जल शक्ति अभियान
संचय जल, बेहतर कल

मध्यप्रदेश

जल शक्तिअभियान–नगरीय जल संरक्षण

Letters from UADD

Index

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क्रमांक/यौ0प्र0/07/2019/6864 भोपाल, दिनांक 27/12/2019

प्रति,

1. समस्त आयुक्त,
नगर पालिक निगम,
मध्यप्रदेश।

2. समस्त संभागीय संयुक्त संचालक/अधीक्षण यंत्री/कार्यपालन यंत्री,
नगरीय प्रशासन एवं विकास
मध्यप्रदेश।

3. समस्त मुख्य नगरपालिका अधिकारी,
नगरपालिका परिषद/नगर परिषद,
मध्यप्रदेश।

विषयः रूफ वाटर हार्वेस्टिंग कार्य सम्पन्न करने के लिए अभियान।

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मध्यप्रदेश शासन, नगरीय प्रशासन एवं विकास विभाग के पत्र क्रमांक 2009/प्र.स.न. प्र.वि./2563 भोपाल दिनांक 27 अक्टूबर 2009 द्वारा यह निर्देशित किया गया है कि मध्यप्रदेश भूमि विकास नियम की धारा 78–4 के अनुसार 140 वर्गमीटर या उससे अधिक क्षेत्रफल वाले भूखंड पर भवन निर्माण में रूफ वाटर हार्वेस्टिंग का प्रावधान किया जाना अनिवार्य है। निकाय द्वारा भवन अनुज्ञा जारी करते समय इस तथ्य की शर्त भी रखी जाती है, इन प्रावधानों को किया गया है अथवा नहीं इस तथ्य की पुष्टि नहीं की जाती अतः इस प्रावधान के पालन को कड़ाई से सुनिश्चित करने के लिए रूफ वाटर हार्वेस्टिंग हेतु धरोहर राशि जमा कराई जाने का प्रावधान किया गया है। यह भी उल्लेखित किया गया है कि यदि रूफ वाटर हार्वेस्टिंग का कार्य हो जाता है तो धरोहर राशि वापस कर दी जाए। यदि रूफ वाटर हार्वेस्टिंग की व्यवस्था आवेदक द्वारा नहीं कराई जाती है तो इस धरोहर राशि से निकाय स्वयं उक्त कार्यवाही करने की व्यवस्था करेगा । इस हेतु शासन ने निकाय में एक नोडल अधिकारी नियुक्त करने का भी निर्देश दिया था। रूफ वाटर हार्वेस्टिंग का कार्य गंभीरता से किया जाना है, अतः निम्नानुसार निर्देशों का कड़ाई से पालन किया जाए।

1. उपरोक्त निर्देशों के पालन में अब तक की गई कार्यवाही की जानकारी संलग्न प्रपत्र एक में तैयार की जाए। नगर निगम यह जानकारी सीधे इस कार्यालय को भेजें परन्तु अन्य निकायों द्वारा यह जानकारी संबंधित संभागीय कार्यपालन यंत्री को 10 दिनों में भेजी जाये जो कि दो दिन में इस जानकारी का संकलन कर संचालनालय, नगरीय प्रशासन एवं विकास को उपलब्ध कराई जावे।

2. Rain Water Harvesting के कार्य को "जन आंदोलन" के रूप में लिये जाने का निर्णय लिया गया है अतः इस कार्य के लिए एक विस्तृत IEC अभियान अतिशीघ्र चालू किया जाये एवं इस अभियान को चला कर आम–जन को इस कार्य से जोड़ा जाए। इस अभियान में समुचित स्थानों पर पब्लिक मीटिंग की जाए और इस कार्य का महत्व बतलाने के साथ–साथ यह जानकारी दी जाय कि Rain Water Harvesting के कार्य कैसे किये जाय। आवश्यकतानुसार पोस्टर/फ्लेक्स आदि के माध्यम से इस अभियान को प्रभावी तौर पर चलाया जा सकता है।

3. Rain Water Harvesting के कार्य किस प्रकार किये जा सकते है, इस विषय से संबंधित निम्नानुसार मानक/मार्गदर्शिकाएं संलग्न हैः– इस विषय में केन्द्रीय जल बोर्ड द्वारा दिल्ली के लिए जारी की गई मानक डिजाइन से संबंधित पुस्तिका, Central Ground Water Board की website से डाउनलोड की जा सकती है http://cgwb.gov.in/documents/Manual-

Artificial-Recharge.pdf. Rain Water Harvesting की तकनीकियों के विषय पर केन्द्रीय भू जल बोर्ड द्वारा जारी की गई गाइड लाईन http://cgwb.gov.in/documents/masterplan-2013.pdf.

केन्द्रीय लोक निर्माण विभाग, नई दिल्ली द्वारा जारी Rain Water Harvesting and Construction" Manual. https://cpwd.gov.in/Publication/rain_wh.pdf. भारतीय मानक ब्यूरो द्वारा निर्धारित मानक IS 15797:2008 'छतों पर वर्षा जल संग्रहण' के मार्गदर्शी सिद्धांतों की पुस्तिका भी आपको उपलब्ध हो सकती है। उपरोक्त तकनीक दिशानिर्देशों के अनुसार आप निकाय में किस प्रकार की तकनीक का उपयोग होना है इसका निर्धारण आप अपने स्तर से कर सकते है एवं इस विषय पर सम्बंधित कार्यपालन यंत्री से राय ले सकते हैं।

4. शहरी विकास एवं आवास मंत्रालय द्वारा जल शक्ति अभियान के तहत Water Harvesting किये जाने वाली तकनीक का विवरण संलग्न किया जा रहा है जो कि http://mohua.gov.in/upload/uploadfiles/files/Guidelines%20for%20Urban%20Water%20conservation%20Jal%20Shakti%20Abhiyan.pdf.

नगरीय निकायों में इस प्रकार के कार्य करने वाले एजेंसी / व्यक्तियों को भी चिन्हित करते हुए यह कार्य सम्पन्न कराने हेतु नियमानुसार कार्यवाही की जा सकती है। रूफ वाटर हार्वेस्टिंग के कार्य नगरीय निकायों में स्थित सभी भवनों (140 वर्ग मीटर से अधिक) पर गंभीरता से करवाये जाने का निर्णय राज्य शासन द्वारा लिया गया है अतः इसके लिए निम्नानुसार कार्यवाही पूर्ण किये जाने के निर्देश दिये जाते है:–

(1) भूजल को रिचार्ज करने का दायित्व न केवल राज्य शासन अथवा निकाय का है बल्कि आमजन एवं निकाय में निवासरत् सभी का यह नैतिक दायित्व है कि वर्षा जल की एक–एक बून्द का समुचित उपयोग करते हुए रूफ वाटर हार्वेस्टिंग का कार्य कराया जाए।

(2) यह कार्य सर्वप्रथम इस वर्षाकाल में समस्त निकाय अपने स्वामित्व के समस्त भवनों में रूफ Roof Water Harvesting Structure का कार्य पूर्ण करे। केन्द्र शासन, राज्य शासन के भवनों पर भी किया जाए साथ ही आवासों एवं वाणिज्यिक भवनों पर भी यह कार्य करवाया जाए।

(3) प्रत्येक वार्ड में यह कार्य भवन स्वामियों के द्वारा ही करवाये जाने को प्रथम प्राथमिकता दी जाना है अतः इस सप्ताह में प्रत्येक वार्ड के कितनें भवन स्वामी यह कार्य इस वर्षा में सम्पन्न करेंगे इसका निर्धारण किया जाए।

(संलग्नः–उपरोक्तानुसार)

(पी. नरहरि)
आयुक्त सह सचिव,
नगरीय प्रशासन एवं विकास,
मध्यप्रदेश, भोपाल

पृष्ठ. क./यां.प्र./07/2019/6865 भोपाल,दिनांकः 09/07/2019

प्रतिलिपिः–

प्रमुख सचिव, म.प्र. शासन, नगरीय विकास एवं आवास विभाग, मंत्रालय वल्लभ भवन, भोपाल की ओर सूचनार्थ।

आयुक्त सह सचिव
नगरीय प्रशासन एवं विकास,
मध्यप्रदेश, भोपाल

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कमांक यां.प्र./7/2019 6967 भोपाल दिनांक 11/7/19

प्रति,

(1) आयुक्त,
नगरपालिक निगम,
रतलाम,उज्जैन,देवास,इन्दौर।

(2) मुख्य नगरपालिका अधिकारी,
नगरपालिका परिषद/नगर परिषद,
जावद एवं नीमच (नीमच जिला)
मंदसौर,भानपुरा, सीतामऊ,मल्हारगढ
(मंदसौर जिला)

विषयः **जल शक्ति अभियान– नगरीय जल संरक्षण।**

भारत सरकार द्वारा नगरीय जल संरक्षण के लिए दिशा निर्देश "Guideliness for Urban Water Conservation - Jal Shakti Abhiyan" अभी हाल ही में जारी किए है जो कि आवास एवं शहरी मामले मंत्रालय, भारत सरकार की वेब साईट से डाउन लोड किए जा सकते हैं। इन दिशा निर्देशों के Annexure-1 में प्रथम चरण के उन जलाभाव वाले निकायों की सूची दी गई है जिनमें कि जल शक्ति अभियान के अंतर्गत नगरीय जल संरक्षण के कार्य तुरन्त किये जाना है। जल के अभाव को दूर करने के लिए जल संरक्षण, तालाबों का पुनर्जीवीकरण, वेस्ट वाटर का पुनर्उपयोग आदि मुद्दों पर कार्य करते हुए बड़े पैमाने पर वृक्षारोपण करने के कार्य किये जाना है। जल शक्ति अभियान दिनांक 01 जुलाई 2019 से भारत सरकार द्वारा लागू किया गया है जिसमें आवास एवं शहरी मामले मंत्रालय भी एक प्रतिभागी है। इस अभियान के तहत जल संरक्षण को जन आंदोलन के रूप में सम्पन्न करने का निश्चय लिया गया है। इस कार्यक्रम हेतु निम्नलिखित क्षेत्रों पर कार्य किया जाना है:–

(1) रेनवाटर हार्वेस्टिंग जिसमें रूफवाटर हार्वेस्टिंग शामिल है,
(2) उपचारित अपशिष्ट जल का पुनर्उपयोग,
(3) जल संरचनाओं का पुनर्जीवीकरण,
(4) वृक्षारोपण,
(5) जन आंदोलन।

इस विषय पर संचालनालय द्वारा जारी पत्र कमांक यॉ.प्र./07/2019/6864 भोपाल दिनांक 09.07.19 के अनुसार तो कार्यवाही की ही जाना है परन्तु भारत सरकार के दिशा निर्देशों के अनुसार यह कार्य भारत सरकार द्वारा चिन्हित 11 जिलों के 29 नगरीय निकायों में संलग्न सूची के अनुसार किया जाना है। इस दिशा में नगरीय निकायों द्वारा निम्नलिखित कार्यवाही किये जाने के निर्देश दिये जाते है:–

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(1) रेनवाटर हार्वेस्टिंग **RWH**

घरों की छतों से सड़कों एवं खुले क्षेत्रों आदि से वर्षा जल को एकत्रित कर भूजल के रिचार्जिग की कार्यवाही को रेनवाटर हार्वेस्टिंग कहा जाता है। नगरीय निकायों के लिए मध्यप्रदेश भूमि विकास नियम की धारा 78–4 के अनुसार 140 वर्गमीटर या उससे अधिक क्षेत्रफल वाले भूखण्डों पर भवन निर्माण में रेनवाटर हार्वेस्टिंग का प्रावधान है। इस विषय पर संचालनालय द्वारा जारी किये गये पत्र कमांक यां.प्र./7/2019/6864 भोपाल दिनांक 09.07.19 के अनुसार कार्यवाही की जाए। इस हेतु प्रत्येक निकाय में एक "रेनवाटर हार्वेस्टिंग सेल" का गठन किया जाए जो कि नगरपालिक निगम के प्रकरण में आयुक्त एवं अन्य निकायों के प्रकरण में मुख्य नगर पालिका अधिकारी के नेतृत्व में कार्य करे।

(2) उपचारित अपशिष्ट जल का पुनर्उपयोग

प्रदेश में सीवरेज परियोजनाओं से बहुत कम निकायों में अपशिष्ट जल का शोधन किये जाने की स्थिति है। जिन निकायों में अपशिष्ट जल शोधन के उपरान्त नदी नालों में बहकर निकल रहा है उसका पुनर्उपयोग किया जाना सुनिश्चित किया जाए। इस शोधित अपशिष्ट जल का उपयोग पार्को में सिंचाई के लिए, अग्निशमन कार्य के लिए, उद्योगों में लगने वाले जल की प्रतिपूर्ति के लिए, नगरीय निकायों से लगे हुये ग्रामीण क्षेत्रों में खेतों की सिचाई एवं अन्य इसी प्रकार के कार्यो के लिए किया जा सकता है। शहरों में ग्रुप हाउसिंग सोसायटी तथा कालोनाईजर्स के द्वारा जो कालोनियां तैयार की जा रही है उसके अपशिष्ट जल के शोधन की व्यवस्था भी इन कालोनियों में कालोनाईजर को करना होती है। इस शोधित जल का उपयोग उन्हीं कालोनियों में हरित क्षेत्रों या पार्को में सिंचाई आदि के लिए भी किया जा सकता है।

(3) जल संरचनाओं का पुनर्जीवीकरण

प्रदेश की अधिकांश निकायों में तालाब, बावडियां आदि जैसी जल संरचनाएं हैं इन जल संरचनाओं का पुनर्जीवीकरण निकायों में उपलब्ध राशि से किया जा सकता है। इस अभियान के दौरान इन जल संरचनाओं के पुनर्जीवीकरण की कार्यवाही प्राथमिकता पर की जावे। भारत सरकार के दिशा निर्देशों के अनुसार इन जल संरचनाओं में सफाई, Desilting, Fencing तथा अतिकमणों के हटाने की कार्यवाही, घरेलू या उद्योगों से आने वाले अपशिष्ट जल को रोकने एवं शोधित करने की कार्यवाही, इन जल संरचनाओं के आस–पास जन उपयोगी स्थान बनाने, NULM के अंतर्गत Vending zone आदि का विकास करने जैसी कार्यवाही की जा सकती है। प्रत्येक जल संरचना की Geo Tagging उनके फोटोग्राफ्स के साथ की जावे तथा इन जल संरचनाओं के जल गुणवत्ता की जांच कर उसमें सुधार करने की कार्यवाही की जावे।

(4) वृक्षारोपण

प्रदेश के शहरी क्षेत्रों में प्रतिवर्ष वृक्षारोपण का कार्य किया जाता है। इस वर्ष भी संचालनालय के पत्र कमांक यां.प्र./7/सामान्य/407/2029/5525 भोपाल दिनांक 7.6.19 द्वारा वृक्षारोपण किये जाने के विस्तृत निर्देश जारी किये गये है एवं इन 29 नगरीय निकायों

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में भी वृक्षारोपण के लक्ष्य निर्धारित किये गये है। जल शक्ति अभियान के दृष्टिगत उक्त निर्धारित लक्ष्य से कम से कम दो गुना कार्य निकायों द्वारा किये जाने की अपेक्षा है।

(5) जन आंदोलन

जल संरचना का कार्य तब तक किया जाना संभव नहीं है जब तक कि सामान्य जन इस कार्य से पूरी तरह से न जुड़े। सामान्य जन को इस कार्य से जोड़ने के लिए निकाय स्तर से गंभीर प्रयास किये जाने की आवश्यकता होगी। जिसके लिए एक विस्तृत IEC Campaign प्रारम्भ की जाए। इस प्रकार की Campaign नगरपालिक निगम इन्दौर द्वारा लम्बे समय से की गई है। उन्होंने रैनवाटर हार्वेस्टिंग के विषय पर विस्तृत पेम्पलेट आदि तैयार किये है एवं आमजन तक पहुंचाने के अच्छे प्रयास किये हैं। नगरपालिक निगम इन्दौर से इस विषय पर मार्गदर्शन लिया जा सकता है। निकाय स्वयं की स्थिति को दृष्टिगत रखते हुए समुचित स्थानों पर पब्लिक मिटिंग कर इस कार्य के महत्व को सामान्य जन को समझाये एवं साथ ही यह कार्य कैसे करना है इसके विषय पर जानकारी दे। पोस्टर, फिल्म आदि के माध्यम से यह कार्य किया जा सकता है। नगरपालिक निगम इन्दौर में इस विषय पर काफी फिल्में तैयार की गई है, जिनकी मदद आपके द्वारा ली जा सकती है। Awareness Campaign के लिए संचालनालय द्वारा आपको आर्थिक सहायता उपलब्ध कराई जा सकेंगी जिसके लिए आपके द्वारा तैयारी की जाकर आपके द्वारा मांग पत्र प्रमुख अभियंता को भेजा जाए।

(6) कार्यक्रम की मॉनिटरिंग

इस कार्यक्रम की मॉनिटरिंग रियल टाईम के आधार पर की जाएगी। इस हेतु भारत सरकार ने जल शक्ति अभियान का पोर्टल आवास एवं शहरी मामले मंत्रालय की वेब साईट पर तैयार किया है। पोर्टल का पता www.moud.in/jalshakti है। इस पत्र में बतलाया गया कि 05 क्षेत्रों में प्रत्येक निकाय द्वारा की गई प्रगति की रियल टाईम एन्ट्री प्रत्येक निकाय द्वारा की जाएगी। अतः निकाय के रूफवाटर हार्वेस्टिंग के प्रभारी का नाम, दूरभाष नंबर तथा ई–मेल आई.डी. तुरन्त संचालनालय के यांत्रिकी प्रकोष्ठ को भेजे। इनके नाम भारत सरकार को भेजे जाएंगे ताकि आपकी नगरीय निकाय से संबंधित पोर्टल का पासवर्ड तथा आई.डी. आपको भेजी जा सके। इस संबंध में श्री आलोक सिंह जिनका दूरभाष नंबर 9685204163 तथा ईमेल alok.baghel@gmail.com से संपर्क किया जा सकता है। Login-ID तथा पासवर्ड मिल जाने के उपरान्त तुरन्त इसमें Data entry प्रारंभ करना है। तदनुसार तैयारी रखी जाए।

इस योजना के संचालन आदि के संबंध में प्रमुख अभियंता, संचालनालय नगरीय प्रशासन एवं विकास के ईमेल पर संपर्क किया जा सकता है।

(पी.नरहरि)
आयुक्त
नगरीय प्रशासन एवं विकास,
मध्यप्रदेश, भोपाल

संचालनालय, नगरीय प्रशासन एवं विकास, म.प्र., भोपाल
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कमांक / या.प्र. / 07 / 2019 / 6968 भोपाल,दिनांक: 11 / 7 / 2019

प्रतिलिपिः–

(1) सचिव, भारत सरकार, आवास एवं शहरी मामले मंत्रालय, निर्माण भवन, नई दिल्ली की ओर सूचनार्थ एवं आवश्यक कार्यवाही हेतु अग्रेषित।

(2) प्रमुख अभियंता, नगरीय प्रशासन एवं विकास, मध्यप्रदेश भोपाल की ओर सूचनार्थ एवं आवश्यक कार्यवाही हेतु अग्रेषित।

आयुक्त,
नगरीय प्रशासन एवं विकास,
मध्यप्रदेश,भोपाल

संचालनालय, नगरीय प्रशासन एवं विकास, म.प्र., भोपाल
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क्र./यां. प्र./07/2019/7083 भोपाल, दिनांक 15/07/2019

प्रति,

1. आयुक्त,
   नगर पालिक निगम,
   रतलाम, उज्जैन, देवास एवं इन्दौर, मध्यप्रदेश।
2. मुख्य नगर पालिका अधिकारी,
   नगर पालिका परिषद् / नगर परिषद्,
   आगर, नलखेड़ा, सुसनेर, बड़वानी, पानसेमल, सोनकच्छ, बद्नावर, धार, देपालपुर, सावेर, भानपुरा, मल्हारगढ़, मंदसौर, सीतामऊ, जावद, नीमच, नरसिंहगढ़, राजगढ़, सारंगपुर, आलोट, जावरा, पिपलोदा, पानखेड़ी (कालापीपल) शाजापुर एवं बड़नगर, म.प्र.।

विषय :- जल शक्ति अभियान – नगरीय जल संरक्षण के संबन्ध में।
संदर्भ :- संचालनालय का पत्र क्र. 6967, भोपाल दिनांक 16/07/2019।

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संदर्भित पत्र के माध्यम से भारत सरकार द्वारा प्रारंभ किये गये जल शक्ति अभियान के संबन्ध में विस्तृत निर्देश दिये गये हैं। मिशन के क्रियान्वयन के लिये निकाय स्तर पर आयुक्त/मुख्य नगर पालिका अधिकारी मुख्यतः जिम्मेदार रहेंगे। साथ ही मिशन के संलान हेतु निकाय स्तर पर एक नोडल अधिकारी भी मनोनित किया जाना है। तत्काल जल शक्ति मिशन के लिये एक नोडल अधिकारी मनोनित करें।

उक्त मिशन के क्रियान्वयन हेतु प्रमुख सचिव, नगरीय आवास एवं विकास विभाग तथा आयुक्त, नगरीय प्रशासन एवं विकास विभाग की उपस्थिति में संचालनालय, नगरीय प्रशासन एवं विकास, शिवाजी नगर, भोपाल में दिनांक 17.07.2019 को अपराह्न 3:00 बजे से बैठक आयोजित की गई है। उक्त बैठक में उपरोक्त नगरीय निकायों के आयुक्त, मुख्य नगर पालिका अधिकारी एवं नोडल अधिकारी अनिवार्य रूप से उपस्थित होना सुनिश्चित करेंगे।

(प्रभाकांत कटारे)
प्रमुख अभियंता,
नगरीय प्रशासन एवं विकास
मध्यप्रदेश, भोपाल।

पृ.क्र./यां. प्र./07/2019/7084 भोपाल, दिनांक 15/07/2019

प्रतिलिपि :-

1. निज सचिव, प्रमुख सचिव, नगरीय आवास एवं विकास, म.प्र. को अवगत कराने हेतु सूचनार्थ।
2. निज सचिव, आयुक्त, नगरीय प्रशासन एवं विकास विभाग को अवगत कराने हेतु सूचनार्थ।
3. समस्त जिला कलेक्टर, मध्यप्रदेश को आवश्यक कार्यवाही हेतु सूचनार्थ।
4. श्री अरूण नामदेव, सहायक यंत्री, नगर पालिका परिषद् अशोक नगर बैठक में उपस्थित रहने हेतु सूचनार्थ।

प्रमुख अभियंता,
नगरीय प्रशासन एवं विकास
मध्यप्रदेश, भोपाल।

संचालनालय, नगरीय प्रशासन एवं विकास, म.प्र., भोपाल
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क्रमांक/या.प्र./07/2019/7156 भोपाल, दिनांक 16/07/2019

प्रति,

1. संयुक्त संचालक,
   इन्दौर, उज्जैन एवं भोपाल संभाग,
   मध्यप्रदेश।

2. अधीक्षण यंत्री/कार्यपालन यंत्री,
   इन्दौर, उज्जैन एवं भोपाल संभाग,
   मध्यप्रदेश।

विषयः– जल शक्ति अभियान– नगरीय जल संरक्षण के संबन्ध में।

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विषयान्तर्गत दिनांक 17.07.2019 को अपरान्ह 3:00 बजे संचालनालय, नगरीय प्रशासन एवं विकास, भोपाल में बैठक का आयोजन किया गया है। आपके संभाग से संबन्धित नगरीय निकायों एवं निकायों के नोडल अधिकारियों की सूची संलग्न है।

सभी संयुक्त संचालक एवं अधीक्षण यंत्री/कार्यपालन यंत्री इस बैठक में सम्मिलित होना सुनिश्चित करें, साथ ही संभागीय कार्यालय स्तर पर भी सहायक यंत्री/उपयंत्री को जल शक्ति अभियान के लिये नोडल अधिकारी नियुक्त किया जाकर बैठक में लाना सुनिश्चित करें।

संलग्न : अधिकारियों की सूची।

(प्रभाकांत कटारे)
प्रमुख अभियंता,
नगरीय प्रशासन एवं विकास
मध्यप्रदेश, भोपाल

पृ. क्रमांक/या.प्र./07/2019/7157 भोपाल, दिनांक 16/07/2019

प्रतिलिपि :–

1. निज सचिव, प्रमुख सचिव, म.प्र. शासन, नगरीय विकास एवं आवास विभाग को अवगत कराने हेतु सूचनार्थ।
2. निज सचिव, आयुक्त, नगरीय प्रशासन एवं विकास को अवगत कराने हेतु सूचनार्थ।

