50–100	Moderate to poor
9.	Denudational hill	Breccia	57–58	–	Poor
10.	Denudational hill	Sandstone	7–8	200–300	Good to moderate
11.	Structural hill	Sandstone	10–15	200–300	Good to moderate
12.	Residual hill	Sandstone	7–8	200–300	Good to moderate
13.	Lineaments/faults	–	–	–	Good to moderate
14.	Escarpment	Basalt / Sandstone	–	–	Poor to nil
15.	Linear ridge	Basalt (massive)	–	–	Moderate to poor
16.	Narrow gorge	Basalt	–	–	Moderate
17.	Messa / butte	Basalt	–	–	

drainage pattern alongwith moderate density of lineament with steep slopes have been observed. All such characteristics make these plateaus a low groundwater potential zone while in less dissected plateau, drainage density is moderate-to-low and infiltration is low and lineament density is also low. In this unit, run-off is also high; therefore, this may be considered as a poor groundwater potential zone.

The denudational hills of the study area are composed of chert breccia and sandstones. In these rocks, joints and fractures are fewer and the secondary porosity is also low. The brecciated denudational hills are zones of high run-off and low infiltration and hence may be classified as poor potential zones.

In the study area, residual hills are composed of sandstone, linear to arcuate in shape showing dendritic drainage. In this geomorphic unit, groundwater potential is moderate and is controlled by fractures and lineaments. In general, these fractures are good for seasonal tapping of groundwater.

The structural hills are exposed in the northern part of the study area. In these hills, movement of groundwater is restricted to joints and fractures. The lineament density is also moderate. Thus, the groundwater conditions in these hills are expected to be good-to-moderate and, therefore, may be classfied as a moderately potential zone. The lineaments are commonly seen in different rock types of varying areal extent. The intersection zones are supposed to have a high potential and can also be used as important parameters for water conservation purposes.

The deposition landforms include alluvial plains, valley-fills and meandering-channels. The alluvial-plains area composed of gravel, sand and silt are observed in the study area at the confluence of Choral and Narmada rivers. Due to favourable conditions, the alluvial plains are high potential zones for groundwater exploration because they act as good recharge zones.

Because of high porosity and permeability, valley-fills act as good zones for groundwater storage and are also the best for groundwater discharge. The meandering channels are formed on the convex side on the banks of the choral river. Porosity and permeability of this unit is very high; dug wells present in this unit indicate excellent groundwater potential.

Conclusions

In hard rock terrain such as the present study area, interpretation of satellite data for delineation of lithological units, weathered zones, mapping of fracture zone and their trends as well as intensity, land use/land cover are discriminatory features and form a valuable aid for the location of groundwater areas (Howe, 1958; Gelenett and Gardner, 1979). In hard rock areas, groundwater exploration still remains a difficult task owing to the complex deformational histories of the wide range of lithological formations.

The groundwater prospect map is a systematic effort and has been prepared considering major controlling factors, which influence the water yield and quality of groundwater. The hydro-geomorphological map is useful for the planning and execution of groundwater exploration.

High potential zones are mainly located along lineaments, alluvial plains and along concave slopes of the area with less than 5% slope. Specially, the areas of valley-fills and meandering-channels are good groundwater potential zones. Moderate potential zones are located in the mid slopes of the intra-drainage divides with low angle concave slope. The geomorphic units like buried pediplains, denudational hills, residual hills, lineaments, faults and narrow gorges serve as moderate groundwater potential zones.

The low potential zones mostly occupy the area with convex slopes of moderate-to-steep nature. They include pediplains, plateaus, denudational hills, escarpments, mesas and buttes. The plateaus, escarpments and buttes act as surfaces of high run-off zones. The denudational hills and pediplains are moderate run-off zones. They show poor recharge conditions.

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