प्रमुख अभियंता,
नगरीय प्रशासन एवं विकास
मध्यप्रदेश, भोपाल

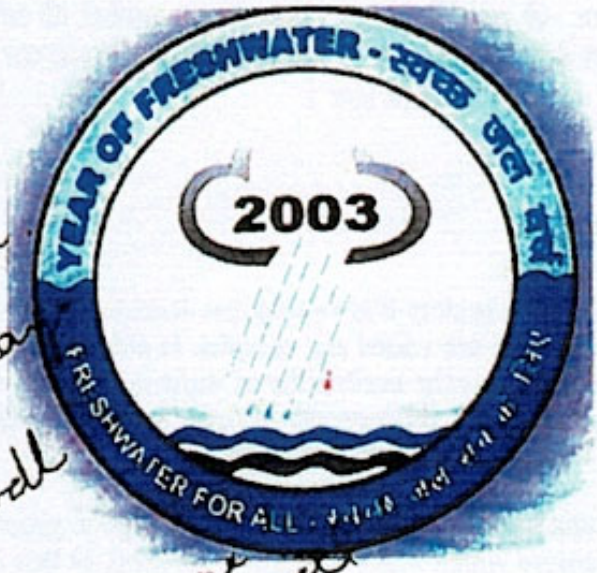
Sr. No.	State/UT	District	City
1	Madhya Pradesh	Agar Malwa	Agar (HQ)
2	Madhya Pradesh	Agar Malwa	Nalkheda (NP)
3	Madhya Pradesh	Agar Malwa	Susner (NP)
4	Madhya Pradesh	Barwani	Barwani (HQ)
5	Madhya Pradesh	Barwani	Pansemal (NP)
6	Madhya Pradesh	Dewas	Dewas (M Corp.) (HQ)
7	Madhya Pradesh	Dewas	Sonkatch (NP)
8	Madhya Pradesh	Dhar	Badnawar (NP)
9	Madhya Pradesh	Dhar	Dhar (M) (HQ)
10	Madhya Pradesh	Indore	Depalpur (NP)
11	Madhya Pradesh	Indore	Indore (M Corp.) (HQ)
12	Madhya Pradesh	Indore	Sawer (NP)
13	Madhya Pradesh	Mandsaur	Bhanpura (NP)
14	Madhya Pradesh	Mandsaur	Malhargarh (NP)
15	Madhya Pradesh	Mandsaur	Mandsaur (M) (HQ)
16	Madhya Pradesh	Mandsaur	Sitamau (NP)
17	Madhya Pradesh	Neemuch	Jawad (NP)
18	Madhya Pradesh	Neemuch	Neemuch (M) (HQ)
19	Madhya Pradesh	Rajgarh	Narsinghgarh (M)
20	Madhya Pradesh	Rajgarh	Rajgarh (HQ)
21	Madhya Pradesh	Rajgarh	Sarangpur (M)
22	Madhya Pradesh	Ratlam	Alot (NP)
23	Madhya Pradesh	Ratlam	Jaora (M)
24	Madhya Pradesh	Ratlam	Piploda (NP)
25	Madhya Pradesh	Ratlam	Ratlam (M Corp.) (HQ)
26	Madhya Pradesh	Shajapur	Pankhedi(Kalapipal)
27	Madhya Pradesh	Shajapur	Shajapur (M) (HQ)
28	Madhya Pradesh	Ujjain	Badnagar (M)
29	Madhya Pradesh	Ujjain	Ujjain (M Corp.) (HQ)

MANUAL - 1

स्वच्छ जल वर्ष 2003
FRESHWATER YEAR – 2003

भूमि जल में वृद्धि के लिए
वर्षा जल के संचयन की तकनीकें

Rain water Harvesting Techniques To Augment Ground Water



Recharge pit.
Recharge Trench.
Tubewell recharge
Recharge well
Trench with recharge well

जल संसाधन मंत्रालय
केन्दीय भूमि जल बोर्ड
फरीदावाद

MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD
FARIDABAD

Storage Tank
Recharge through existing Tube well
Abandoned tube well

प्रस्तावना

प्रगतिशील युग में जल की वढ़ती खपत वहुत ही स्वाभाविक प्रकिया है। हमारे देश की समस्याएं विविध एवं जटिल हैं क्योंकि भारतवर्ष में जल की उपलब्धता क्षेत्रीय वर्षा एवं भौगोलिक परिस्थितियों पर आधारित है । इसके साथ वढ़ती हुई जनसंख्या शहरीकरण का वढ़ता क्षेत्र अपना प्रभाव जल की उपलब्धि एवं गुणवत्ता पर डाल रहे हैं ।

इन परिस्थितियों में कृत्रिम जल भरण की प्रकियाएक आवश्यक पहलू है जो कि हर तरह से लाभप्रद है। इससे भूजल के रूप में वर्षा एवं अतिरिक्त जल वचा कर रखा जा सकता है जिससे भू जल स्तर की गिरावट की क्षीणता पर रोक लगाना संभव है । साथ ही यह पर्यावरण के अनुकूल है ।

केन्द्रीय भूमि जल वोर्ड ने आठवीं योजना से कृत्रिम जल भरण पर काफी अध्ययन किया है एवं विभिन्न तरीकों की उपयोगिता को समझा है । इस संस्करण में कुछ तकनीकों की जानकारी दी गई है जो विभिन्न भौगोलिक एवं जमीन के नीचे की स्थितियों के लिए उपयुक्त है । यह स्वच्छ जल वर्ष 2003 में कृत्रिम पुनर्भरण की गतिविधियों को वढ़ावा देने में लाभप्रद होगा ।

In a progressive society it is natural that demands of water remain on the rise. In this context the issues are varied and complex in our country, because in India there are remarkable variation in the availability of water on account of the regional rainfall and geography. Alongwith, the increasing population and urbanization are having telling effect on the availability and quality of water.

In this situation the activity of artificial recharge to ground water is an indispensable measure which is substantially beneficial, as this will help store the surplus rainwater in the form of ground water and in turn arrest the decline of water level and degradation of the quality. All the same it is ecofriendly.

Since eighth plan the Central Ground Water Board has carried out intensive studies on the effectiveness of different techniques of artificial recharge to ground water. This compilation contains some of the techniques that are suited to different geographic and geologic condition. This would help boost the activity of artificial recharge to ground water in Freshwater Year 2003.

Chairman

Central Ground Water Board

भूमि जल संसाधनों में वृद्धि के लिए वर्षा जल का संचयन

1.0 वर्षा जल सतही अपवाह के रूप में वहकर नष्ट हो जाने से पहले सतह पर या उपसतही जलभृत में एकत्रित या संचित किये जाने की तकनीक को वर्षा जल संचयन (रेन वाटर हारवेस्टिंग) कहते हैं । भूमि जल का कृत्रिम पुनर्भरण वह प्रक्रिया है जिससे भूमि जल जलाश्य का प्राकृतिक स्थिति में भण्डारण की दर से ज्यादा भण्डारण होता है ।

2.0 आवश्यकता

- हमारी मॉग की पूर्ति के लिए सतही जल की कमी को पूरा करने हेतु ।
- गिरते भूमि जल स्तर को रोकने हेतु ।
- खास जगह व समय पर भूमि जल उपलब्धता वढ़ाने व प्रोत्साहनात्मक विकास के लिए वर्षा जल का उपयोग करने हेतु ।
- वर्षा जल द्वारा उपसतही मिट्टी में अन्तःस्यन्दन को वढ़ाने के लिए जो शहरी क्षेत्रों में निर्माण के कारण अत्यधिक कम हो चुका है ।
- जल मिश्रण द्वारा भूमि जल की गुणवत्ता को वढ़ाने के लिए ।
- कृपि पैदावार वढ़ाने के लिए।
- वनस्पति के फैलाव में वृद्धि द्वारा क्षेत्र की पारिस्थितिक को सुधारने हेतु ।

3.0 लाभ

- उपसतही जलाश्य में पुनर्भरण की लागत सतही जलाश्यों से कम होती है ।
- जलभृत वितरण प्रणाली के रूप में भी कार्य करता है ।
- भण्डारण के उद्देश्य से भूमि व्यर्थ नहीं जाती और ना ही आवादी को हटाने की आवश्यकता होती है ।
- भूमि जल का वाष्पीकरण व प्रदूपण सीधे रूप से नहीं हो पाता ।
- भूमि के नीचे (उपसतह) में जल का भण्डारण पर्यावरण के अनुकूल है ।
- यह जलभृत में उत्पादकता को वढ़ाता है ।
- यह वाढ़ के खतरे को कम करता है ।
- इससे भूमि जल स्तर में वृद्धि होती है ।
- सूखे के खतरे व प्रभाव को कम करता है ।
- मृदा अपरदन कम करता है ।

RAIN WATER HARVESTING TO AUGMENT GROUND WATER RESOURCES

1.0 Rain water harvesting is the technique of collection and storage of rain water at surface or in sub-surface aquifers, before it is lost as surface run-off. The augmented resource can be harvested in the time of need. Artificial recharge to ground water is a process by which the ground water reservoir is augmented at rate exceeding that under natural conditions of replenishment.

2.0 NEED

- To overcome the inadequacy of waters to meet our demands.
- To arrest decline in ground water levels.
- To enhance availability of ground water at specific place and time and utilize rain water for sustainable development.
- To increase infiltration of rain water in the subsoil which has decreased drastically in urban areas due to paving of open area.
- To improve ground water quality by dilution.
- To increase agriculture production.
- To improve ecology of the area by increase in vegetation cover, etc.

3.0 ADVANTAGES

- Cost of recharge to sub-surface reservoir is lower than surface reservoirs.
- The aquifer serves as distribution system also.
- No land is wasted for storage purpose and no population displacement is involved.
- Ground water is not directly exposed to evaporation and pollution.
- Storing water underground is environment friendly.
- It increases the productivity of aquifer.
- It reduces flood hazards.
- Effects rise in ground water levels.
- Mitigates the effects of drought.
- Reduces soil erosion.

4.0 अभिकल्प विचार

- भूमि जल संसाधनों में वृद्धि के लिए वर्षा जल संचयन प्रणाली की अभिकल्प तैयार करने के लिए जिन मुख्य बातों का ध्यान रखा जाना चाहिए वे हैं :-
- क्षेत्र की भूजलीय स्थिति जिसमें जलभृत का प्रकार व विस्तार, मृदा आवरण, भू आकृति, जलस्तर की गहराई व भूमि जल की रसायनिक गुणवत्ता आदि शामिल हैं।
- स्रोत जल की उपलब्धता, जो भूजल पुनर्भरण के लिए प्राथमिक आवश्यकता है, का आंकलन मुख्य रूप से नान-कोमिटिड अतिरिक्त मानसून अपवाह के रूप मे किया जाता है ।
- अपवाह में योगदान करने वाले क्षेत्र का आकलन जैसे उपलब्ध क्षेत्र, भूमि उपयोग की पद्धति, औद्योगिक, आवासीय, हरित पट्टी, पक्का क्षेत्र व छत का क्षेत्रफल इत्यादि ।
- जल मौसम विज्ञान के घटकों का आंकलन जैसे वर्षा की अवधि, सामान्य पद्धति व वर्षा की तीव्रता आदि ।

5.0 क्रियाशील क्षेत्र

- जहां भूमि जलस्तर में लगातार गिरावट आ रही हो ।
- जहां जलभृत का अधिकांश भाग असंतृप्त कर दिया गया हो।
- जहां आवश्यकता के महीनों में भूमि जल की उपलब्धता अत्यंत कम हो ।
- जहां तेज़ी से हो रहे शहरीकरण के कारण उपसतही मृदा में अन्तःस्यंदन काफी कम हो गया हो तथा भूजल पुनर्भरण में कमी आ गई हो ।

6.0 पुनर्भरण करने के तरीके व तकनीक

भूमिजल पुनर्भरण मुख्यतः निम्नलिखित तरीकों द्वारा किया जा सकता है ।

- शहरी क्षेत्र

छत से प्राप्त वर्षाजल / वर्षाजल से उत्पन्न अपवाह संचित करने के लिए निम्नलिखित संरचनाओं का प्रयोग किया जा सकता है ।

(i) पुनर्भरण पिट (गड्ढा)
(ii) पुनर्भरण खाई(ट्रेन्च)
(iii) नलकूप
(iv) पुनर्भरण कूप

- ग्रामीण क्षेत्र

वर्षा जल संचित करने के लिए निम्नलिखित संचनाओं का प्रयोग किया जा सकता है

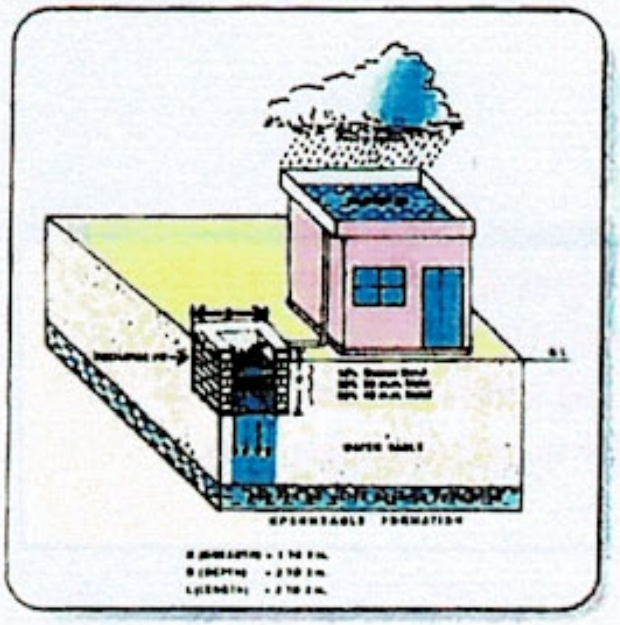
(i) गली प्लग
(ii) परिरेखा बांध (कंटूर बंड)
(iii) गेवियन संरचना
(iv) परिस्त्रवण टैंक (परकोलेशन टैंक)
(v) चैक बांध / सीमेन्ट प्लग / नाला बंड
(vi) पुनर्भरण शाफ्ट
(vii) कूप डग वैल पुनर्भरण
(viii) भूमि जल बांध / उपसतही डाईक

URBAN AREAS

In urban areas, rain water available from roof tops of buildings, paved and unpaved areas goes waste. This water can be recharged to aquifer and can be utilized gainfully at the time of need. The rain water harvesting system needs to be designed in a way that it does not occupy large space for collection and recharge system. A few techniques of roof top rain water harvesting in urban areas are described below.

(i) ROOF TOP RAIN WATER HARVESTING THROUGH RECHARGE PIT

- In alluvial areas where permeable rocks are exposed on the land surface or at very shallow depth, roof top rain water harvesting can be done through recharge pits.
- The technique is suitable for buildings having a roof area of 100 sq.m. and are constructed for recharging the shallow aquifers.
- Recharge Pits may be of any shape and size and are generally constructed 1 to 2 m. wide and 2 to 3 . deep which are back filled with boulders (5-20 cm), gravels (5-10mm) and coarse sand (1.5- 2mm) in graded form. Boulders at the bottom, gravels in between and coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of the coarse sand layer and can easily be removed. For smaller roof area, pit may be filled with broken bricks/ cobbles.
- A mesh should be provided at the roof so that leaves or any other solid waste / debris is prevented from entering the pit and a desilting /collection chamber may also be provided at the ground to arrest the flow of finer particles to the recharge pit.
- The top layer of sand should be cleaned periodically to maintain the recharge rate.
- By-pass arrangement be provided before the collection chamber to reject the first showers.



(ii) पुनर्भरण खाई (ट्रन्च) द्वारा छत से प्राप्त वर्षा जल का संचयन

- पुनर्भरण खाई 200-300 वर्ग मी0 क्षेत्रफल वाली छत के भवन के लिए उपयुक्त है तथा जहां भेद्य स्तर छिछले गहराई में उपलब्ध होता हो ।
- पुनर्भरण करने योग्य जल की उपलब्धता के आधार पर खाई 0.5 से । मी0 चौड़ी, । से 1.5 मी0 गहरी तथा 10 से 20 मी0 लम्बी हो सकती है ।
- यह शिलाखण्ड 5 से 20 से0मी0 वजरी 5 10मि0मी0 एवं मोटी रेत 1.5-2 मि0मी0 से कमानुसार भरा होता है । तल में शिलाखण्ड वजरी वीच में तथा मोटी रेत सवसे ऊपर भरी होती है ताकि अपवाह के साथ आने वाली गाद मोटी रेत पर जमा हो जाए जिसे आसानी से हटाया जा सके ।
- जाली छत स जल निकलने वाले पाईप पर लगाई जानी चाहिए ताकि पत्तों या अन्य ठोस पदार्थों को खाई में जाने से रोका जा सके एव सूक्ष्म पदार्थों को खाई में जाने से रोकने के लिए गादनिस्तारण कक्ष य संग्रहण कक्ष जमीन पर वनाया जाना चाहिए।
- प्रथम वर्षा के जल को संग्रहण कक्ष में जाने से रोकने के लिए कक्ष से पहले एक उपमार्ग व्यवस्था की जानी चाहिए ।
- पुनर्भरण दर को वनाए रखने के लिए रेत की ऊपरी सतह की आवधिक सफाई की जानी चाहिए ।

भूजल स्तर में गिरावट के कारण

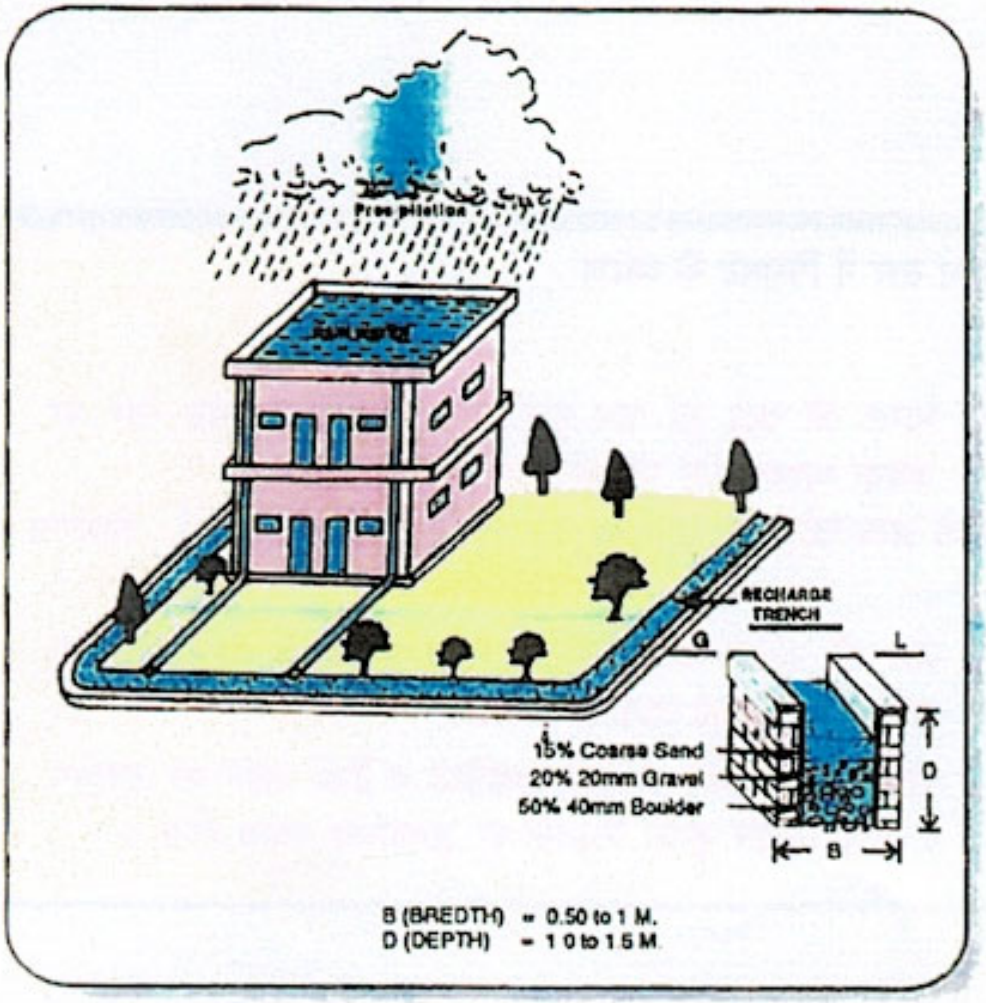
- भारत की वढ़ी हुई मांग पूरा करने के लिए स्थानीय स्तर पर अथवा व्यापक स्तर पर जल का अति दोहन।

जल के अन्य स्त्रोतों का उपलब्ध न होना जिससे भूजल पर पूर्ण निर्भरता ।

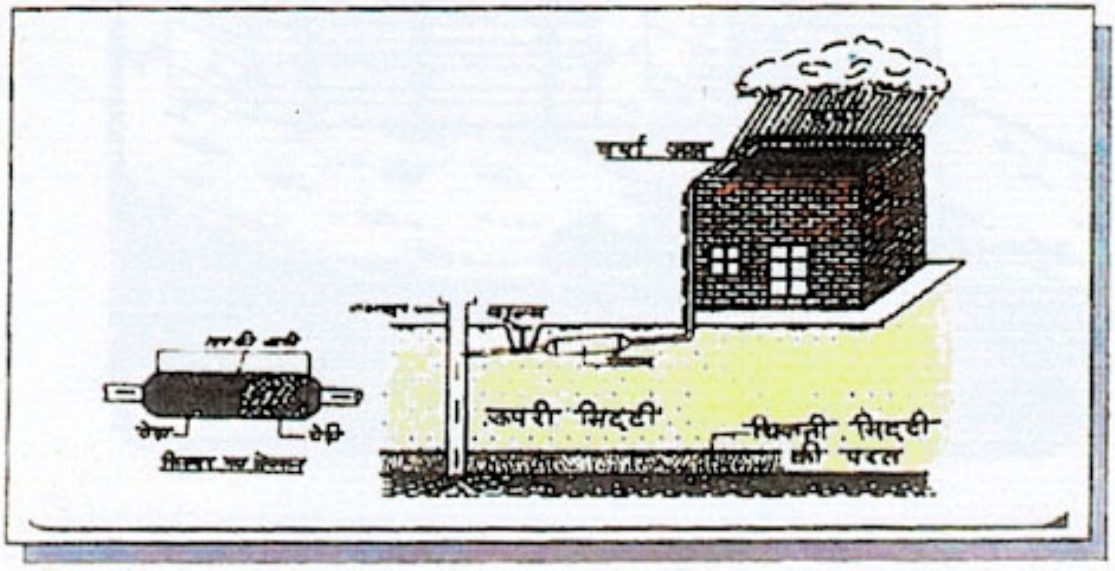
- जल की उचित मात्रा निश्चित समय पर प्राप्त करने के लिए अपने संसाधनों की व्यवस्था करना ।
- प्राचीन साधनों जैसे तालावों वावड़ियों व टैंकों आदि का उपयोग न करना जिससे भूजल निकासी पर अत्याधिक दवाव होना ।

(ii) ROOF TOP RAIN WATER HARVESTING THROUGH RECHARGE TRENCH

- Recharge trenches are suitable for buildings having roof area of 200-300 sq. m. and where permeable strata is available at shallow depths.
- Trench may be 0.5 to 1 m wide, 1 to 1.5m. deep and 10 to 20 m. long depending upon availability of water to be recharge.
- These are back filled with boulders (5-20cm), gravel (5-10 mm) and coarse sand (1.5-2 mm) in graded form – boulders at the bottom, gravel in between and coarse sand at the top so that the silt content that will come with runoff will be coarse sand at the top of the sand layer and can easily be removed.
- A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the trenches and a desilting/collection chamber may also be provided on ground to arrest the flow of finer particles to the trench.
- By-pass arrangement be provided before the collection chamber to reject the first showers.
- The top layer of sand should be cleaned periodically to maintain the recharge rate.

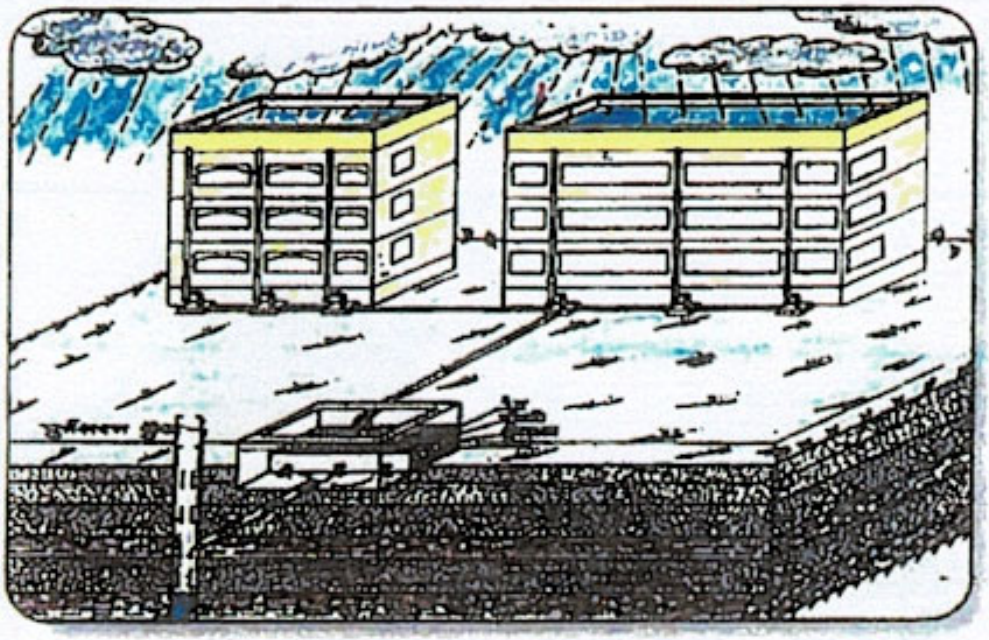


- ऐसे क्षेत्र जहां छीछले जलभृत सूख गये हैं व मौजूदा नलकूप गहरे जलभृत से जल निकाल रहे हों वहां गहरे जलभृत को पुनर्भरित करने के लिए मौजूद नलकूप द्वारा छत से प्राप्त वर्षा जल के संचयन की पद्धति अपनाई जा सकती है ।
- पानी इकट्ठा करने के लिए छत की नाली को 10 से0 मी0 व्यास के पाईप से जोड़ा जाता है । पहली बरसात के अपवहित जल को छत से आने वाले पाईप के निचले सिरे से बाहर निकाल दिया जाता है । इसके पश्चात् नीचे के पाईप को बंद करके आगे की बरसात का पानी लाईन पर लगे "T" पाईप के माध्यम से पी0 वी0 सी0 फिल्टर तक लाया जाता है। जल के नलकूप में जाने के स्थान से पहले फिल्टर लगाया जाता है । फिल्टर 1 से 1 2 मी0 लम्बा होता है व पी0 वी0 सी0 पाईप का बना होता है । इस का व्यास छत के आकार के अनुसर बदल सकता है । यदि छत का क्षेत्रफल 150 वर्ग मी0 से कम हो तो पाईप का व्यास 15 से0 मी0 व अधिक हो तो 20 से0 मी0 तक हो सकता है । फिल्टर के दोनों सिरों पर 6.25 से0 मी0 के रिड्यूसर लगाए जाते हैं । फिल्टर पदार्थ आपस में न मिल सके इसलिए फिल्टर को पी0 वी0 सी0 जाली द्वारा तीन कक्षों में बांटा जाता है । पहले कक्ष में बजरी (6 से0 10 मि0मी0) बीच वाले कक्ष में पैबल (12-20 मि0मी0) तथा आखिरी कक्ष में बड़े पैबल (20-40 मि0मी0) भरे जाते हैं ।
- यदि छत का क्षेत्रफल ज्यादा हो तो फिल्टर पिट बनाया जा सकता है । छत से प्राप्त वर्षा जल को जमीन पर बने गाद निस्तारण कक्ष या संग्रहण कक्ष में ले जाया जाता है । जल एकत्र करने वाले कक्ष आपस में जुड़े होते हैं साथ ही पाईप के माध्यम से, जिसका ढाल 1:15 हो फिल्टर पिट से जुड़े होते हैं । फिल्टर पिट का आकार व प्रकार उपलब्ध अपवहित जल पर निर्भर करता है तथा फिल्टर पदार्थ द्वारा कमबार वापस भर दिया जाता है तल में बोल्डर (शिलाखण्ड), बीच में ग्रैवल (बजरी) व सबसे ऊपर मोटी रेत भरी जाती है । इन स्तरों की मोटाई 0 .3 से 0.5 मी0 तक हो सकती है व ये स्तर आपस में जाली द्वारा अलग-अलग भी रखे जा सकते हैं । संग्रहण कक्ष को दो कक्षों में बांट दिया जाता है । एक कक्ष में फिल्टर करने वाले पदार्थ व दूसरे कक्ष में फिल्टर होकर आये अतिरिक्त जल को भरा जा सकता है जिससे जल की गुणवत्ता की जांच की जा सकती है । फिल्टर किये गये जल को पुनर्भरित करने के लिए इस कक्ष के निचले भाग से निकाले गये पाईप को पुनर्भरण पिट से जोड़ दिया जाता है ।



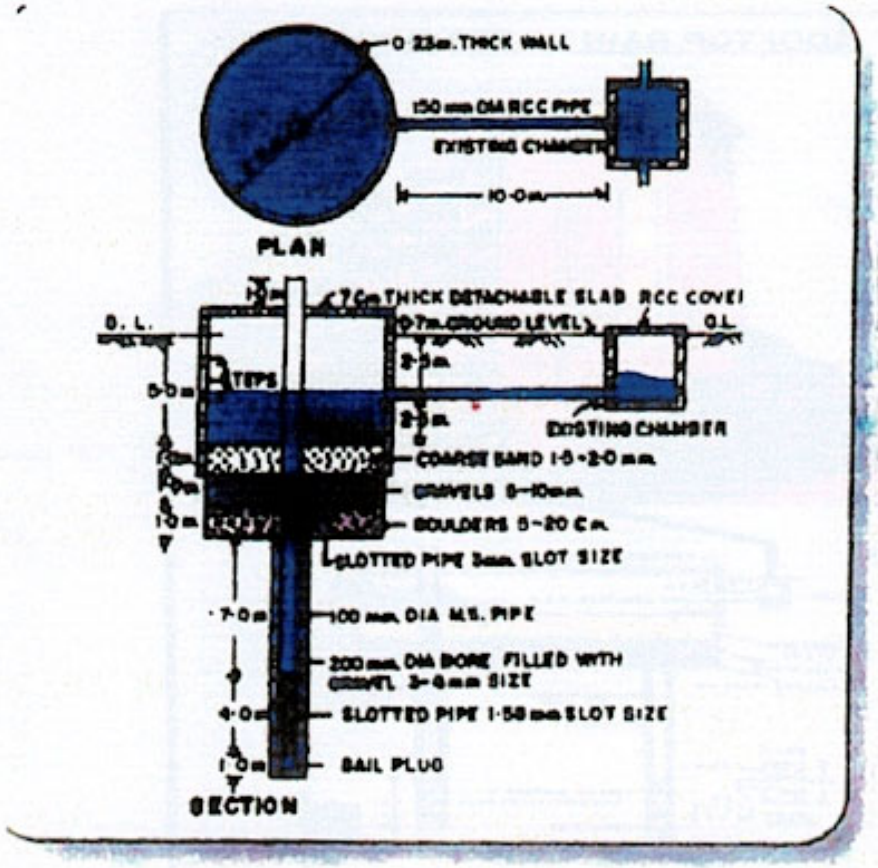
(iii) ROOF TOP RAIN WATER HARVESTING THROUGH EXISTING TUBEWELLS

- In areas where the shallow aquifers have dried up and existing tubewells are tapping deeper aquifer, roof to rain water harvesting through existing tubewell can be adopted to recharge the deeper aquifers.
- PVC pipes of 10 cm dia are connected to roof drains to collect rainwater. The first roof runoff is let off through the bottom of drainpipe. After closing the bottom pipe, the rainwater of subsequent rain showers is taken through a T to an online PVC filter. The filter may be provided before water enters the tubewells. The filter is 1 –1.2 m. in length and is made up of PVC pipe. It's diameter should vary depending on the area of roof, 15 cm if roof area is less than 150 sq m and 20 cm if the roof area is more. The filter is provided with a reducer of 6.25 cm on both the sides. Filter is divided into three chambers by PVC screens so that filter material is not mixed up. The first chamber is filled up with gravel (6-10mm), middle chamber with pebbles (12-20 mm) and last chamber with bigger pebbles (20-40 mm).
- If the roof area is more, a filter pit may be provided. Rainwater from roofs is taken to collection/desilting chambers located on ground. These collection chambers are interconnected as well as connected to the filter pit through pipes having a slop of 1:15. The filter pit may vary in shape and size depending upon available runoff and are back-filled with graded material, boulder at the bottom, gravel in the middle and sand at the top with varying thickness (0.30-0.50m) and may be separated by screen. The pit is divided into two chambers, filter material in one chamber and other chamber is kept empty to accommodate excess filtered water and to monitor the quality of filtered water. A connecting pipe with recharge well is provided at the bottom of the pit for recharging of filtered water through well.



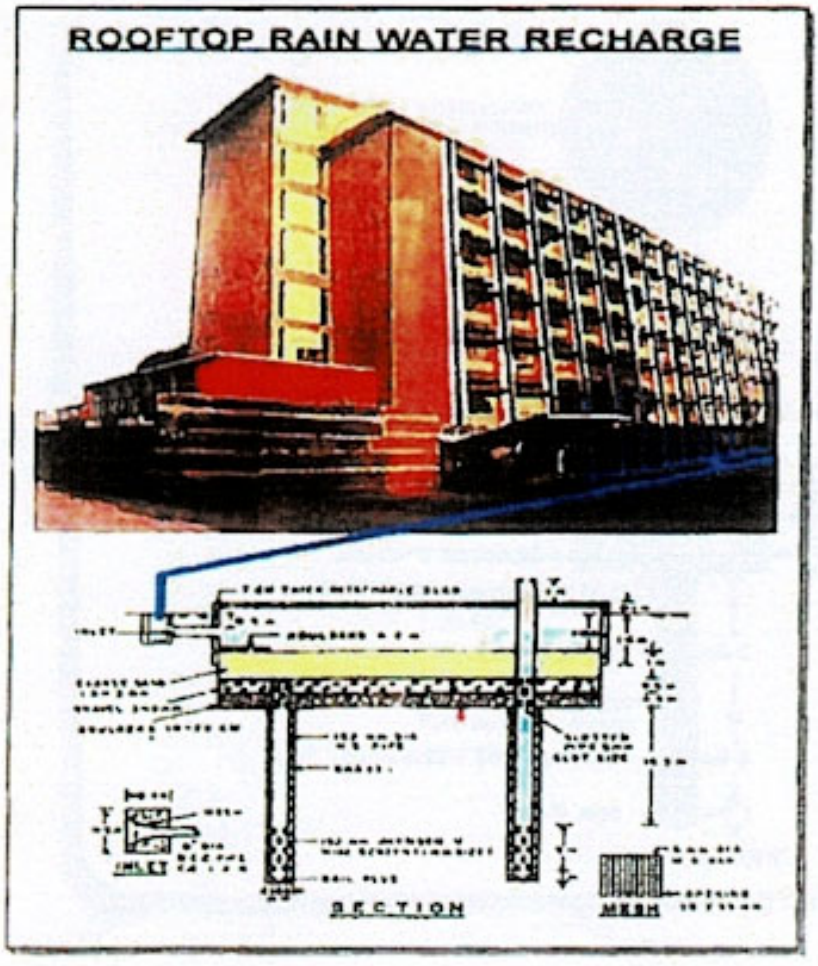
(iv) पुनर्भरण कुँओं के साथ खाई द्वारा छत से प्राप्त वर्षा जल का संग्रहण

- ऐसे क्षेत्रों में जहां सतही मृदा अपारगम्य है तथ अधिक मात्रा में छत से प्राप्त वर्षा जल या सतही अपवाह काफी कम समयान्तराल में भारी वर्षा के कारण उपलब्ध हो, ऐसे में खाई/ पिट में बने फिल्टर माध्यम में जल संग्रहण किया जाता है तथा विशेष रूप से निर्मित पुनर्भरण कुँओं के द्वारा भूमि जल का लगातार पुनर्भरण किया जाता है ।
- यह तकनीक उस क्षेत्र के लिए आदर्शत: उपयुक्त हैं जहाँ पारगम्य स्तर भूमि सतह के 3 मी0 के अन्दर मौजूद है ।
- 100 से 300 मि0 मी0 व्यास का पुनर्भरण कुँआ जिसकी कम से कम गहराई जल स्तर से 3 से 5 मी0 नीचे तक हो बनाया जाता है । क्षेत्र की लियोलोजी के अनुसार कूप संरचना का डिज़ाईन तैयार किया जाता है जिसमें छीछले व गहरे जलभृत के सामने छिद्रयुक्त पाईप डाला जाता है ।
- पुनर्भरण कुँए को मध्य मे रखते हुए जल की उपलब्धता पर आधारित 1.5 से 3 मी0 चौड़ी तथा 10 से 30 मी0 लम्बी पार्श्विक खाई का निर्माण किया जाता है।
- खाई में कुँओं की संख्या जल की उपलब्धता व क्षेत्र विशेष में चट्टानों की उद्धर्व पारगम्यता के अनुसार निर्धारित की जा सकती है ।
- पुनर्भरण कुँओं के लिए फिल्टर माध्यम के रूप में कार्य करने के लिए खाई को बोल्डर, ग्रैवल व मोटी रेत से भर दिया जाता है ।
- यदि जलभृत काफी गहराई 20 मी0 से ज्यादा पर उपलब्ध हो तब अपवहित जल की उपलब्धता के आधार पर 2 से 5 मी0 व्यास व 3 से 5 मी गहरी छिछली शाफ्ट का निर्माण किया जा सकता है । उपलब्ध जल को गहरे जलभृत में पुनर्भरित करने के लिए शाफ्ट के अन्दर 100 से 300 मि0 मी0 व्यास का पुनर्भरण कुँआ बनाया जाता है । पुनर्भरण कुँओं को जाम होने से बचाने के लिए शाफ्ट के तल में फिल्टर पदार्थ भर दिया जाता है ।



(iv) ROOF TOP RAIN WATER HARVESTING THROUGH TRENCH WITH RECHARGE WELL

- In areas where the surface soil is impervious and large quantities of roof water or surface runoff is available within a very short period of heavy rainfall, the use of trench/ pits is made to store the water in a filter media and subsequently recharge to ground water through specially constructed recharge wells.
- This techniques is ideally suited for area where permeable horizon is within 3m below ground level.
- Recharge well of 100-300 diameter is constructed to a depth of at least 3 to 5 m below the water level. Based on the lithology of the area well assembly is designed with slotted pipe against the shallow and deeper aquifer.
- A lateral trench of 1.5 to 3m width and 10 to 30 m length, depending upon the availability of water is constructed with the recharge well in the centre.
- The number of recharge wells in the trench can be decided on the basis of water availability and local vertical permeability of the rocks.
- The trench is backfilled with boulders, gravels and coarse sand to act as a filter media for the recharge wells.
- I f the aquifer is available at greater depth say more than 20 m, a shallow shaft of 2 to 5 m diameter and 3-5 metres deep may be constructed depending upon availability of runoff. Inside the shaft a recharge well of 100-300 mm dia is constructed for recharging the available water to the deeper aquifers. At the bottom of the shaft a filter media is provided to avoid choking of recharge well.



ग्रामीण क्षेत्र

ग्रामीण क्षेत्र में वर्षा जल का संचयन वाटर शेड को एक इकाई के रूप लेकर करते हैं । आमतौर पर सतही फैलाव तकनीक अपनाई जाती है क्योंकि ऐसी प्रणाली के लिए जगह प्रचुरता में उपलब्ध होती है तथा पुनर्भरित जल की मात्रा भी अधिक होती है। ढलान, नदियों व नालों के माध्यम से व्यर्थ जा रहे जल को बचाने के लिए निम्नलिखित तकनीकों को अपनाया जा सकता है ।

(i) गली प्लग द्वारा वर्षा जल का संचयन

- गली प्लग का निर्माण स्थानीय पत्थर चिकनी मिट्टी व झाड़ियों का उपयोग कर वर्षा ऋतु में पहाड़ों के ढलान से छोटे कैचमैन्ट में बहते हुये नालों व जलधाराओं के आर पार किया जाता है ।
- गली प्लग मिट्टी व नमी के संरक्षण में मदद करता है ।
- गली प्लग के लिए स्थान का चयन ऐसी जगह करते हैं जहां स्थानीय रूप से ढलान समाप्त होता हो ताकि बंड के पीछे पर्याप्त मात्रा में जल एकत्रित रह सके ।

(ii) परिरेखा (कन्टूर) बांध के द्वारा वर्षा जल संचयन

- परिरेखा बांध वाटर शेड में लम्बे समय तक मृदा नमी को संरक्षित रखने की प्रभावी पद्धति है ।
- यह कम वर्षा वाले क्षेत्रों के लिए उपयुक्त होती है जहां मानसून का अपवहित जल समान ऊँचाई वाले कन्टूर के चारों तरफ ढलान वाली भूमि पर बांध बना कर रोका जा सकता है ।
- बहते हुए जल को कटाव वेग प्राप्त करने से पहले बंड के बीच में उचित दूरी रख कर रोक दिया जाता है ।
- दो कन्टूर बंड के बीच की दूरी क्षेत्र के ढलान व मृदा की पारगम्यता पर निर्भर होती है । मृदा की पारगम्यता जितनी कम होगी कन्टूर बंड के बीच दूरी उतनी कम होगी ।
- कन्टूर बंड साधारण ढलान वाली ज़मीन के लिए उपयुक्त होते हैं इनमें सीढ़ियां बनाया जाना शामिल नहीं होता ।

ज़मीन के ढाल के अनुसार बंड के बीच की दूरी

ज़मीन का ढाल प्रतिशत	बंड की ऊँचाई (मीटर में)	बंड के बीच की दूरी (मीटर में)
0-1	1.05	150
1-1.5	1.20	96
1.5-2.0	1.35	77
2-3	1.50	60
3-4	1.60	48
4-5	1.80	40
5-6	1.95	35

RURAL AREAS

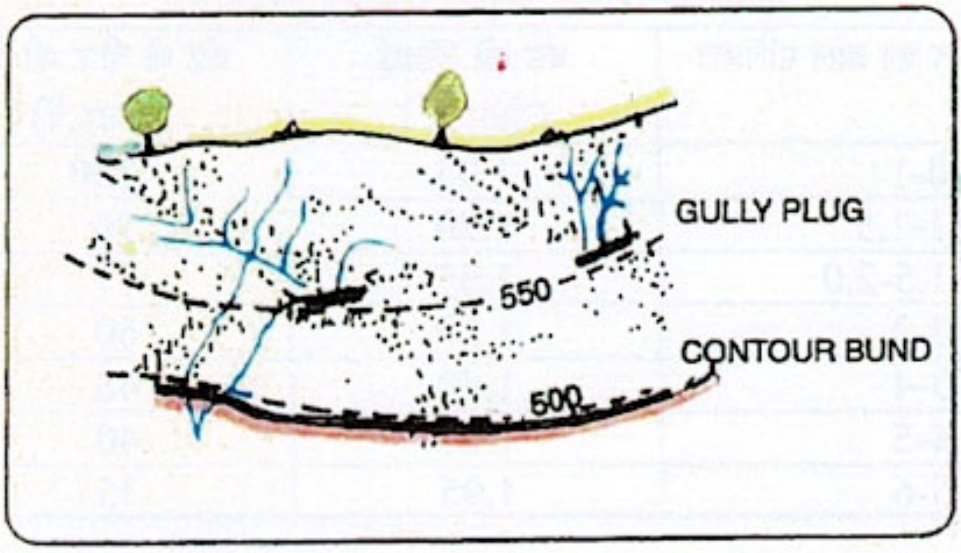
In rural areas, rain water harvesting is taken up considering watershed as a unit. Surface spreading techniques are common since space for such systems is available in plenty and quantity of recharged water is also large. Following techniques may be adopted to save water going waste through slopes, rivers, rivulets and nalas.

(i) RAIN WATER HARVESTING THROUGH GULLY PLUG

- Gully Plugs are built using local stones, clay and bushes across small gullies and streams running down the hill slopes carrying drainage to tiny catchments during rainy season.
- Gully Plugs help in conservation of soil and moisture.
- The sites for gully plugs may be chosen whenever there is a local break in slope to permit accumulation of adequate water behind the bunds.

(ii) RAIN WATER HARVESTING THROUGH CONTOUR BUND

- Contour Bunds are effective methods to conserve soil moisture in watershed for long duration.
- These are suitable in low rain fall areas where monsoon run off can be impounded by constructing bunds on the sloping ground all along the contour of equal elevation.
- Flowing water is intercepted before it attains the erosive velocity by keeping suitable spacing between bunds.
- Spacing between two contour bunds depends on the slope the area as the permeability of the soil. Lesser the permeability of soil, the close should be spacing of bunds.
- Contour bunding is suitable on lands with moderate slopes without involving terracing.

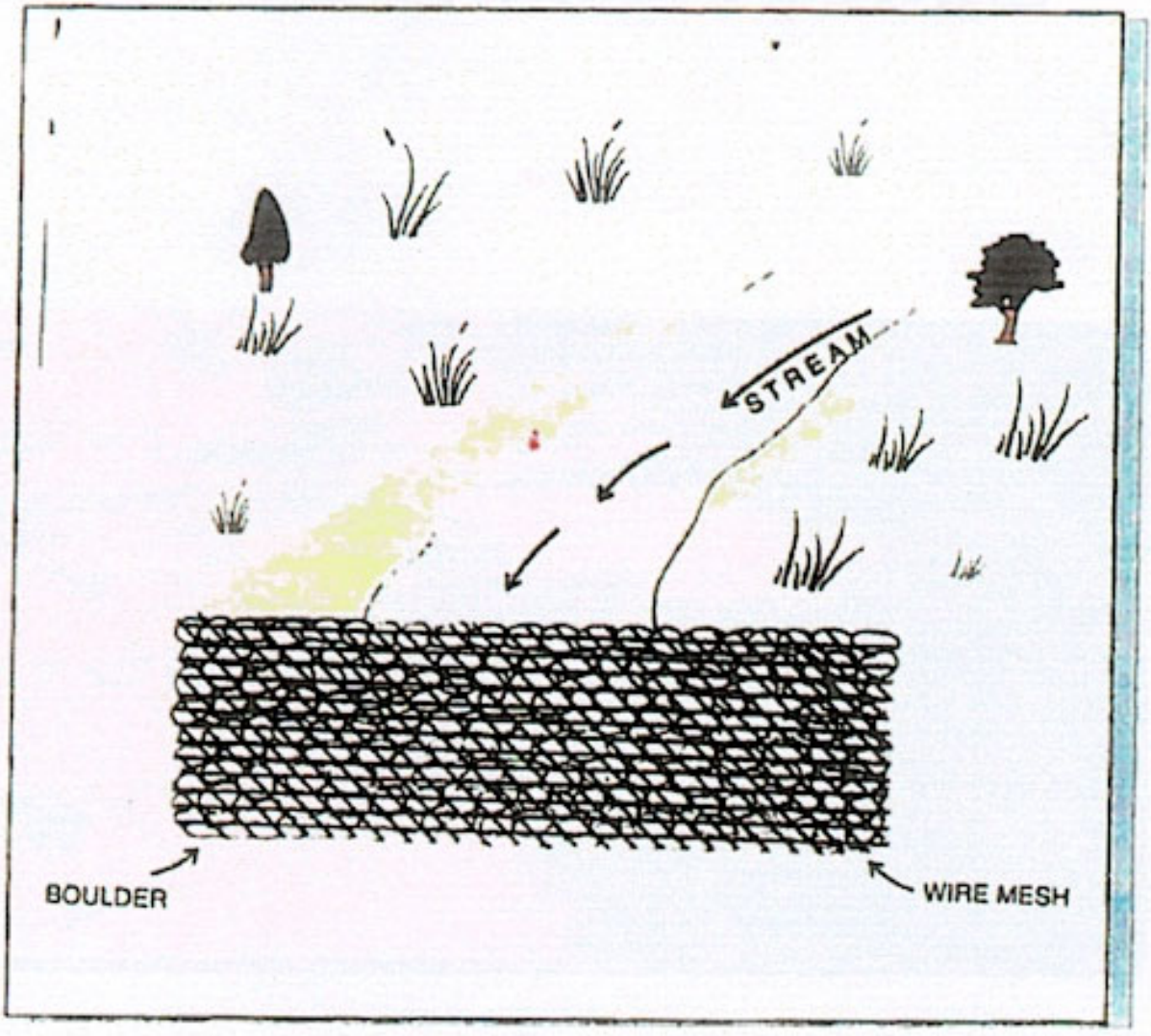


(iii) गेबियन संरचना द्वारा वर्षा जल संचयन

- यह एक प्रकार का चैक डेम होता है जिसका निर्माण सामान्यतः छोटी जलधाराओं पर जलधाराओं के वहाव को संरक्षित करने के लिए किया जाता है । साथ ही जलधारा के वाहर विल्कुल भी प्लावन नहीं हो पाता ।
- जलधारा पर छोटे वांध का निर्माण स्थानीय रूप से उपलब्ध शिलाखण्डों को लोहे के तारों की जालियों में डालकर तथा जलधारा के किनारों पर वांध कर किया जाता है ।
- इस प्रकार की संरचनाओं की ऊँचाई लगभग 0.5 मी0 होती है व ये साधारणतया 10 मी0 से कम चौड़ाई वाली जलधाराओं में प्रयोग होती है ।
- कुछ जल पुनर्भरण के स्त्रोत में जमा छोड़ कर शेप अधिक जल इस संरचना के ऊपर से वह जाता है । जलधारा की गाद शिलाखण्डों के वीच जम जाती है और फिर उसमें वनस्पति के उगने से वांध अपारगम्य वन जाता है और वरसात के अपवहित सतही जल को अधिक समय तक रोक कर भूमि जल में पुनर्भरित होने में मदद करता है ।

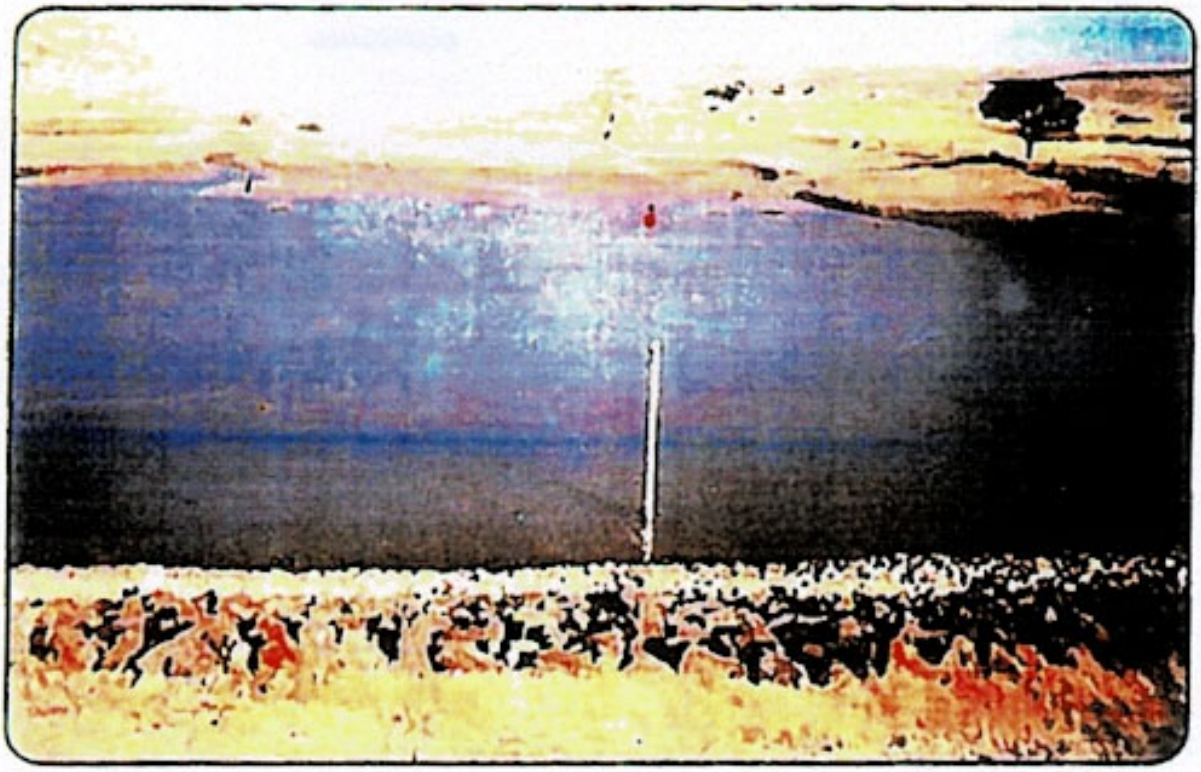
(iii) RAIN WATER HARVESTING THROUGH GABION STRUCTURE

- This is a kind of check dam commonly constructed across small streams to conserve stream flows with practically no submergence beyond stream course.
- A small bund across the stream is made by putting locally available boulders in a mesh of steel wires and anchored to the stream banks.
- The height of such structures is around 0.5 m and is normally used in the streams with width of less than 10 m.
- The excess water over flows this structure storing some water to serve as source of recharge. The silt content of stream water in due course is deposited in the interstices of the boulders in due course and with growth of vegetation, the bund becomes quite impermeable and helps in retaining surface water run off for sufficient time after rains to recharge the ground water body.



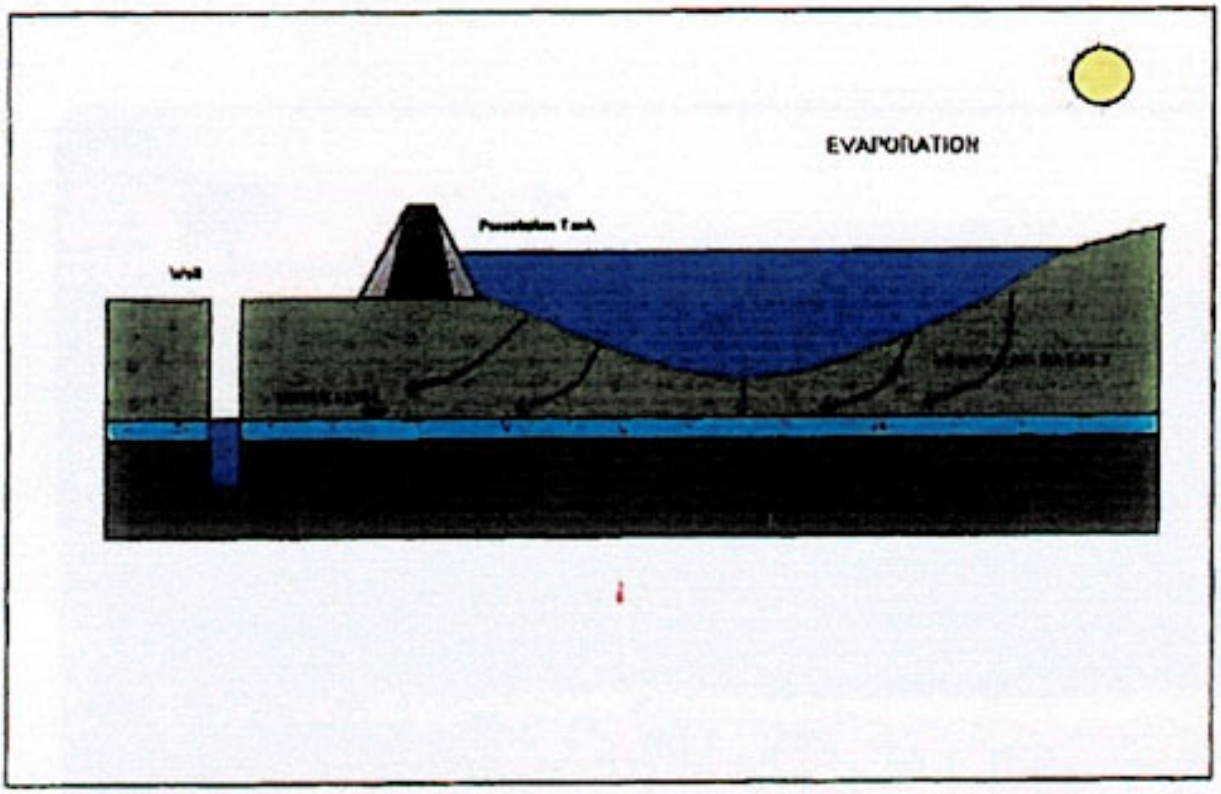
(iv) परिस्त्रवण टैंक (परकोलेशन टैंक) द्वारा वर्षा जल संचयन

- परिस्त्रवण टैंक कृत्रिम रूप से सृजित सतही जल संरचन है। इसके जलाशय में अत्यंत पारगम्य भूमि जलप्लवित हो जाती है जिससे सतही अपवाह परिस्त्रवित होकर भूमि जल भण्डार का पुनर्भरण करता है।
- परिस्त्रवण टैंक का निर्माण यथासंभव (preferably), द्वितीय से तृतीय चरण की जलधारा पर किया जाना चाहिए यह अत्यधिक दरार वाली कच्ची चट्टानों (fractured & weathered rocks) जो सीध में नीचे वहने वाली जलधारा (down stream) तक फैली हों, पर स्थित होना चाहिए ।
- निचली जलधारा के पुनर्भरण क्षेत्र में पुनर्भरित जल विकसित करने के लिए पर्याप्त संख्या में कुँऐं व कृपि भूमि होनी चाहिए ताकि संचित जल का लाभ उठाया जा सके ।
- परिस्त्रवण टैंक का आकार टैंक तल के संस्तर की परिस्त्रवण क्षमता के अनुसार निर्धारित किया जाना चाहिए। सामान्यतः परिस्त्रवण टैंक का डिज़ाईन 0.1 से 0.5 एम० सी० एम० की भण्डारण क्षमता के लिए होता है । यह आवश्यक है कि टैंक का डिज़ाईन इस तरह का हो जिसमें सामान्यतः 3 से 4.5 मी० का टैंक में जमा जल का शीर्ष (column) रहे ।
- परिस्त्रवण टैंक अधिकांशता जमीनी वांध (earthen dam) ही होते हैं जिनमें केवल उत्प्लव मार्ग (spill way) के लिए चिनाई की गई संरचना होती है । परिस्त्रवण टैंक का उद्देश्य भूमि जल भण्डारण का पुनर्भरण करना होता है इसलिए संस्तर के नीचे रिसाव होने दिया जाता है । 4.5 मी० तक की ऊँचाई वाले वॉथ के लिए खाईयों का काटा जाना अनिवार्य नहीं होता व प्राकृतिक भूमि व वॉध तल के वीच वाधओं का निर्माण ही पर्याप्त होता है ।



(iv) RAIN WATER HARVESTING THROUGH PERCOLATION TANK

- Percolation tank is an artificially created surface water body, submerging in its reservoir a highly permeable land so that surface runoff is made to percolate and recharge the ground water storage.
- Percolation tank should be constructed preferably on second to third order steams, located on highly fractured and weathered rocks, which have lateral continuity down stream.
- The recharge area down stream should have sufficient number of wells and cultivable land to benefit from the augmented ground water.
- The size of percolation tank should be governed by percolation capacity of strata in the tank bed. Normally percolation tanks are designed for storage capacity of 0.1 to 0.5 MCM. It is necessary to design the tank to provide a ponded water column generally between 3 & 4.5 m.
- The percolation tanks are mostly earthen dams with masonry structure only for spillway. The purpose of the percolation tanks is to recharge the ground water storage and hence seepage below the seat of the bed is permissible. For dams upto 4.5 m height, cut off trenches are not necessary and keying and benching between the dam seat and the natural ground is sufficient.



(v) चैक डैम / गीमेन्ट प्लग / नाला बंड के द्वारा वर्षा जल संचयन

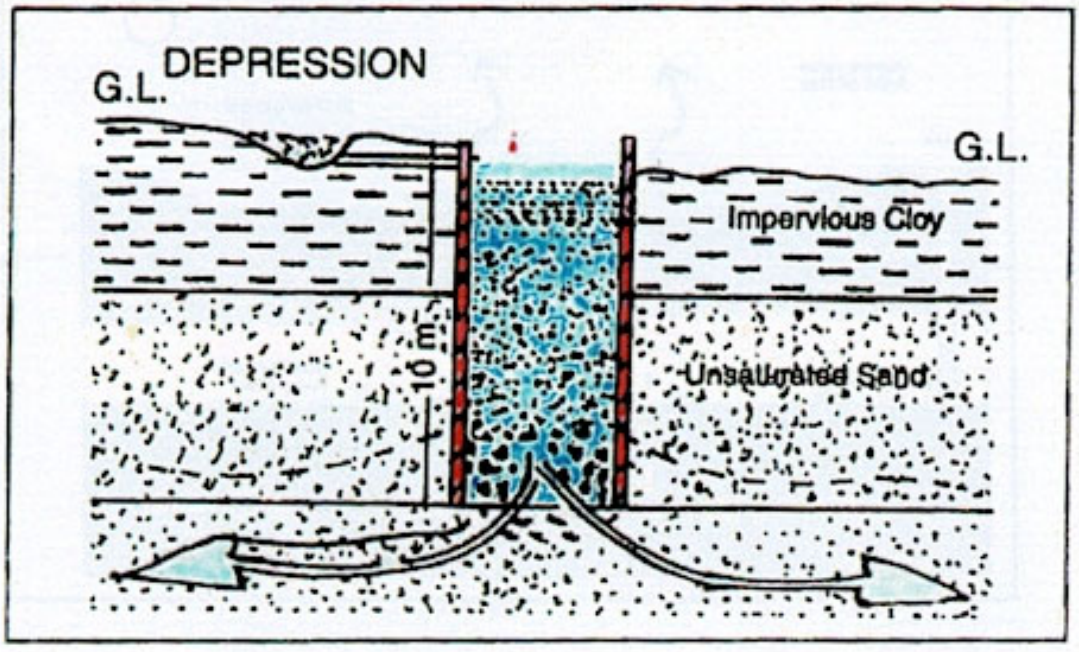
- चैक डैम का निर्माण अतिसामान्य ढलान वाली छोटी जलधाराओं पर किया जाता है । चयनित जगह पर पारगम्य स्तर या वैदरड स्तर की पर्याप्त मोटाई होनी चाहिए ताकि एकत्रित जल कम समयान्तराल में पुनर्भरित हो सके ।
- इन संरचनाओं में संचित जल अधिकतर नालों के प्रवाह क्षेत्र में सीमित रहता है तथा इसकी ऊँचाई सामान्यतः 2 मी0 से कम होती है व अतिरिक्त जल को संरचना की दीवार के ऊपर से वह कर जाने दिया जाता है अत्यधिक जल द्वारा गड्ढे न बने व कटाव ना हो इसलिए डाउन स्ट्रीम की तरफ जल कुशन (water cushion) बनाए जाते हैं ।
- जलधारा के अधिकांश अपवाह का उपयोग करने के लिए इस तरह के चैक डैम की श्रृंखला का निर्माण किया जा सकता है ताकि क्षेत्रीय पैमाने पर पुनर्भरण हो सके ।
- चिकनी मिट्टी से भरे सीमेन्ट बैगों को दीवार की तरह लगाकर छोटे नालों पर अवरोध के रूप में सफलतापूर्वक इस्तेमाल हो रहा है । कई स्थानों पर नाले के आरपार उथली खाई खोदी जाती है व दोनों तरफ एस्बेस्टस की शीट लगा दी जाती है ।नाले पर एस्बेस्टस शीट की दोनों श्रृंखलाओं के बीच का स्थान चिकनी मिट्टी द्वारा भर दिया जाता है । इस तरह कम लागत वाले चैक डैम का निर्माण किया जाता है । संरचना को मज़बूती प्रदान करने के लिए जलधारा के ऊपरी भाग की तरफ चिकनी मिट्टी से भरे सीमेन्ट बैगों को ढलवा कम में लगा दिया जाता है ।

(v) RAIN WATER HARVESTING THROUGH CHECK DAMS / CEMENT PLUGS / NALA BUNDS

- Check dams are constructed across small streams having gentle slope. The site selected should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time.
- The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream side.
- To harness the maximum run off in the stream, series of such check dams can be constructed to have recharge on regional scale.
- Clay filled cement bags arranged as a wall are also being successfully used as a barrier across small nalas. At places, shallow trench is excavated across the nala and asbestos sheets are put on two sides. The space between the rows of asbestos sheets across the nala is backfilled with clay. Thus a low cost check dam is created. On the upstream side clay filled cement bags can be stacked in a slope to provide stability to the structure.

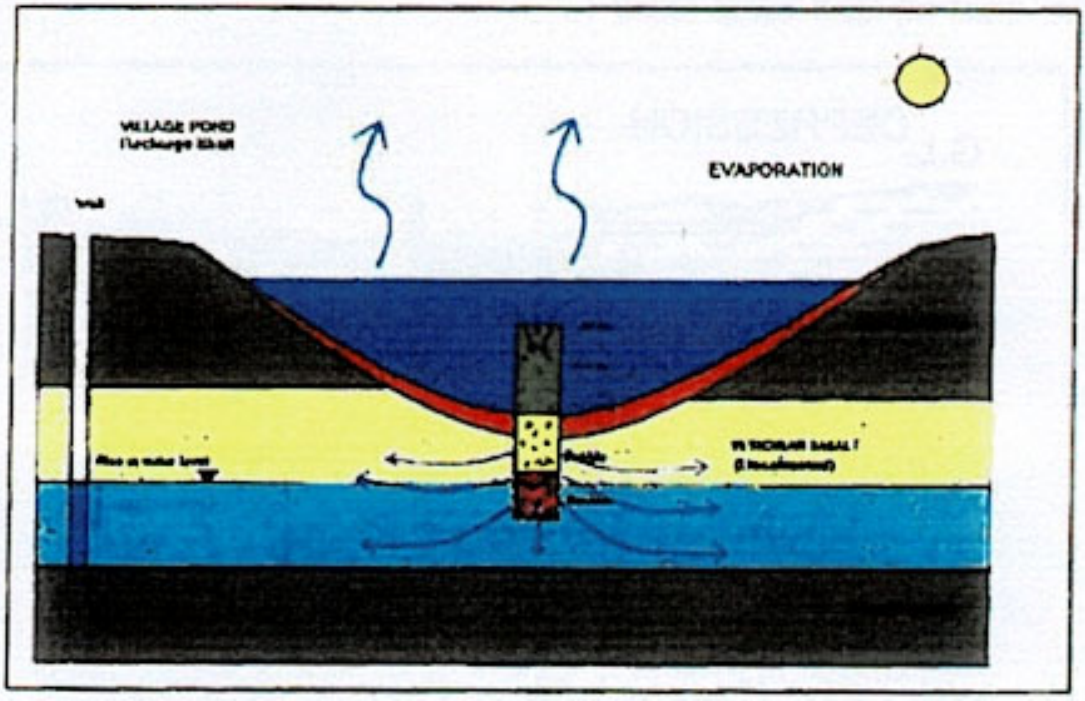
(vi) पुनर्भरण शाफ्ट द्वारा व वर्षा जल संचयन

- अपरिरूद्धजलभृत जिसके ऊपर कम पारगम्य स्तर हो के पुनर्भरण के लिए सबसे उपयुक्त व कम लागत वाली तकनीक है ।
- अगर स्तर नहीं ढहने वाले प्रवृति का हो तो पुनर्भरण शाफ्त का निर्माण हाथों से किया जा सकता है । शाफ्ट का व्यास सामान्यतः 2 मी0 से अधिक होता है ।
- शाफ्ट का अंतिम सिरा ऊपरी अपारगम्य स्तर के नीचे अधिक पारगम्य स्तर में होना चाहिए। यह आवश्यक नहीं की शफ्ट जलस्तर को छूता हो ।
- अपंक्तिवद्ध (अनलाइन्ड) शाफ्ट में पहले वोल्डर / पैवल फिर बजरी व अन्त में मोटी रेत भरी जानी चाहिए ।
- यदि शाफ्ट लाईन्ड हो तो पुनर्भरित जल को फिल्टर तक पहुँचाने वाले एक छोटे चालक पाईप (कन्डक्टर पाईप) के माध्यम से शाफ्ट में डाला जाता है ।
- इस तरह की पुनर्भरण संरचनाऐं ग्रामीण टैंको के लिए काफी लाभप्रद होती हैं जहां छिछली चिकनी मिट्टी की परत जल के जलभृत में रिसाव होने में बाधक होती है ।
- ऐसा देखा गया है कि बरसात के मौसम में गॉवों के टैंक पूरी तरह से भरे होते हैं लेकिन गाद भरने के कारण इन टैंकों से जल का नीचे रिसाव नहीं हो पाता तथा साथ ही बने नलकूप व कुँऐ सूखे रह जाते हैं । गॉवों के तालावों से जल वाष्पीकृत हो जाता है तथा लाभकारी उपयोग के लिए उपलब्ध नहीं हो पाता ।
- तालावों में पुनर्भरण शाफ्ट के निर्माण से अतिरिक्त उपलब्धता (सरप्लस) जल को भूजल में पुनर्भरित किया जा सकता है । जल की उपलब्धता के अनुसार पुनर्भरण शाफ्ट 3 से 5 मी0 व्यास व 10-15 मी0 गहराई तक बनाई जाती है । शाफ्ट का ऊपरी सिरा टैंक के तल स्तर (bed level) के ऊपर पूर्ण आपूर्ति स्तर के आधे तक रखा जाता है यह वोल्डर गैवल व मोटी रेत द्वारा पुनः भर दिया जाता है ।
- संरचना की मज़बूती के लिए ऊपरी एक या दो मीटर की गहराई वाले भाग की ईटों व सीमेंट मिश्रित मसाले से चिनाई की जाती है ।
- इस तकनीक के माध्यम से ग्रामीण तालाव (टैंक) में इकट्ठे हुए सम्पूर्ण जल में से पूर्ण आपूर्ति स्तर के 50 प्रतिशत से अधिक को भूजल में पुनर्भरित किया जा सकता है । पुनर्भरण के पश्चात् निस्तार के लिए पर्याप्त जल टैंक में बचा रह जाता है ।



(vi) RAIN WATER HARVESTING THROUGH RECHARGE SHAFT

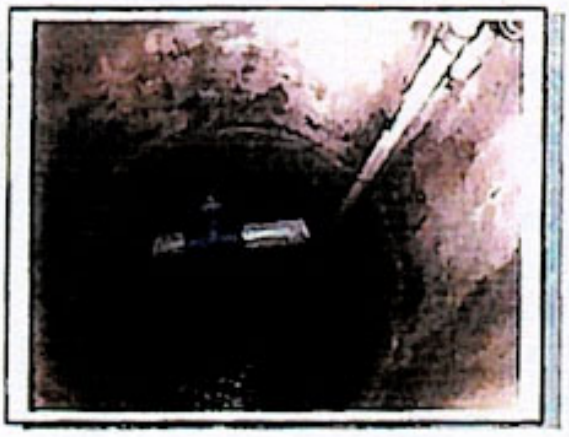
- This is the most efficient and cost effective technique to recharge unconfined aquifer overlain by poorly permeable strata.
- Recharge shaft may be dug manually if the strata is of non-caving nature. The diameter of shaft is normally more than 2 m.
- The shaft should end in more permeable strata below the top impermeable strata. It may not touch water table.
- The unlined shaft should be backfilled, initially with boulders/ cobbles followed by gravel and coarse sand.
- In case of lined shaft the recharge water may be fed through a smaller conductor pipe reaching up to the filter pack.
- These recharge structures are very useful for village ponds where shallow clay layer impedes the infiltration of water to the aquifer.
- It is seen that in rainy season village tanks are fully filled up but water from these tanks does not percolate down due to siltation and tubewell and dugwells located nearby remains dried up. The water from village tanks get evaporated and is not available for the beneficial use.
- By constructing recharge shaft in tanks, surplus water can be recharged to ground water. Recharge shafts of 0.5 to 3 m. diameter and 10 to 15 m. deep are constructed depending upon availability of quantum of water. The top of shaft is kept above the tank bed level preferably at half of full supply level. These are back filled with boulders, gravels and coarse sand.
- In upper portion of 1 or 2 m depth, the brick masonry work is carried out for the stability of the structure.
- Through this technique all the accumulated water in village tank above 50% full supply level would be recharged to ground water. Sufficient water will continue to remain in tank for domestic use after recharge.



(vii) पुनर्भरण कुंओं द्वारा वर्षा जल संचयन

- चालू व बंद पड़े कुँओं को सफाई व गादनिस्तारण के पश्चात् पुनर्भरण संरचना के रूप में प्रयोग में लाया जा सकता है ।
- पुनर्भरित किये जाने वाले जल को गाद निस्तारण कक्ष से एक पाईप के माध्यम से कुँए के तल या जल स्तर के नीचे ले जाया जाता है ताकि कुँए के तल में गड्ढे होने व जलभृत में हवा के बुलबुलों को फंसने से रोका जा सके ।
- पुनर्भरण जल गाद मुक्त होना चाहिए तथा गाद हटाने के लिए अपवाहित जल को या तो गादनिस्तारण कक्ष या फिल्टर कक्ष से गुज़ारा जाना चाहिए ।
- जीवाणु संदूषक को नियंत्रित रखने के लिए क्लोरीन आवधिक रूप से डाली जानी चाहिए ।

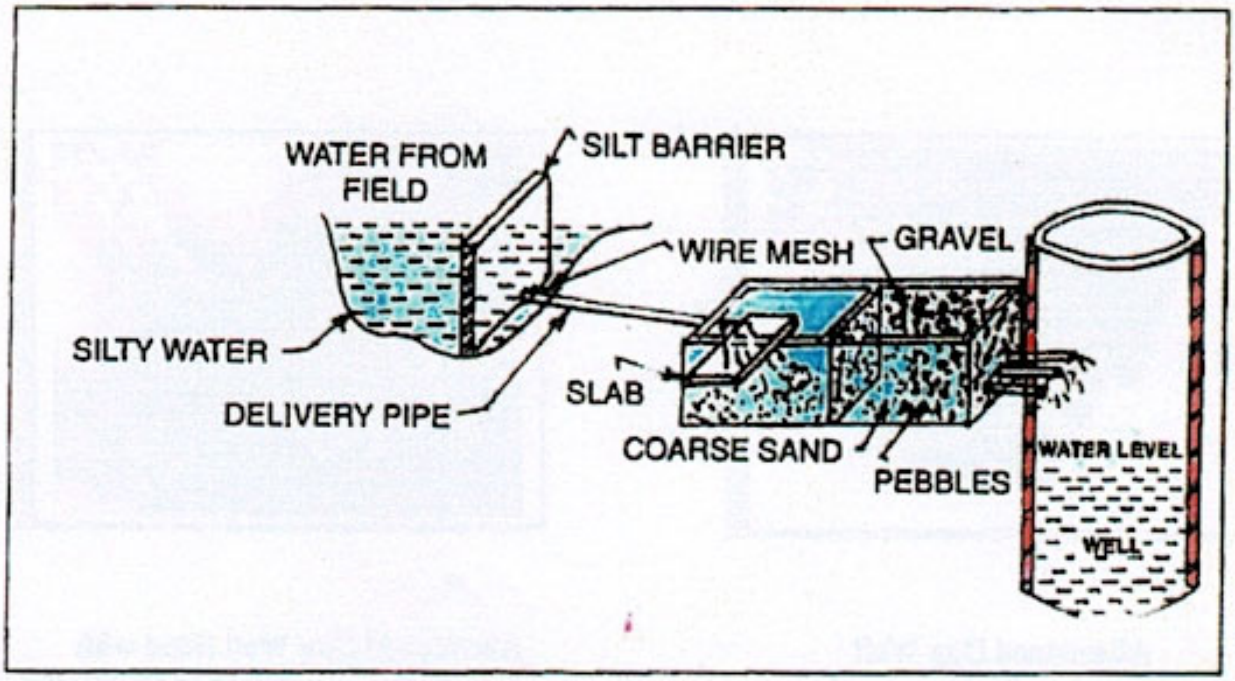
Abandoned Dug Well



Abandoned Dug Well fitted with Rain Water Harvesting Mechanism

(vii) RAIN WATER HARVESTING THROUGH DUGWELL RECHARGE

- Existing and abandoned dug wells may be utilized as recharge structure after cleaning and desilting the same.
- The recharge water is guided through a pipe from desilting chamber to the bottom of well or below the water level to avoid scouring of bottom and entrapment of air bubbles in the aquifer.
- Recharge water should be silt free and for removing the silt contents, the runoff water should pass either through a desilting chamber or filter chamber.
- Periodic chlorination should be done for controlling the bacteriological contaminations.



(viii) भूमिगत जलवांध या उपसतही डाईक

- भूमिगत जलवांध या उपसतही डाईक नदी के आर पार एक प्रकार का अवरोधक होता है जो वहाव की गति को कम करता है । इस तरह से भूजल वांध के ऊपरी क्षेत्र में जलस्तर जलभृत के सूखे भाग को संतृप्त करके वढ़ता है ।
- उपसतही डाईक के निर्माण के लिए स्थल का चयन ऐसी जगह किया जाता है जहां अपारगम्य स्तर छिछली गहराई में हों और सकड़े निकास वाली चौड़ी खाई हो ।
- उपयुक्त स्थल चुनाव के पश्चात् नाले की पूर्ण चौड़ाई में 1.2 मी0 चौड़ी तथ कड़ी चट्टानों / अभेद्य सतह तक एक खाई खोदी जाती है । खाई को चिकनी मिट्टी या ईंटों / कंक्रीट की दीवार से जल स्तर के आधा मीटर नीचे तक भर दिया जाता है ।
- पूर्ण रूप से अप्रवेश्यता सुनिश्चित करने के लिए 3000 पी0 एस0 आई0 की पी0 वी0 सी0 चादर जिसकी टियरिंग शक्ति 400 से 600 गेज हो अथवा कम घनत्व वाली 200 गेज की पोलीथीन फिल्म का प्रयोग भी डाईक की सतहों को ढकने के लिए किया जा सकता है ।
- चूंकि जल का संचयन जलभृत में होता है इसलिए जमीन का जलप्लावन रोका जा सकता है तथ जलाश्य के ऊपर की जमीन को वांध वनने के पश्चात् प्रयोग में लाया जा सकता है । इससे जलाश्य से वाष्पीकरण द्वारा नुकसान नहीं होता और ना ही जलाश्य में गाद जमा हो पाती है । वांध के वैठ जाने (टूट जाने) जैसे भंयकर खतरे को भी टाला जा सकता है ।

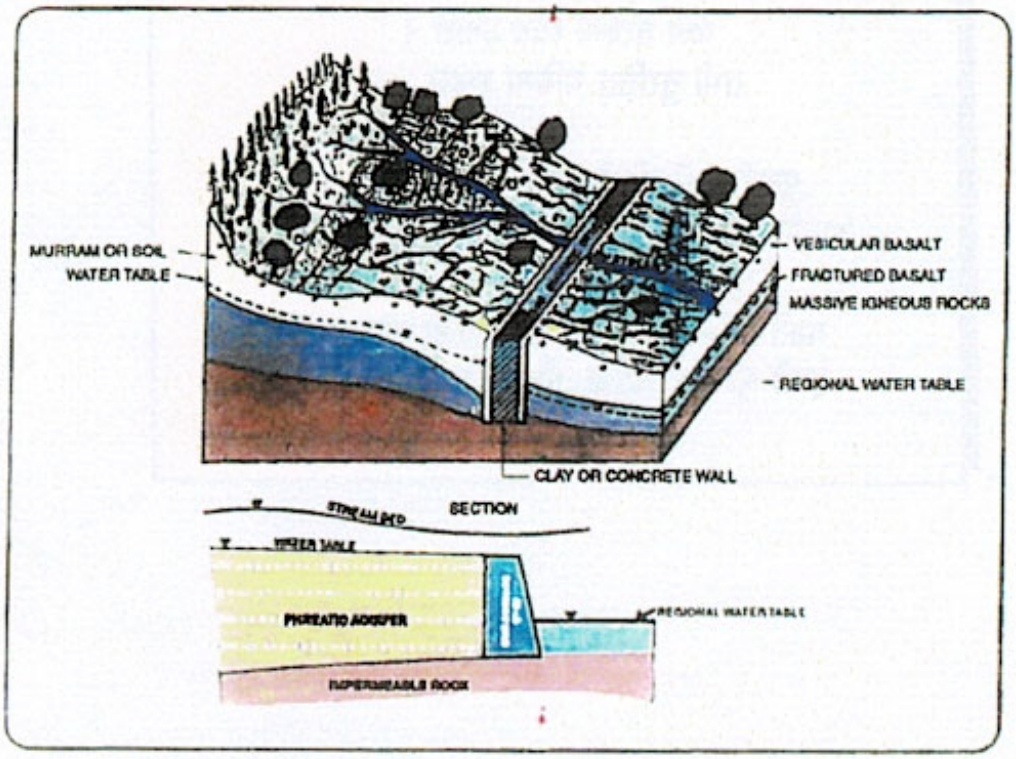
जल संरक्षण ध्येय हमारा ।
तभी सुरक्षित भविष्य हमारा ।।

पुनर्भरण में रखिये तीन बात का ध्यान ।
आवक संग्रह और रिसन सफल करें अभियान ।।

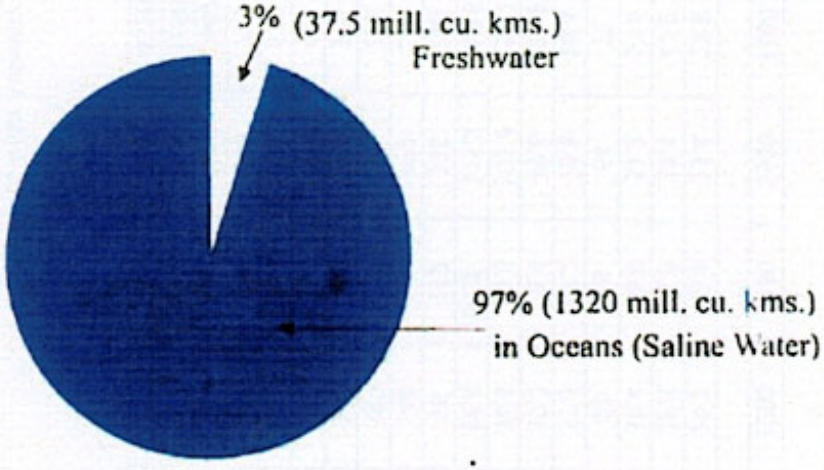
वहते जल को वॉधकर करो सबका उपकार ।
इससे भूमिजल बढ़ेगा होगा सम्पन्न संसार ।।

(viii) GROUND WATER DAMS OR SUB-SURFACE DYKES

- Sub surface dyke or under-ground dam is a subsurface barrier across stream which retards the base flow and stores water upstream below ground surface. By doing so, the water levels in upstream part of ground water dam rises saturating otherwise dry part of aquifer.
- The site where sub-surface dyke is proposed should have shallow impervious layer with wide valley and narrow out let.
- After selection of suitable site, a trench of 1-2 m wide is dug across the breadth of stream down to impermeable bed. The trench may be filled with clay or brick/ concre e wall upto 0.5m. below the ground level.
- For ensuring total imperviousness, PVC sheets of 3000 PSI tearing strength at 400 to 600 gauge or low-density polythene film of 200 gauges can also be used to cover the cut out dyke faces.
- Since the water is stored within the aquifer, submergence of land can be avoided and land above the reservoir can be utilized even after the construction of the dam. No evaporation loss from the reservoir and no siltation in the reservoir takes place. The potential disaster like collapse of the dams can also be avoided.

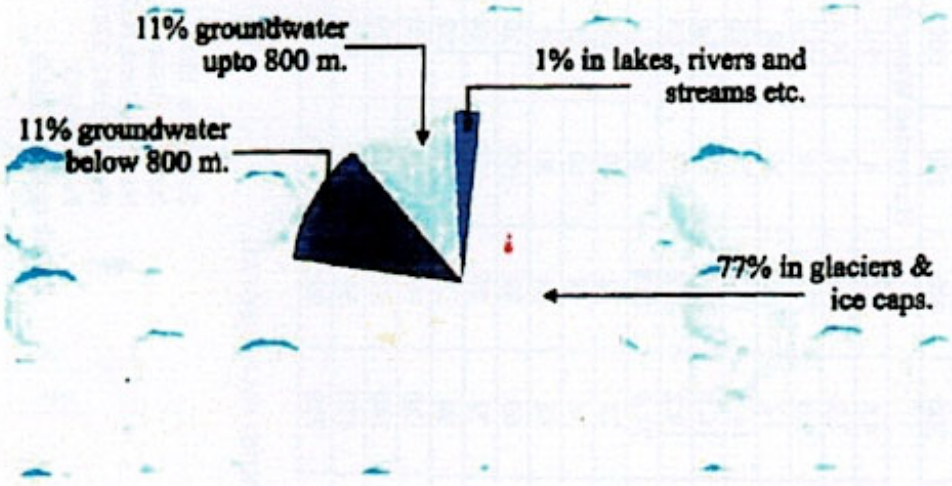


TOTAL WATER ON EARTH



Of the total water on earth only 3% constitutes freshwater. Rest is saline water in the oceans.

DISTRIBUTION OF FRESH WATER ON EARTH



- 11% of the total freshwater on earth is groundwater available upto a depth of 800m which can be extracted for use.
- Mindless extraction and over exploitation of very small quantity of this precious nature resource has caused a rapid depletion and deterioration in its quantity and quality both.

AVAILABILITY OF RAIN WATER THROUGH ROOF TOP RAIN WATER HARVESTING

Rainfall (mm)	100	200	300	400	500	600	800	1000	1200	1400	1600	1800	2000
Roof Top Area (Sq m)	**Harvested Water from Roof Top (cum)**												
20	1.6	3.2	4.8	6.4	8	9.6	12.8	16	19.2	22.4	25.4	28.8	32
30	2.4	4.8	7.2	9.6	12	14.4	19.2	24	28.8	33.6	38.4	43.2	48
40	3.2	6.4	9.6	12.8	16	19.2	25.6	32	38.4	44.8	51.2	57.6	64
50	4	8	12	16	20	24	32	40	48	56	64	72	80
60	4.8	9.6	14.4	19.2	24	28.8	38.4	48	57.6	67.2	76.8	86.4	96
70	5.6	11.2	16.8	22.4	28	33.6	44.8	56	67.2	78.4	89.6	100.8	112
80	6.4	12.8	19.2	25.6	32	38.4	51.2	64	76.8	89.6	102.4	155.2	128
90	7.2	14.4	21.6	28.8	36	43.2	57.6	72	86.4	100.8	115.2	129.6	144
100	8	16	24	32	40	48	64	80	96	112	128	144	160
150	12	24	36	48	60	72	96	120	144	168	192	216	240
200	16	32	48	64	80	96	128	160	192	224	256	288	320
250	20	40	60	80	100	120	160	200	240	280	320	360	400
300	24	48	72	96	120	144	192	240	288	336	384	432	480
400	32	64	96	128	160	192	256	320	384	448	512	576	640
500	40	80	120	160	200	240	320	400	480	560	640	720	800
1000	80	160	240	320	400	480	640	800	960	1120	1280	1440	1600
2000	160	320	480	640	800	960	1280	1600	1920	2240	2560	2880	3200
3000	240	480	720	960	1200	1440	1920	2400	2880	3360	3840	4320	4800

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MANUAL - 2

Anil Kumar Sharma

RAIN WATER HARVESTING AND CONSERVATION

MANUAL

GOVT. OF INDIA
CONSULTANCY SERVICES ORGANISATION
CENTRAL PUBLIC WORKS DEPARTMENT
NIRMAN BHAWAN NEW DELHI-110011

CONTENTS

FOREWORD

Shortage of water for industrial and domestic use and even for drinking purpose is a cause of concern through out the world specially in developing and under developed countries. India is already experiencing water shortage and the problem will become very acute in the near future unless preventive measures are taken on a substantial scale. Rain Water Harvesting and Conservation is needed on a massive scale. A comprehensive treatise on this crucial topic is need of the hour. Although guidelines have been issued from time to time by various organizations it is for probably the first time that the existing guidelines have been compiled at one place in a user friendly manual.

The Govt. of India is laying emphasis for rain water harvesting and conservation, it has therefore been felt necessary that the officers of CPWD should also have easy and ready access to such guidelines issued by the Department/Ministry on this subject and to enable them to take timely and appropriate action. The publication of this Manual fulfils this important requirement.

Even though the "Rain Water Harvesting & Conservation" Manual has been compiled basically for the use in CPWD it may also be useful to a large number of Government Organisations and Public Sector Undertakings. I am sure this will herald an era of water conservation and the peril of water shortage will be suitably contained.

This Manual is a result of combined efforts of a large number of officers. I would like to express my appreciation to the guidance given by Shri H.K. Munjal, ADG(TD) and the efforts put in by the Committee consisting of Shri N.M.D. Jain, E.D., CSO, Shri C.B. Lal, C.E., (SPG) Project, Shri A.K. Sinha, S.E. CSC, Shri Ashok Khurana, S.E., CPWD, Shri Abhai Sinha, Director, CSO, CPWD.

The manual is one more step on the path of technical excellence to which CPWD is perpetually committed.

(Er.Krishan Kumar)
Director General (Works)

New Delhi.
Dated:11.06.2002.

PREFACE

There is an increasing trend towards construction of buildings for residential as well as non residential purposes in urban areas and making the open areas as pucca for parking etc. This trend has decreased drastically infiltration of rain water into the sub soil and recharging of ground water has diminished due to over development which has depleted the aquifers. Surface water is inadequate to meet our demand and we have to depend on ground water. Thus there is need to recharge the ground water. The artificial recharging of ground water is a process by which ground water reservoir is augmented at a rate exceeding that obtained under natural conditions. The artificial recharge techniques enhance the sustainable yield in area and utilizes the rainfall runoff which otherwise goes to sewer or storm water drains. The conservation and storage of access surface water for future requirements is necessary because these requirements often change within a season or a period so the basic purpose of artificial recharging of ground water is to restore supplies from aquifiers depleted due to excessive ground water development. Rain water harvesting can be done by storage of rain water on surface for future use and recharging of ground water. **The "Consultancy Services Organisation" CPWD has brought out a Manual entitled "Rain Water Harvesting & Conservation"** which is a compilation of guidelines for optimum utilization of Rain Water. The Rain water Harvesting & Conservation is nothing but means understanding the importance of rain and to make optimum use of rain water at the place where it fails.

It has been possible to bring out this Manual on account of efforts of Shri N.M.D. Jain, ED(CSO), Shri Jagmohan Swarup, Director (CSO), Shri Abhai Sinha, Director (CSO) and their team (Shri P.S. Bassi, EE(CSO), Shri Rajesh Kumar, Architect (CSO) & Shri PP Mohanakumaran, PA to Dir (CSO)I.

11/6/02

(Er.H.K. Munjal)
Addl. Director General(TD)

New Delhi.
Dated: 11.06.2002

CHAPTER 1

INTRODUCTION

1.1 In spite of astonishing achievements in the field of Science & Technology, nature remains to be a mystery for human beings. Though water is also being obtained through desalination, artificial rain by cloud seeding etc. in some of the developed countries, the shortage of water even for drinking purpose is a perpetual phenomenon throughout the world, especially in developing and underdeveloped countries. India is likely to experience 'Water Stress' from the year 2007 onwards it will be pertinent to shift the thrust of the policies from 'Water Development' to 'Sustainable Water Development'. A vital element of this shift in strategy is the increasing importance of Water Harvesting and Artificial Recharge of Ground Water.

1.2 Countries like Slovakia, Israel, use water about 4-5 times before disposing off, however, in India it is used only once before being disposed. This is certainly not a very encouraging situation.

1.3 The never-ending exchange of water from the atmosphere to the oceans and back again is known as the hydrologic cycle. This cycle is the source of all forms of precipitation (hail, rain, sleet and snow), and thus of all water. Precipitation stored in streams, Lakes, and soil evaporates while water stored in plants transpires to form clouds, which store the water in the atmosphere.

1.4 Making the most efficient use of our State's limited and precious resources is essential. This includes using appliances and plumbing fixtures that conserve water, not wasting water and taking advantage of alternative water sources such as grey water reuse and rainwater harvesting.

1.5 Water is essential for life and plays a major role in creating earth's climate. By modifying land use, the proportion of the different pathways, evaporation, percolation and run off change. A change in evaporation from a region has impacts upon climate. Changes in percolation change ground water availability, both for humans, and natural springs and streams. Changes in run off will change stream flow and erosion patterns, which in turn modifies the sediment load of stream.

1.6 Rain Water Harvesting & Conservation, is the activity of direct collection of Rain Water. The conservation of Rain Water so collected can be stored for direct use or can be re-charged into the Ground Water. The main goal is to minimize flow of Rain Water through Drains / Nallahas to the Rivers without making any use of the same. It is a known fact that the Ground Water level is depleting and going down and down in the last decades. Thus Rain Water Harvesting & Conservation aims at optimum utilization of the natural resource, that is, Rain Water, which is the first form of water that we know in the hydrological cycle and hence is a primary source of water for us. The Rivers, Lakes and Ground Water are the secondary sources of water. In present times, in absence of Rain Water harvesting and conservation, we depend entirely on such secondary sources of water and in the process it is forgotten that rain is the ultimate source that feeds to these secondary sources. The value of

this important primary source of water must not be lost. **Rain Water Harvesting & Conservation means to understand the value of rain and to make optimum use of Rain Water at the place where it falls.**

1.7 The artificial recharge to ground water is a process by which the ground water reservoir is augmented at a rate exceeding that obtained under natural conditions of replenishment. Any man made scheme or facility that adds water to an aquifer may be considered to be an artificial recharge system. Theoretically this will imply that the vertical hydraulic conductivity is high, while the horizontal hydraulic conductivity is moderate.

1.8 In Artificial recharge techniques normally address to following issues:

(i) To enhance the sustainable yield in areas where over development has depleted the aquifer.

(ii) To utilize the rainfall runoff, which is going to sewer or storm water drain.

(iii) Conservation and storage of excess surface water for future requirements, since these requirements often change within a season or a period.

(iv) Surface water is inadequate to meet our demand and we have to depend on ground water.

(v) Due to rapid urbanization, infiltration of rainwater into the sub soil has decreased drastically and recharge of ground water has diminished.

(vi) To arrest seawater ingress.

(vii) To improve the vegetation cover and reduce flood hazard

(viii) To raise the water levels in wells and bore wells that are drying up.To remove bacteriological and other impurities from sewage and waste water so that water is suitable for reuse.

(ix) To improve the quality of existing Ground Water through dilution.

(x) To reduce power consumption.

1.9 The basic purpose of artificial recharge of Ground Water is to restore supplies from aquifers depleted due to excessive Ground Water development.

There are two main techniques of rainwater harvesting:

(i) Storage of rain water on surface for future use

(ii) Recharge to ground water

1.10 Rain Water Harvesting from Roofs Consists of collecting, storing and putting to use rooftop rainwater from houses or any construction is rooftop rainwater harvesting.

1.11 Rainwater harvesting can also be collecting, filtering and recharging Ground Water through percolation pits, open wells or bore wells.

1.12 The sub-surface reservoirs are very attractive and technically feasible alternatives for storing surplus monsoon run off, the sub-surface reservoirs can store substantial quantity of water. The sub-surface geological formations may be considered as '

Warehouse ' for storing water that come from sources located on the land surface. Besides suitable litho logical conditions, other considerations for creating sub-surface storages are favorable geological structures and physiographic units, whose dimensions and shape will allow retention of substantial volume of water in porous and permeable formations. The sub-surface reservoirs, located in suitable hydro geological situations, are environment friendly and economically viable proposition. The sub-surface storages have advantages of being free from the adverse effects like inundation of large surface area, loss of cultivable land, displacement of local population, substantial evaporation losses and sensitivity to earthquakes. No gigantic structures are needed to store water.

1.13 The storage of rainwater on surface is a traditional technique and structures used were underground tanks, ponds, check dams, weirs etc. Recharge to ground water is a new concept of rain water harvesting and the structures generally used are:

1.14 The Need: Rain Water Harvesting and Conservation can be understood by the fact that even CHIRAPUNJI, which receives about 11000 mm rain fall annually, suffers from acute shortage of drinking water due to the reasons that Rain Water is not harvested and conserved and is allowed to drain away.

The annual rainfall over India is computed to be 1.170 mm, which is much higher than the global average of 800 mm. However, this rainfall in India occurs during short periods of high intensity and because of such high intensity and short duration most of the rain falling on the surface tends to flow away fast leaving little scope for re-charging of Ground Water resulting thereby lack of water in most part of the country even for domestic uses.

It is needed to implement measures to make sure that Rain Water falling over a region is tapped to the maximum possible extent through Rain Water harvesting and conservation, either by recharging it into the Ground Water resources or storing it for direct use.

(a) Pits, (b) Trenches, (c) Dug Wells, (d) Hand pumps, (e) Recharge wells, (f) Recharge shafts, (g) Lateral shafts with bore wells, (h) Spreading techniques.

All these structures with their specifications and situations where these are to be used are detailed in chapter No.5

1.15 The Govt of India has also realized the importance and necessity of rain water harvesting so Ministry of Urban Development & Poverty Alleviation has issued Gazette Notification of making suitable provision in the building bye-laws 1983 to ensure that the buildings that are erected in Delhi provide for the water harvesting through storing of rain water run off to recharge underground aquifer. The copy of the Gazette Notification is as on page -

1.16 The Ministry of Environment & Forest, Govt of India has also issued notification for Rain Water Harvesting with draft proposal. The copy of the notification dated 6th Oct. 2000 is on page –

The copy of the Gazette Notification issued by Ministry of Urban Development & Poverty Alleviation vide No.N-11011/9/98-DDVI(Pt.)/DDIB dtd 28th July, 2001 regarding modifications / additions to the building bye laws 1983 is as under:-

NOTIFICATION

S.O.—Whereas the issue of making suitable provision in the Building Bye laws 1983 to ensure that the buildings that are erected in Delhi provide for the water harvesting through storing of rain water runoff to recharge underground aquifers has been under the consideration of the Government.

Whereas the following modifications/additions which the Central Government proposed to make in the Building Bye-laws, 1983 in this regard were published for public information vide Public Notice dated 20th June, 2001 and were advertised in the leading newspapers on 30.6.2001. In all five objections/suggestions were received and they were examined by a Committee under the convenorship of Chief Planner of Town and Country Planning Organisation.

Whereas after thorough consideration of the report Central Government has decided to make the following Modifications/additions in the Building Byelaws, 1983.

Now, therefore, in exercise of the powers conferred by sub-section (2) of Section 11A of Delhi Development Act, 1957, the Central Government hereby makes the following modifications/additions to the Building Bye-laws, 1983 with effect from the date of publication of this notification in the Gazette of India.

MODIFICATIONS

1. Clause 22.4 Part – III (Structural Safety and Services) of the Building Bye-laws, 1983.
2. 22.4.1 Water harvesting through storing of water runoff including rain water in all new buildings on plots of 100 sq. mtrs and above will be mandatory. The plans submitted to the local bodies shall indicate the system of storm water drainage along with points of collection of rain water in surface reservoirs or in recharge wells. These provisions will be applicable as per the Public Notice (s) of Central Ground Water Authority issued from time to time.
3. 22.4.2 All buildings having a minimum discharge of 10,000 litres and above per day shall incorporate waste water recycling system. The recycled water should be used for horticultural purposes.

Note: These modifications/amendments will be applicable from the date of Notification.

(No.N-11011/9/98-DDVI(Pt) DDIB)

Sd/-

(Devendra Kumar Goel)

Under Secretary to the Govt of India

Annexure – A

Certificate: The following certificate is to be submitted along with the building drawings while submitting the plans.

3. Certified that the building plans submitted for approval satisfy the water harvesting requirements as well as minimum anticipated discharge of waste water as stipulated under clause 22.4.1 , 22.4.2 and the information given therein is factually correct to the best of our knowledge and understanding.

Signature of owner with date

Name in Block Letters

Address

Signature of Architect with date

Name in Block letters

Address

Copy of the Draft Gazette Notification of dated 6.10.2000 proposed to be issued Ministry of Environment & Forests regarding Rain Water Harvesting in Hilly Region is as under:

NOTIFICATION

S.O 916(E)—The following notification which the Central Government proposes to issue in exercise of the powers conferred by sub-section (1) read with clause (v) of sub-section (2) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986) is hereby published as required under sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986 for information of all persons likely to be affected thereby and notice is hereby given that the said draft notification will be taken into consideration after the expiry of a period of sixty days from the date on which copies of the Gazette of India containing this notification are made available to the public.

Any person desirous of making any objection or suggestion in respect of the said draft notification may forward the same in writing for consideration of the Central Government within the period so specified to the Secretary to the Government of India, Ministry of Environment and Forests, Paryavaran Bhawan, CGO complex, Lodhi Road, New Delhi – 110003.

DRAFT PROPOSALS

It is proposed to issue a notification to protect and improve the quality of environment in the Himalayas, which would include the States of Arunachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and Districts of Dehra Dun, Haridwar, Almora, Pithoragarh, Chamoli, Pauri Garhwal, Nainital, Uttar Kashi, Udham Singh Nagar, Rudra Prayag, Bageshwar, Tehri Garhwal and Champawat of Uttar Pradesh and Darjeeling district of West Bengal in the scope of this notification.

In order to ensure environmentally sound development of hill towns, the following restriction and conditions are proposed for all future activities in the areas in the Himalayan region.

Location Planning In Urban Areas in Hills

(i) No construction should be undertaken in areas having slope above 30 or areas which fall in hazard zones or areas falling on the spring lines and first order streams identified by the State Governments on the basis of available – scientific evidence.

(ii) Construction should be permitted in areas with slope between 10 to 30 or spring recharge areas or old landslide zones with such restrictions as the competent local authority may decide.

(iii) Tourist resorts, commercial complexes and institutional buildings should be located in areas with surplus water and electricity so as not to affect the rights of existing users without their prior consultation.

(iv) Where cutting in an area causes ecological damage and slope instability in adjacent areas, such cuttings shall not be undertaken unless appropriate measures are taken to avoid such damages.

(v) An integrated development plan may be prepared taking into consideration environmental and other relevant factors including ecologically sensitive areas, hazard zones, drainage channels, steep slopes and fertile land. Areas rich in ground water may not be diverted for construction activities.

RAIN WATER HARVESTING

(i) All buildings to be constructed in future in urban areas should have provision for roof top rain water harvesting commensurate with its plinth area with minimum capacity of 5 KL for plinth area above 200 sqm , 2KL for plinth area of 200 sqm or below in case of – residential buildings and minimum capacity of 0.01 cum per sqm of plinth area in case of commercial and institutional buildings such as tourist complexes, hotels, shopping complexes, and Government buildings.

Provided that minimum standards for commercial and institutional buildings shall also apply to such buildings in areas not covered within the limits of urban areas.

(ii) Where minimum standards have already been laid down by the State Governments, such standards shall take precedence.

(iii) The institutional and commercial buildings should not draw water from existing water supply schemes which adversely affects water supply to local villages or settlements.

(iv) In rural areas rain water harvesting should be undertaken through such structures as percolation tanks and storage tanks and any other means.

(v) Spring sanctuary development should be undertaken in the spring recharge zones to augment spring water discharge.

(vi) Rain water collected through storm water drains should be used to clean the waste disposal drains and sewers.

(vii) Ground water aquifer recharge structures should be constructed wherever such structures do not lead to slope instabilities.

HILL ROADS

Instructions to be issued by the State Governments for construction of Hill Roads:

(i) For construction of any road in the Himalayan region of more than 5 km (including extension/widening of existing roads) length where the same may not be tarred roads and environmental Impact assessment is otherwise not required, environmental impact assessment should be carried out in accordance with instructions to e issued for this purpose by the State Governments.

(ii) Provisions should be made in the design of the road for treatment of hill slope instabilities resulting from road cutting, cross drainage works arid culverts using bioengineering and other appropriate techniques by including the cost of such measures is the cost estimate of the proposed road.

(iii) Provisions should also be made for disposal of debris from construction sites in appropriate manner at suitable and identified locations so as not to affect the ecology of the area adversely, further, the dumped material should be treated using bio engineering and other appropriate techniques and the cost of such measures should be included in the cost estimate of the proposed road.

(iv) Wherever hot mix plants are used they should be set up at least 2 km away from settlements and minimum area of 200 sqm surrounding the site should be devoid of vegetation.

(v) No stone quarrying should be carried out without proper overall management and treatment plan including rehabilitation plan and financial provision for rehabilitation of the site should be included in the cost of the management plan.

(v) All hill roads should be provided with adequate number of road side drains and these drains shall be kept free from blockage for runoff disposal in the event that this is not done and this fact leads to damages that could otherwise have been prevented, the persons responsible should be liable for prosecution/damages, further, the cross drains shall be treated suitably using bioengineering and other appropriate technologies so as to minimize slope instability.

(vii) The runoff from the road side drains should be connected with the natural drainage system in the area

(viii) Fault zones and historically land slide prone zones should be avoided during alignment of a roads, where for any reason it is not possible to do so notice should be given providing full justification and the construction should be carried out only after sufficient measures have been taken to minimize the associated risks.

(ix) Notice should be given about all fault zones and land slide zones along the roads indicating the beginning and the end of such areas.

(x) Ridge alignment should be preferred to valley alignment

(xi) Alignment should be selected so as to minimize loss of vegetal cover

(xii) South or South west alignment should be preferred to avoid moist areas

(xiii) Appropriate design standards should be followed while designing the roads inciuding mass balancing of cut and fill and avoidance of unnecessary cutting.

(xiv) Encouragement should be provided for use of debris material for local development.

CHAPTER 2

RAIN WATER HARVESTING

2.1 Rain Water Harvesting can be defined as activity of direct collection of Rain Water and storage of Rain Water as well as other activities aimed at harvesting and conserving surface and Ground Water, prevention of loss through evaporation and seepage and other hydrological studies and engineering inventions aiming at most efficient utilization of the Rain Water towards best use for the humanity.

2.2 Glossary of Terms:

2.2.1 Aquifer (also called ground water aquifer) any underground formation of soil or rock which can yield water.

2.2.2 Artificial recharge: Any man made scheme or facility that adds water to an aquifer is artificial recharge system

2.2.3 Bore well: Small diameter wells, which are generally deeper than open wells.

2.2.4 Dug Wells: Traditionally used large diameter wells. Defined precisely as pits excavated in the ground until the water table is reached, supported on the sides by RCC/Bricks/Stones Walls, Diameters could vary from 0.6 metres onwards.

2.2.5 Ground Water: The water retained in the intergranular pores of soil or fissures of rock below the water table is called ground water

2.2.6 Masonry: A wall or other structures made using building blocks like bricks or stone with binding materials like cement or lime.

2.2.7 Open Wells: Same as dug well. These wells were kept open in earlier days for manual withdrawal of water. Today, with electrical or diesel/petrol pumps, these can be fully covered.

2.2.8 Runoff: Runoff is the term applied to the water that flows away from a surface after falling on the surface in the form of rain

2.2.9 Recharge: The process of surface water (from rain or reservoirs) joining the ground water aquifer

2.2.10 Water Table: The level of water within it granular pores of soil or fissures of rock, below which the pores of the host are saturated.

2.3 Central PWD has been constructing and maintaining very large number of government buildings and there is enormous scope for the department to contribute towards this process of Rain Water harvesting and conservation.

2.4 The decision whether to store or recharge water depends on the rainfall pattern of a particular region. In a region where rain fall through out the year, barring a few dry periods, in such situations a small domestic sized water tank for storing rainwater can be used. Since the period between two spells of rain is short.

In other region where total annual rain fall occurs only during three to four months of monsoon, the water collected during monsoon has to be stored throughout the year which means that huge volumes of storage container are required so it is feasible to use rain water to recharge ground water aquifers rather than for storage.

2.5 Quantity of Rain Water & General Arrangement

The quantity of Rain Water, which can be harvested depends upon the annual rainfall, the area of the plot (catchment area) and soil characteristics. The amount of water infiltrated into the soil varies with the condition of soil surface and the moisture content of the soil at the time of rainfall. The total amount of water infiltered depends on the infiltration opportunity time, which depends mainly on the slope of the land and the field structures like contour bunds, terraces and other structures, which tend to hold the runoff water over long periods on the land surface.

Rainfall data for major cities are as given on the next page Table No.1 (source Climatological tables of observations in India (1951-1980).

2.6 Artificial Recharge Structures for Surface Run Off.

2.6.1 Ditch and furrow method (Refer Drawing No.01)

In areas with irregular topography, shallow, flat- bottomed and closely spaced ditches or furrows provide maximum water contact area for recharge water from source stream or canal. This technique requires less soil preparation than the recharge basins and is less sensitive to silting.

2.6.2 Lateral ditch pattern (Refer Drawing No.01)

The water from stream is diverted to the feeder canal/ditch from which smaller ditches are made in right angles. The rate of flow of water from the feeder canal to these ditches is controlled by gate valves. The furrow depth is kept according to the topography and also with the aim that maximum wetted surface is available along with maintenance of uniform velocity. The excess water is routed to the main stream through a return canal along with residual silt.

2.6.3 Percolation tanks (PT) Spreading, Basin (Refer Drawing No.02)

These are the most prevalent structures in India as a measure to recharge the ground water reservoir both in alluvial as well as hard rock formations. The efficacy and feasibility of these structures is more in hard rock formations where the rocks are highly fractured and weathered. In the states of Maharashtra, Andhra Pradesh, Madhya Pradesh. Karnataka and Gujrat, the percolation tanks have been constructed in plenty in basaltic lava flows and crystalline rocks. Percolation tanks are also constructed to recharge deeper aquifers where shallow or superficial formations are highly impermeable or clayey with certain modification.

While taking decision on construction of percolation tanks following points should be kept in mind.

(i) In semi arid region the storage capacity of percolation tanks should be such that the water should percolate to ground water reservoir before onset of summer because during summer season evaporation losses would be higher.

(v) No stone quarrying should be carried out without proper overall management and treatment plan including rehabilitation plan and financial provision for rehabilitation of the site should be included in the cost of the management plan.

(v) All hill roads should be provided with adequate number of road side drains and these drains shall be kept free from blockage for runoff disposal in the event that this is not done and this fact leads to damages that could otherwise have been prevented, the persons responsible should be liable for prosecution/damages, further, the cross drains shall be treated suitably using bioengineering and other appropriate technologies so as to minimize slope instability.

(vii) The runoff from the road side drains should be connected with the natural drainage system in the area

(viii) Fault zones and historically land slide prone zones should be avoided during alignment of a roads, where for any reason it is not possible to do so notice should be given providing full justification and the construction should be carried out only after sufficient measures have been taken to minimize the associated risks.

(ix) Notice should be given about all fault zones and land slide zones along the roads indicating the beginning and the end of such areas.

(x) Ridge alignment should be preferred to valley alignment

(xi) Alignment should be selected so as to minimize loss of vegetal cover

(xii) South or South west alignment should be preferred to avoid moist areas

(xiii) Appropriate design standards should be followed while designing the roads inciuding mass balancing of cut and fill and avoidance of unnecessary cutting.

(xiv) Encouragement should be provided for use of debris material for local development.

RAIN WATER HARVESTING

(i) All buildings to be constructed in future in urban areas should have provision for roof top rain water harvesting commensurate with its plinth area with minimum capacity of 5 KL for plinth area above 200 sqm , 2KL for plinth area of 200 sqm or below in case of – residential buildings and minimum capacity of 0.01 cum per sqm of plinth area in case of commercial and institutional buildings such as tourist complexes, hotels, shopping complexes, and Government buildings.

Provided that minimum standards for commercial and institutional buildings shall also apply to such buildings in areas not covered within the limits of urban areas.

(ii) Where minimum standards have already been laid down by the State Governments, such standards shall take precedence.

(iii) The institutional and commercial buildings should not draw water from existing water supply schemes which adversely affects water supply to local villages or settlements.

(iv) In rural areas rain water harvesting should be undertaken through such structures as percolation tanks and storage tanks and any other means.

(v) Spring sanctuary development should be undertaken in the spring recharge zones to augment spring water discharge.

(vi) Rain water collected through storm water drains should be used to clean the waste disposal drains and sewers.

(vii) Ground water aquifer recharge structures should be constructed wherever such structures do not lead to slope instabilities.

HILL ROADS

Instructions to be issued by the State Governments for construction of Hill Roads:

(i) For construction of any road in the Himalayan region of more than 5 km (including extension/widening of existing roads) length where the same may not be tarred roads and environmental impact assessment is otherwise not required, environmental impact assessment should be carried out in accordance with instructions to e issued for this purpose by the State Governments.

(ii) Provisions should be made in the design of the road for treatment of hill slope instabilities resulting from road cutting, cross drainage works arid culverts using bioengineering and other appropriate techniques by including the cost of such measures is the cost estimate of the proposed road.

(iii) Provisions should also be made for disposal of debris from construction sites in appropriate manner at suitable and identified locations so as not to affect the ecology of the area adversely, further, the dumped material should be treated using bio engineering and other appropriate techniques and the cost of such measures should be included in the cost estimate of the proposed road.

(iv) Wherever hot mix plants are used they should be set up at least 2 km away from settlements and minimum area of 200 sqm surrounding the site should be devoid of vegetation.

(v) No stone quarrying should be carried out without proper overall management and treatment plan including rehabilitation plan and financial provision for rehabilitation of the site should be included in the cost of the management plan.

(v) All hill roads should be provided with adequate number of road side drains and these drains shall be kept free from blockage for runoff disposal in the event that this is not done and this fact leads to damages that could otherwise have been prevented, the persons responsible should be liable for prosecution/damages, further, the cross drains shall be treated suitably using bioengineering and other appropriate technologies so as to minimize slope instability.

(vii) The runoff from the road side drains should be connected with the natural drainage system in the area

(viii) Fault zones and historically land slide prone zones should be avoided during alignment of a roads, where for any reason it is not possible to do so notice should be given providing full justification and the construction should be carried out only after sufficient measures have been taken to minimize the associated risks.

(ix) Notice should be given about all fault zones and land slide zones along the roads indicating the beginning and the end of such areas.

(x) Ridge alignment should be preferred to valley alignment

(xi) Alignment should be selected so as to minimize loss of vegetal cover

(xii) South or South west alignment should be preferred to avoid moist areas

(xiii) Appropriate design standards should be followed while designing the roads inciuding mass balancing of cut and fill and avoidance of unnecessary cutting.

(xiv) Encouragement should be provided for use of debris material for local development.

(ii) The percolation tank should be provided in the catchment where submergence area are smaller and such submergence area should be in un-cultivatable land.

(iii) Percolation tank should be located in highly fractured and weathered rock for speedy re-charge. In case of alluvium soil, the boundary formation(natural bunds) is ideal for locating percolation tank.

(iv) The aquifer to be recharged should have sufficient thickness of permeable zone to accommodate the recharge.

(v) The percolation tank should be provided in a region where sufficient number of wells and cultivatable land is there, to take advantage of recharge water.

(vi) Normally 50% of total quantum of rain fall in catchment area should be considered to beside the number and size of percolation tanks.

(vii) Suitable provision in the form of waste weir or spill – way to be made to allow the flow of surplus water which is in excess of maximum capacity of percolation tank in a particular day.

(viii) To avoid erosion of embankment due to ripple action stone pitching to be provided up to high flood level in up stream side.

Table No. 1—Rainfall Data for Major Cities

[Source Climatological tables of observations in India (1951-1980) by Indian Metrological Department].

S. No.	City	Annual rain fall (mm)(R)	S.No.	City	Annual rain fall (mm)(R)
	A-1 Class				
1	Mumbai	2146.6	38	Solapur	750.8
2	New Delhi (Safdarjung)	797.3	39	Thiruvananthapuram	1827.7
3	New Delhi (Palam)	794.0	40	Tiruchirappali	880.2
	A-Class				
4	Ahmedabad	803.4	41	Varanasi	1025.4
5	Bangalore	970.0	42	Vishakhapatnam	968.8
	C-Class				
6	Calcutta	1641.4	43	Portblair	3168.8
7	Chennai	1333.8	44	Dibrugarh	2588.7
8	Hyderabad	812.5	45	Tezpur	1768.3
	B-1 Class				
9	Bhopal	1146.7	46	Chapra	1028.3
10	Indore	1008.3	47	Jamshedpur	1320.7
11	Jaipur	673.9	48	Muzaffarpur	1239.8
12	Kanpur	832.6	49	Bhuj	413.6
13	Lucknow	1021.5	50	Karnal	814.1
14	Ludhiana	752.3	51	Simla	1424.8
15	Nagpur	1112.7	52	Bidar	981.1
16	Pune	721.7	53	Hoshangabad	1225.9
17	Surat	1209.4	54	Ratlam	1033.5
	B-2 Class				
18	Agra	776.5	55	Ujjain	934.1
19	Allahabad	1017.7	56	Kolhapur	1138.5
20	Amritsar	681.2	57	Imphal	1353.1
21	Aurangabad	688.05	58	Shillong	2050.5
22	Bareli	1071.9	59	Kohima	1856.0
23	Chandigarh	1059.3	60	Bhubaneshwar	1542.2
24	Coimbatore	631.0	61	Cuttack	1475.3
25	Gorakhpur	1228.1	62	Pathankot	1319.0
26	Guwahati	1717.7	63	Alwar	774.6
27	Gwalior	899.0	64	Vellure	1004.4
28	Jabalpur	1331.6	65	Agartala	2178.6
29	Kochi	3228.3	66	Aligarh	781.6
30	Kota	761.4	67	Dehradun	2315.4
31	Madurai	873.3	68	Roorkee	1156.4
32	Meerut	901.0	69	Darjiling	2667.1
33	Nasik	703.0			
34	Patna	1003.4			
35	Rajkot	726.9			
36	Ranchi	1431.6			
37	Salem	1014.0			

2.7 Sample Calculation for Quantity of Rain Water which can be harvested

2.7.1 How much water can be harvested

The total amount of water i.e. received in the form of rainfall over an area is called the rainwater endowment of that area. Out of this the amount that can be effectively harvested is called the rainwater harvesting potential.

Rain water harvesting potential = Rain fall (mm) x collection efficiency

Annual rain fall of any city / place	(Say) 600 mm (Ref Table No.1)
Area of Roof Catchment	100 Sqm
Height of rain fall	0.6m
Vol. Of rain fall over the plot	= Area plot x height of rain fall
Rain water endowment of that area	= 100 Sqm x 0.6 m = 60 cum
	=60,000 litres (Say 'A')

Sample calculation for effectively harvested water from total rainfall

(i) Considering roof catchment is having tile finish so coefficient for roof surface can be adopted as 0.85 (Ref Table No.2)

(ii) Another constant coefficient for evaporation, spillage and first flush wastage can be considered as 0.80 (for all situations)

Statistically and approximately only effectively harvested water quantity may be considered as = Rain Water endowment of that area ('A') x 0.80 x Surface efficient (to be obtained from Table No.2)

= 60,000 x 0.80x0.85

= 40,800 litres

This volume is about twice the annual drinking water requirement of a 5 member family. The average drinking water is required per person per day is 10 litres.

2.7 The collection efficiency accounts for the facts that all the rain water falling over an area cannot be effectively harvested because of evaporation, spillage etc. Factor like run off coefficient as stated for various types of roof and land surfaces etc. as shown in Table No.2 and the first flush wastage i.e. first spell of rain is flushed out, evaporation and spillage does not enter the system so a constant co-efficient of 0.80 may be adopted for all situations. This is done because the first spell of rain carries with it a relatively larger amount of pollutenants from the air and catchment surface.

TABLE No. 2

RUNOFF CO-EFFICIENT OF VARIOUS SURFACES

		Co-efficient
1. Roof Catchment		
1.1	Tiles	0.8-0.9
1.2	Corrugated metal sheets	0.7-0.9
2. Ground Surface Covering		
2.1	Untreated Ground Catchments	
2.1.1	Soil on slope less than 10%	0.0-0.3
2.1.2	Rocky material catchment	0.2-0.5
2.1.3	Business Area	
2.1.3.1	Down town	0.70- 0.95
2.1.3.2	Neighbourhood	0.50 - 0.70
2.2	Residential Complexes in Urban Areas	
2.2.1	Single family	0.30 - 0.50
2.2.2	Multiunits,detached	0.40 - 0.60
2.2.3	Multiunits, attached	0.60 - 0.75
2.3	Residential Complexes in Suburban Areas Apartments	0.50 - 0.70
2.4	Industrial	
2.4.1	Light	0.50 - 0.70
2.4.2	Heavy	0.60 - 0.90
2.5	Parks, cemeteries	0.10 - 0.25
2.6	Play grounds	0.20 - 0.35
2.7	Railroad yard	0.20 - 0.35
2.8.	Unimproved Land Areas	0.10 - 0.30
2.9	Aspheltic or concrete pavement	0.70 - 0.95
2.10	Brick pavement	0.70 - 0.85
2.11	Lawns, sandy soil having slopes	
2.11.1	Flat 2%	0.05 - 0.10
2.11.2	Average 2 to7%	0.10 - 0.15

2.11.3	Steep 7%	0.15 - 0.20
2.12	Lawns, clayey soil having slopes	
2.12.1	Flat 2%	0.13 - 0.17
2.12.2	Average 2 to7%	0.18 - 0.22
2.12.3	Steep 7%	0.25 - 0.35
2.13	General Driveways and walls	0.15 - 0.30

(Source ASCE and WPCF 1969)

Whereas the use of the runoff coefficients implies there is a constant ratio of rainfall to runoff, the actual ratio will vary over the course of a storm due to condition of the area and the variability of the rainfall pattern. A common practice is to use average coefficients for various types of areas and assumed that the coefficients will be constant throughout the duration of the storm.

CHAPTER 3

ROOF TOP RAIN WATER HARVESTING

3.1 Domestic Rain Water harvesting or roof top Rain Water harvesting is the technique through which Rain Water is captured from roof catchments and stored in tanks/ reservoirs/Ground Water acquifers. It consists of conservation of roof top Rain Water in urban areas and utilizing it to augment Ground Water storage by artificial recharge. It requires connecting the outlet pipe from roof top to divert collected water to existing well/tube well/bore well or a specially designed well.

The details of such sample schematic arrangements under few typical type of colonies have been shown in Drawing No.03 to 08 for general guidance.

3.2 The approximate volume of water available for harvesting with respect to roof top area and annual rain fall of that area has been shown in Table No .3 on page - or designing the Rain Water Harvesting Structures.

3.3 Roof Top Rain Water Harvesting & Conserving Systems, both small and large are comprised of six basic components as described below:

(i) Catchment Area/Roof: Surface upon which rain falls

(ii) Gutters and Downspouts: transport channels from catchment surface to storage

(iii) Leaf Screens and Roof Washers: Systems that remove contamination and debris.

(iv) Cisterns or Storage Tanks: where collected Rain Water is stored

(v) Conveying: the delivery system for treated Rain Water, either by gravity or pump

(vi) Water Treatment: filters and equipment and additives to settle, filter and disinfect.

3.4 The system involves collecting water that falls on zinc, asbestos or tiles roof of a house during rain storms, and conveying it by an Aluminium, PVC wood or plastic drain or collector to a nearby covered storage unit or cistern. Rain Water yield varies with the size and texture of the catchment area. A smoother, cleaner and more impervious roofing material contributes to better water quality and greater quantity.

TABLE NO.3

AVAILABILITY OF RAIN WATER THROUGH ROOF TOP RAIN WATER HARVESTING

Rainfall(mm) Roof top area (Sqm)	100	200	300	400	500	600	800	1000	1200	1400	1600	1800	2000
	Harvested Water from Roof Top (cum)												
20	1.6	3.2	4.8	6.4	8	9.6	12.8	16	19.2	22.4	25.6	28.8	32
30	2.4	4.8	7.2	9.6	12	14.4	19.2	24	28.8	33.6	38.4	43.2	48
40	3.2	6.4	9.6	12.8	16	19.2	25.6	32	38.4	44.8	51.2	57.6	64
50	4	8	12	16	20	24	32	40	48	56	64	72	80
60	4.8	9.6	14.4	19.2	24	28.8	38.4	48	57.6	67.2	76.8	86.4	96
70	5.6	11.2	16.8	22.4	28	33.6	44.8	56	67.2	78.4	89.6	100.8	112
80	6.4	12.8	19.2	25.6	32	38.4	51.2	64	76.8	89.6	102.4	115.2	128
90	7.2	14.4	21.6	28.8	36	43.2	57.6	72	86.4	100.8	115.2	129.6	144
100	8	16	24	32	40	48	64	80	96	112	128	144	160
150	12	24	36	48	60	72	96	120	144	168	192	216	240
200	16	32	48	64	80	96	128	160	192	224	256	288	320
250	20	40	60	80	100	120	160	200	240	280	320	360	400
300	24	48	72	96	120	144	192	240	288	336	384	432	480
400	32	64	96	128	160	192	256	320	384	448	512	576	640
500	40	80	120	160	200	240	320	400	480	560	640	720	800
1000	80	160	240	320	400	480	640	800	960	1120	1280	1440	1600
2000	160	320	480	640	800	960	1280	1600	1920	2240	2560	2880	3200
3000	240	480	720	960	1200	1440	1920	2400	2880	3360	3840	4320	4800

(Extract from CGWB Guide) Central Ground Water Board

3.5 The broad idea about the particular dia of pipe which will be required to cater the certain roof surface area for given average rate of rain fall in millimeter per hour is shown in Table No. 4 is on page -

TABLE NO.4

SIZING OF RAIN WATER PIPES FOR ROOF DRAINAGE

S.No.	Diameter of pipe (mm)	Average rate of Rain Fall (mm per hour)					
		50	75	100	125	150	200
		Roof Area (Sqm)					
(i)	50	13.4	8.9	6.6	5.3	4.4	3.3
(ii)	65	24.1	16.0	12.0	9.6	8.0	6.0
(iii)	75	40.8	27.0	20.4	16.3	13.6	10.2
(iv)	100	85.4	57.0	42.7	34.2	28.5	21.3
(v)	125	-	-	80.5	64.3	53.5	40.0
(vi)	150	-	-	-	-	83.6	62.7

(Extract from SP-35)

This Table will help in determining the number of pipes of particular dia are required for given roof surface area and average of rate of rain fall in millimeter per hour for that area.

3.5 The graph No.1 shown on page No. gives fair idea about amount of peak precipitation may likely to happen (shown in Y - axis) for different duration of rain falls shown in curved lines with respect to recurrence intervals shown in the years (along X – axis). This will give idea about peak rain fall intensity for a particular station for which settlement time are to be designed for 15 minutes duration of peak rain falls.

CHAPTER – 4

DESIGN OF STORAGE / SETTLEMENT TANKS

4.1 Design for Storage Tanks

The quantity of water stored in a water harvesting system depends on size of the catchment area and the size of the storage tanks. The storage tanks has to be designed according to the water requirements, rain fall and catchment availability. The rain water is to be stored for drinking purpose in a situation shown in para 2.4

4.2 Basic Data

(i) Avg annual rainfall

(ii) Size of catchment

(iii) Drinking water requirements

Suppose the system has to be designed for meeting drinking water requirement of a 5 member family living in a building with a roof top area of 100 Sqm. Avg. annual rain fall is 600 mm. Daily drinking & cooking water requirement per person is 10 litres.

We shall first calculate the maximum amount of rain fall that can be harvested from roof top.

Area of Roof top	=	100 Sqm
Average annual rain fall	=	600 mm
Runoff co-efficient for tiles surface (typical case)	=	0.85 (Ref Table No.2)
Co-efficient for evaporation, spillage and first flush etc. annual water harvesting potential from	=	0.80 (Ref Para 2.9)

100 Sqm roof top = (Area of roof top) x (Annual rain falls in metre) x (Run off coefficient to be obtained from Table No.2) x (Constant co-efficient Refer Para 2.8)

= 100 x .60 x .85x0.80 = 40.8 cum = 40,800 litres

The tank capacity has to be designed for dry period i.e. the period between two consecutive rainy season. With monsoon extending over 4 months the dry season is of 245 days has been considered.

Drinking water requirement for family for dry season 245x5x10=12,250 litres

As a safety factor, the tank should be built 20% larger than required i.e. 14700 litres = (1.2 x 12250)

This tank can meet the basic drinking & cooking water requirement of a 5 member family for the dry period.

4.2 Design parameters for settlement tank

Settlement tanks are used to remove silt and other floating impurities from rain water. Settlement tank is like an ordinary container having provision for in flow, out flow and over flow. Settlement tank can have an unpaved bottom surface to allow standing water to percolate into the soil. Apart from removing silt from water the desilting chamber acts like a buffer in the system.

For designing the optimum capacity of the tank following aspects have to be considered:

(i) Size of catchment

(ii) Intensity of rainfall

(iii) Rate of recharge

Since the desilting tank also acts as buffer tank, it is designed such that it can retain a certain amount of rainfall, since the rate of recharge may not be comparable with the rate of run off. The capacity of tank should be enough to retain the run off occurring from conditions of peak rain fall intensity. In Delhi peak hourly rain fall 90 mm. The rate recharge in comparison to run off is a critical factor. However, since accurate recharge rate are not available without detailed Geo-hydrological studies. The rates have to be assumed.

The capacity of recharge tank is designed to retain runoff for at least 15 minutes of rainfall of the peak intensity (for Delhi 22.5 mm/ per 15 minutes say 25 mm per 15 minutes)

Suppose the following data is available

Surface Area of roof top catchment (A)	100Sqm
Peak rainfall in 15 min (r)	25 mm
Runoff co-efficient (C)	0.85

Then capacity of tank = A x r x C =100x0.025x0.85 =2.125 cum = 2,125 litres.

To obtain indicative peak rain fall for various stations the basic rain fall data for that station may be collected from Indian Metrological Office and refer para 3.5 and Graph No.1 (from which peak rain fall for different duration of rain fall can be obtained for given recurrence interval in years and this recurrence interval can be related to the expected life of settlement tank structure.

4.3 Options for settlement tank

Any container with adequate capacity of storage can be used as a settlement tank. Generally masonry or concrete underground tanks are preferred. Since they do not occupy any surface area. For over ground tanks pre-fabricated PVC or ferro cement tanks can be used and prefabricated tanks are easier to install so it should be preferred.

CHAPTER – 5

RE-CHARGE STRUCTURE AND ITS DESIGN

5.1 Re-charge structures :

The basic purpose of artificial recharge of Ground Water is to restore supplies from aquifers depleted due to excessive Ground Water development and usage.

Detailed knowledge of geological and hydrological features of the area is necessary for adequately selecting the site and type of recharge structures. In particular, the features parameters and data to be considered are: geological boundaries, hydrological boundaries, inflow and outflow of water, storage capacity, porosity, hydraulic conductivity, transmissivity, natural discharge of springs, water resources available for recharge, natural recharge, water balance, lithology, depth of aquifer, tectonic boundaries. The aquifer best suited for artificial recharge are those aquifers which absorb large quantity of water and do not release the same to quickly.

5.2 The various type of recharge structures are :

(i) Recharge Through Abandoned Dug Well

(ii) Recharge Through Hand Pump

(iii) Recharge pit

(iv) Recharge Through Trench

(v) Gravity Head Recharge Tube Well

(vi) Recharge Shaft

5.3 DESIGN GUIDELINES:

In general the recharge structures are designed with total volume as twice the peak discharge as detailed below:

5.3.1 ABANDONED DUG WELL (Ref Drawing No9 & 10)

(i) A dry/unused dug well can be used as a recharge structure

(ii) The recharge water is guided through a pipe to the bottom of well or below the water level to avoid scouring of bottom and entrapment of air bubbles in the aquifer.

(iii) Before using the dug well as recharge structure, its bottom should be cleaned and all the fine deposits should be removed

(iv) Recharge water should be silt free as far as possible.

(v) It should be cleaned annually preferably.

(vi) It is suitable for large building having the roof area more than 1000 Sqm

(vii) Cost Rs.5000 to Rs.8000 as per prevailing rates in the year 2000 in Delhi.

(viii) The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

5.3.2 ABANDONED / RUNNING HAND PUMP (Ref Drawing No.11)

(i) An abandoned/running hand pump can be used for recharge

(ii) The structures are suitable for the small building having the roof area upto 150 Sqm

(iii) Water is diverted from rooftop to the hand pump through pipe of 50 to 100 mm dia

(iv) For running hand pump a closing valve is fitted in conveyance system near hand pump to avoid entry of air in suction pipe

(v) Recharge water should be silt free

(vi) The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

(vii) Cost Rs.1500/- to Rs.2500/- as per prevailing rates in the year 2000 in Delhi.

5.3.3 RECHARGE PIT (Ref Drawing No.12)

(i) Recharge pits are constructed for recharging the shallow aquifer.

(ii) These are constructed generally 1 to 2 m wide and 2 to 3 m deep

(iii) After excavation, the pits are refilled with pebbles and boulders

(iv) Water to be recharged should be silt free as far as possible.

(v) Cleaning of the pit should be done annually preferably.

(vi) It is suitable for small buildings having the roof top area upto 100 Sqm

(vii) Recharge pit may be of any shape i.e. circular, square or rectangular.

(viii) The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

(ix) If the pit is of trapezoidal shape, the side slopes should be steep enough to avoid silt deposition.

(x) Cost Rs.2500/- to Rs.5000/- as per prevailing rates in the year 2000 in Delhi.

5.3.4 RECHARGE TRENCH (Ref Drawing NO.13& 14)

(i) It is constructed when permeable strata of adequate thickness is available at shallow depth

(ii) It is a trench of shallow depth filled with pebbles and boulders

(iii) These are constructed across the land slope

(iv) The trench may be 0.5 to 1 m wide 1 to 1.5 m deep and 10 to 20 m long depending upon the availability of land and roof top area

(v) It is suitable for the buildings having the roof area of 200 to 300 Sqm

(vi) Cleaning of trench should be done periodically.

(vii) Cost Rs.5000 – 10,000/- as per prevailing rates in the year 2000 in Delhi.

5.3.5 GRAVITY HEAD RECHARGE WELL (Ref Drawing No15 TO 19)

(i) Bore wells/tube wells can be used as recharge structure

(ii) This technique is suitable where

(a) Land availability is limited

(b) When aquifer is deep and over laid by impermeable strata (clay)

(iii) The roof top Rain Water is channelised to the well and recharges under gravity flow condition

(iv) Recharge water should be silt free as far as possible.

(v) The well can also be used for pumping

(vi) Most suitable for the areas where Ground Water levels are deep

(vii) The number of recharging structures can be determined in limited area around the buildings depending upon roof top area and aquifer characteristics.

(viii) The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

(ix) Cost Rs.50,000/- to Rs.80,000/- as per prevailing rates in the year 2000 in Delhi.

TABLE NO. 5

Roof Area Sqm	Total Rainfall Volume for considering Delhi.	Vol. Available for recharge 80% Cum	Type of Structure recommended for recharge	
			Alluvial Area	Hard Rock Area
50	30	24	Recharge pit/hand pump	Recharge pit/hand pump
100	60	48	"	"
150	90	72	"	"
200	120	96	Trench	Trench/hand pump
300	180	144	"	"
400	240	192	Gravity head recharge well	Gravity head recharge well
500	300	240	"	"
600	360	288	"	"
800	480	384	"	"
1000	600	480	"	"
1500	900	720	"	Recharge shaft/dug well
2000	1200	960	"	"
2500	1500	1200	Recharge shaft/ dug well	"
3000	1800	1440	"	"
4000	2400	1920	"	"
5000	3000	2400	"	"

(Source : Central Ground Water Board)

(ii) With reference to the local conditions of the area, further identify the most appropriate techniques of artificial recharge suitable at various sites/ locations on the basis of total available volume of rainwater which can be harvested and the location of available aquifer. whether it is at shallow depths i.e. 6 to 8 meters from ground level or at sufficient depths i.e. more than 8 meters from ground level.

(iii) Determine the number of each type of artificial recharge structure needed to achieve the quantitative targets. The recharge structure should be designed with volume of water it may store for equivalent of 24hours rainfall and surface area of run-off for which the recharge structure has been considered, without giving any allowance for percolation during this period of 24 hours.

(iv) For individual structure at different locations ,finalise the design specifications from the details given in case studies. If required ,the necessary advice from local Geological Department or Central Ground Water Board may be obtained.

(v) Finalise the design of the conveyance system required to bring the source water to the recharge structure site and the treatment required in the form of settlement tanks.

(vi) Plan the required monitoring system to evaluate the efficiency of recharge scheme and ensure regular maintenance of recharge structures before onset of monsoon every year.

5.6.2 In a given plot attempt should be made to keep the maximum plot area as katcha area which allows rain water for percolation to ground water.

5.6.3 The rain water from seasons first rain should normally not be used for percolation to recharge structure because it contains pollutants from the air and catchment surface. For such water suitable arrangement for by-pass in pipe system should be introduced.

5.6.4 A suitable provision should be made if possible to allow rain water to percolate to ground water after passing it through settlement tank because such rain water contains silt which is deposited on sand bed and reduces the percolation rates.

5.6.5 The recharge structure should be made on a plot at the places of lower levels / elevations so that rain water may flow towards it under normal gravitation flow.

5.6.6 On a vast and sloppy land patch, the contour bunds preferably of mud with height varying from 15 cm to 30 cm should be made to store run off temporarily over the katcha land area, thus allowing more time for percolation of water to the ground water and arresting the flow of run off to the drains / sewers.

5.6.7 For recharge of run off from roads suitable arrangements in the foot path by introducing some katcha area should be made.

5.6.8 In large residential and office complexes the drive ways, pucca path and areas should had some katcha area which may facilitate rain water to percolate to ground water.

5.6.9 Ideal conditions for rain water harvesting and artificial recharge to ground water Artificial recharge techniques are adopted where:

(i) Adequate space for surface storage is not available specially in urban areas.

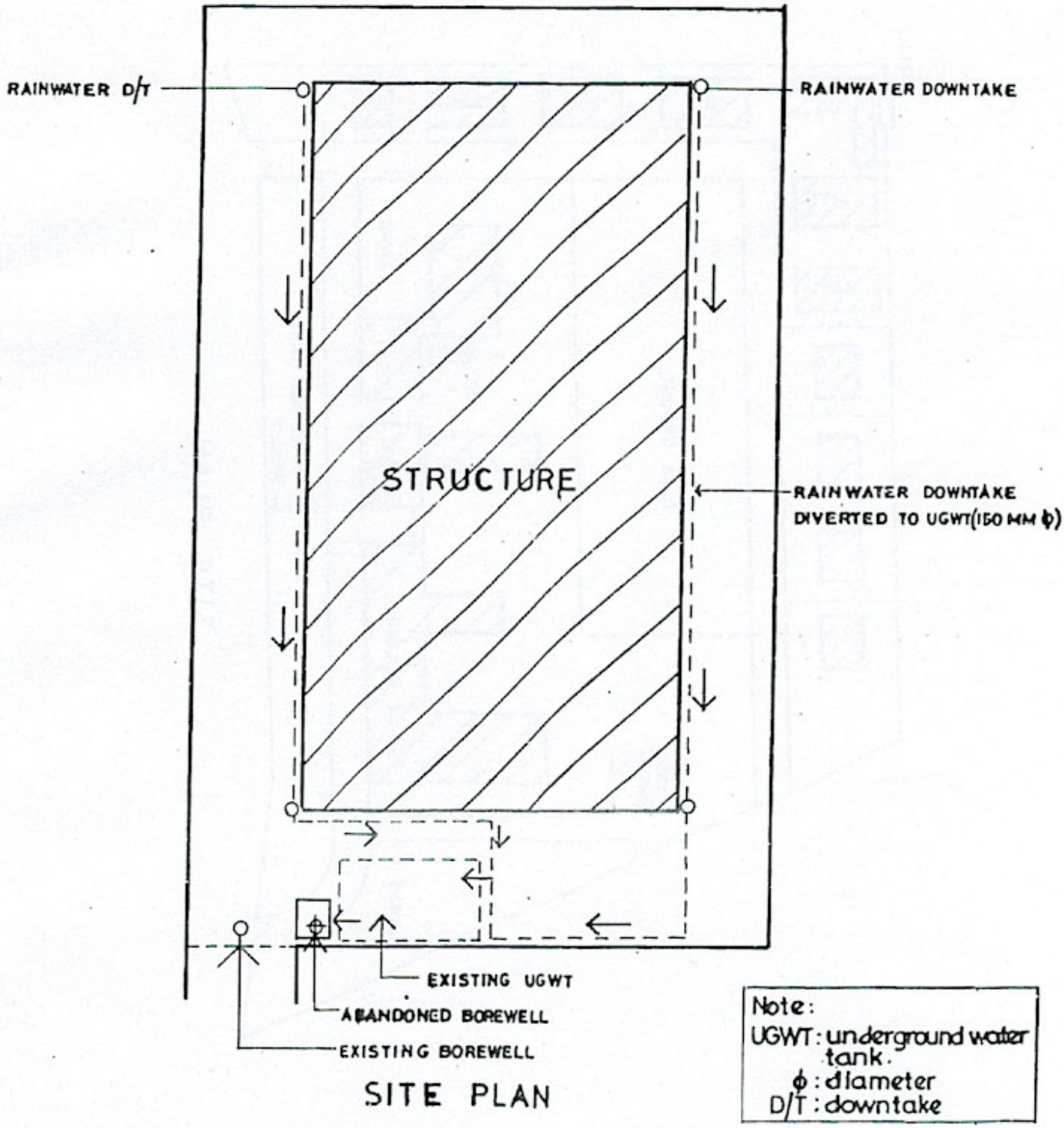
(ii) Water level is deep enough (more than 8 mtr) and adequate sub- surface storage is available.

(iii) Permeable strata is available at shallow/moderate depth upto 10 to 15 mtr.

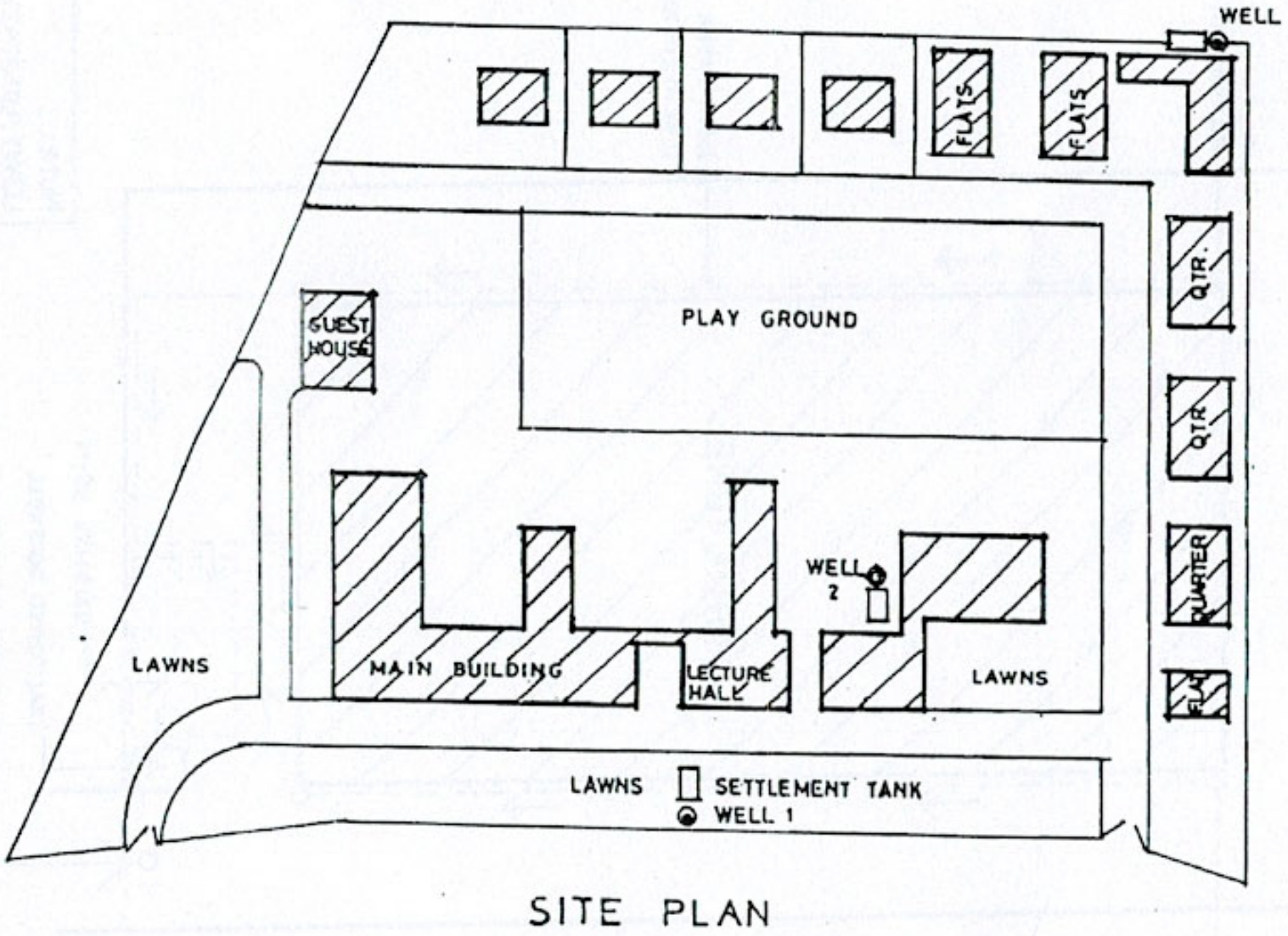
(iv) Where adequate quality of surface water is available for recharge to ground water

(v) Ground water quality is bad and our aim is to improve it

(vi) Where there is possibility of intrusion of saline water especially in coastal area.



Drg-04: Scheme for water harvesting



SITE PLAN

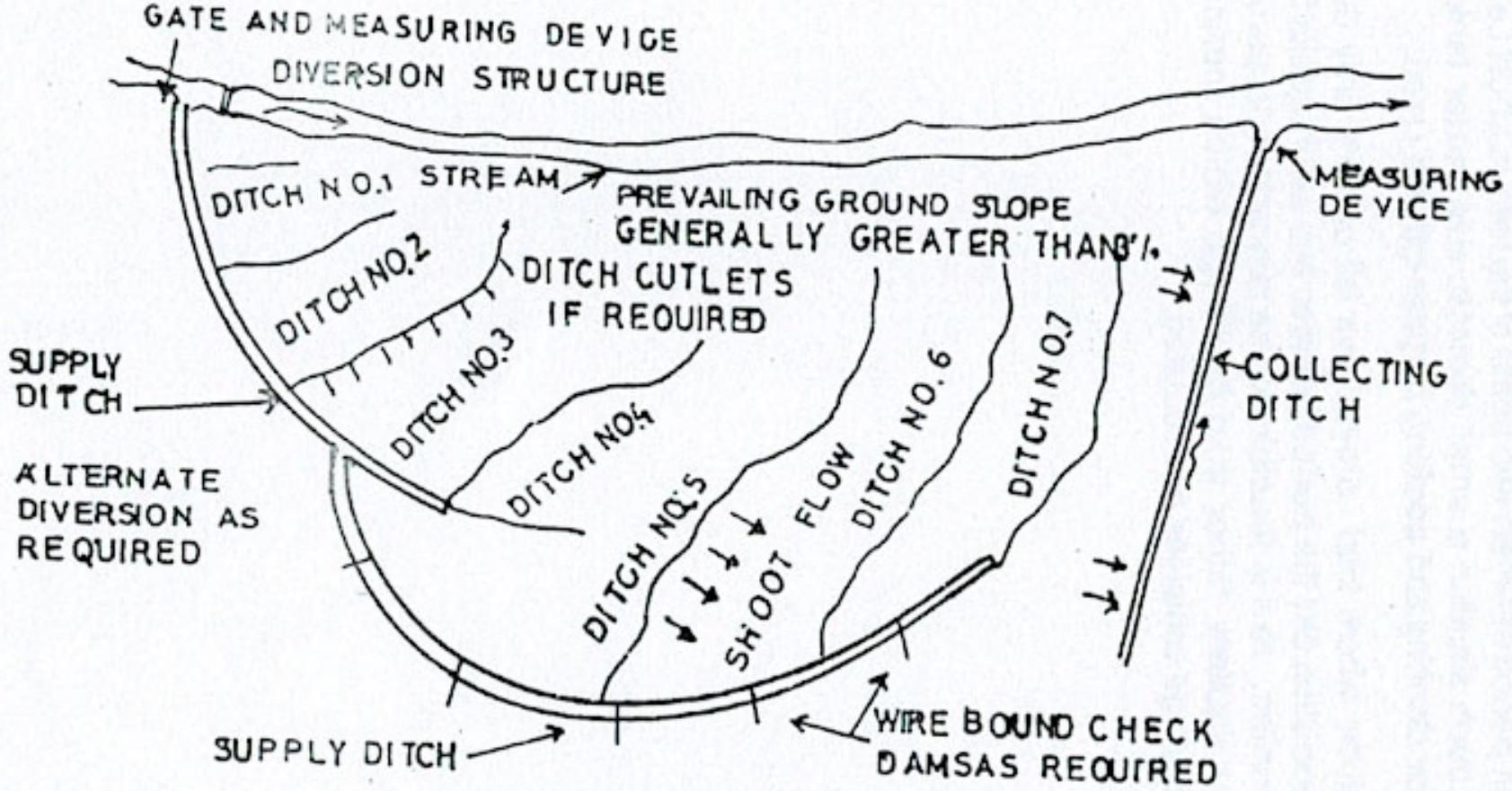
Drg-05: Scheme for water harvesting

(vii) Where the evaporation rate is very high from surface water bodies.

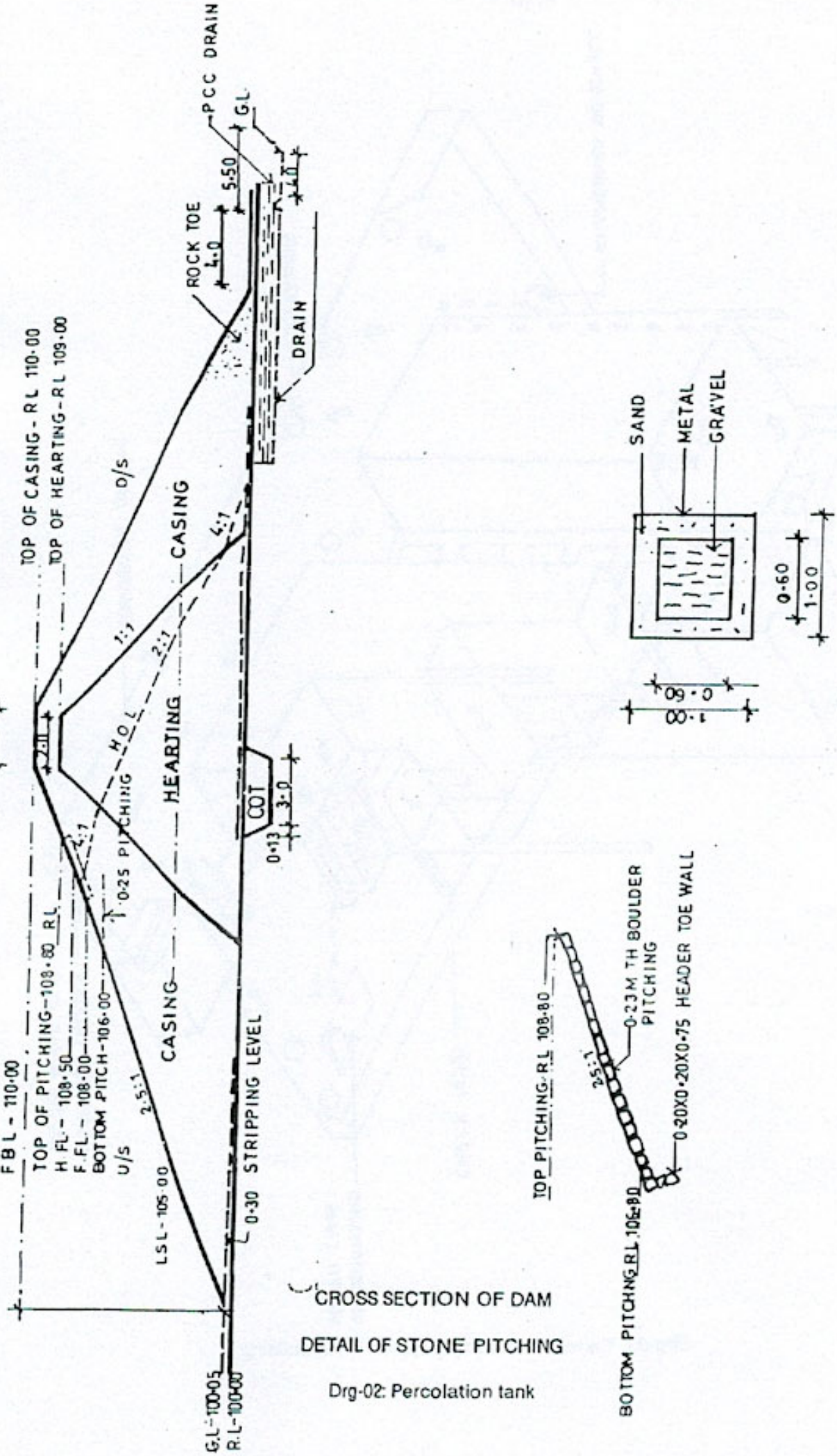
5.6.10 The decision whether to store or recharge rain water depends on the rain fall pattern of a particular region.

(i) If the rain fall period between two spells of the rain is short i.e. two to tour months, in such situation a small domestic size water tank for. storing rain water for drinking and cooking purpose can be used.

(ii) In other regions where total annual rain fall occurs only during 3 to 4 months of monsoon and the period between two such spells is very large i.e. 7 to 8 months, so it is feasible to use rain water to percolate to the ground water aquifers rather than for storage which means that huge volumes of storage container are required.



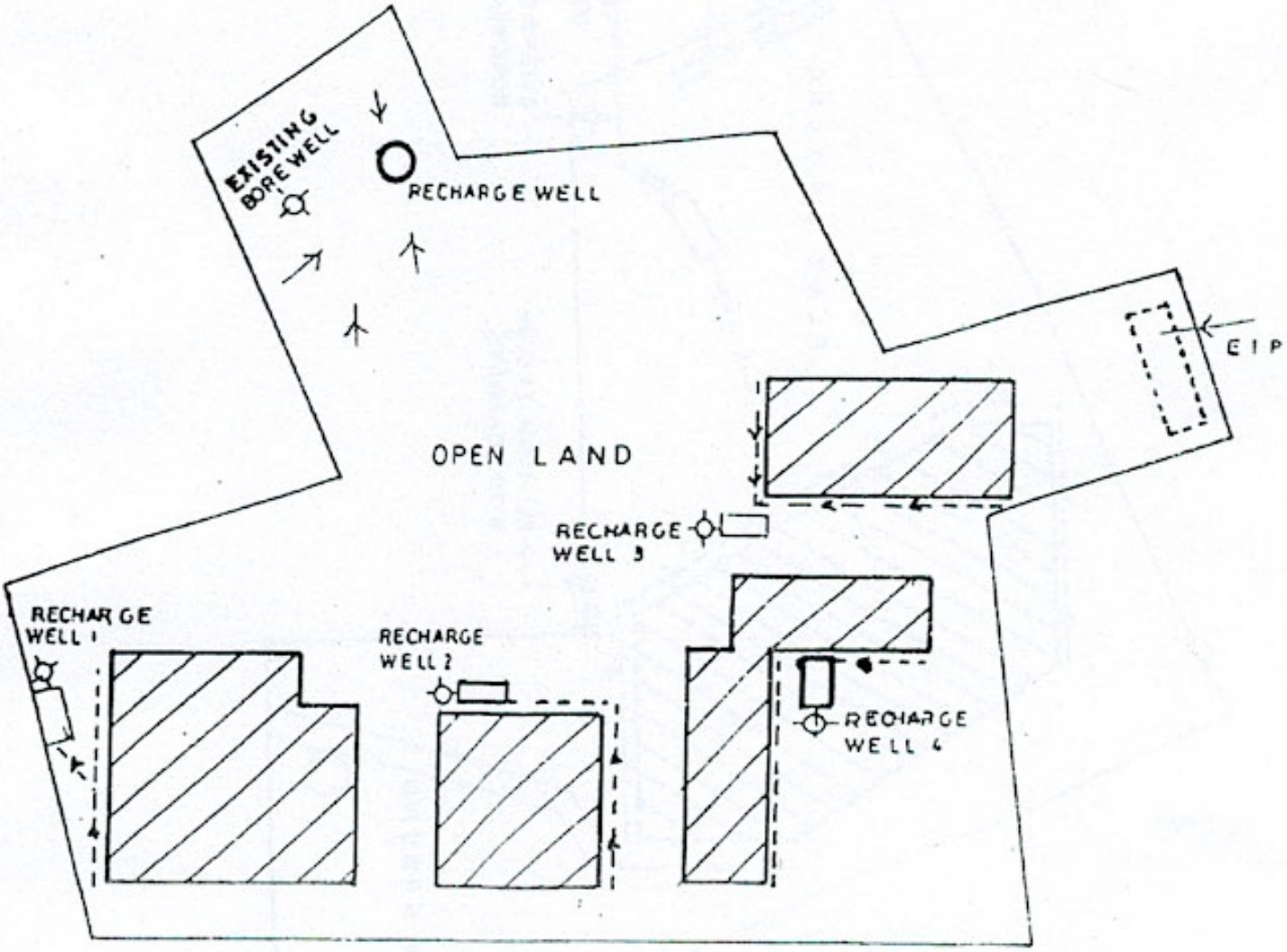
Drg-01: Ditch and furrow method



CROSS SECTION OF DAM

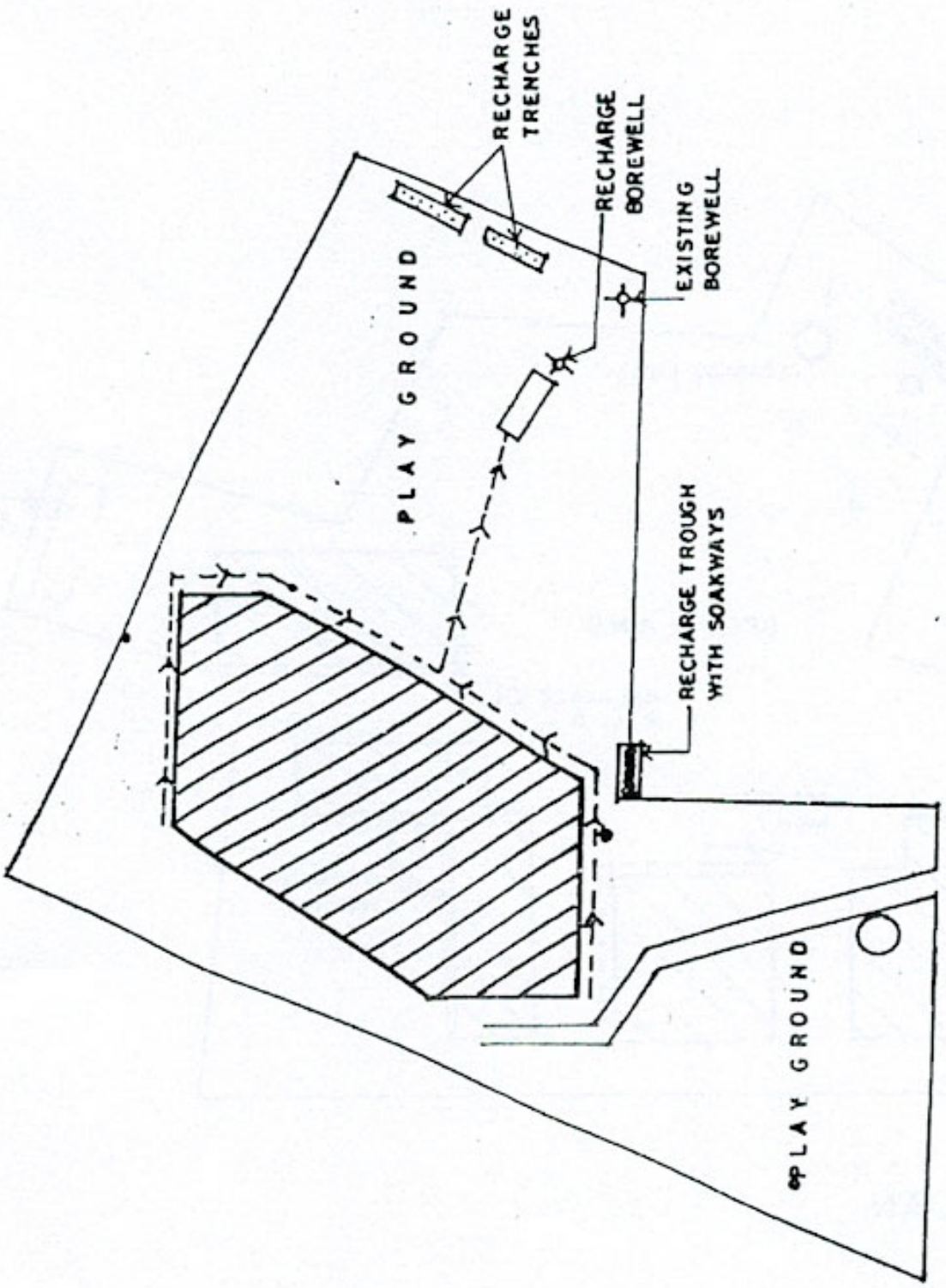
DETAIL OF STONE PITCHING

Drg-02: Percolation tank



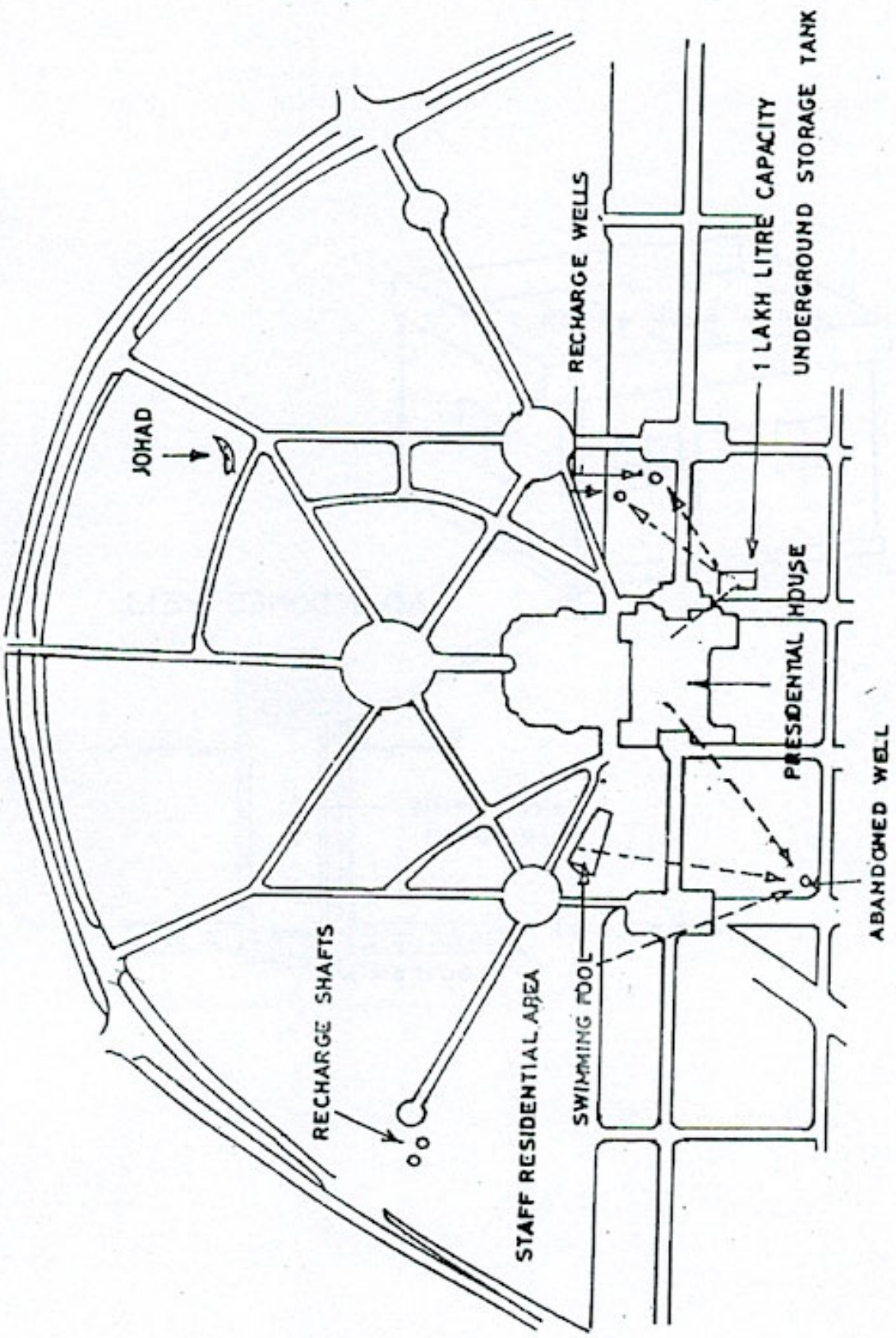
SITE PLAN

Drg-06: Scheme for water harvesting



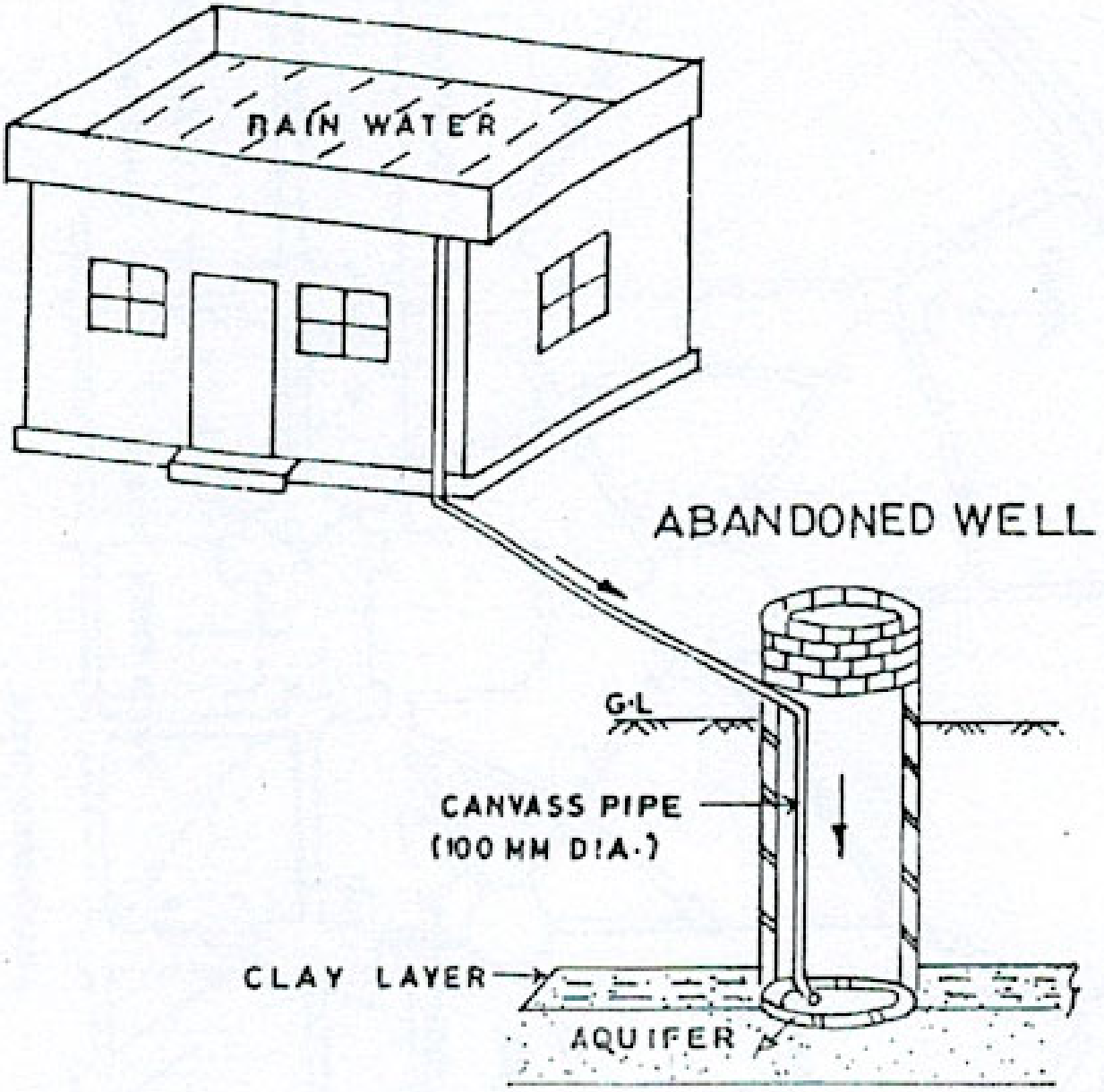
SITE PLAN

Drg-07: Scheme for water harvesting

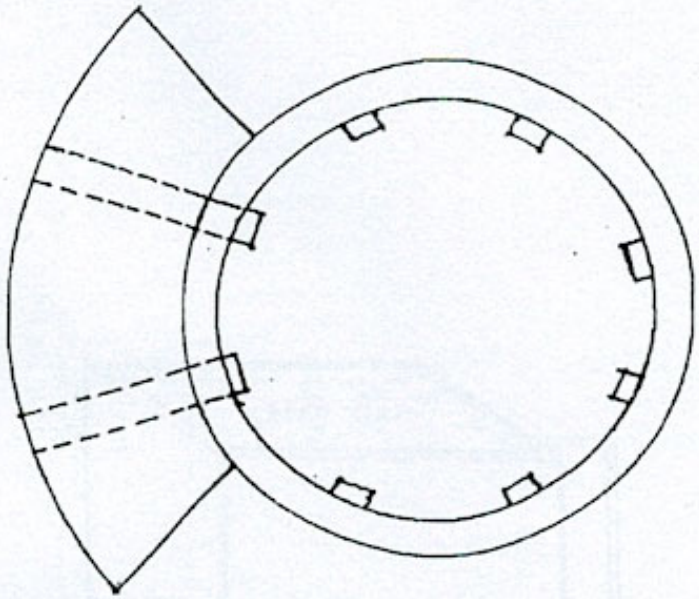


SITE PLAN

Drg-08: Scheme for water harvesting



Drg-09: Recharge through abandoned dug well



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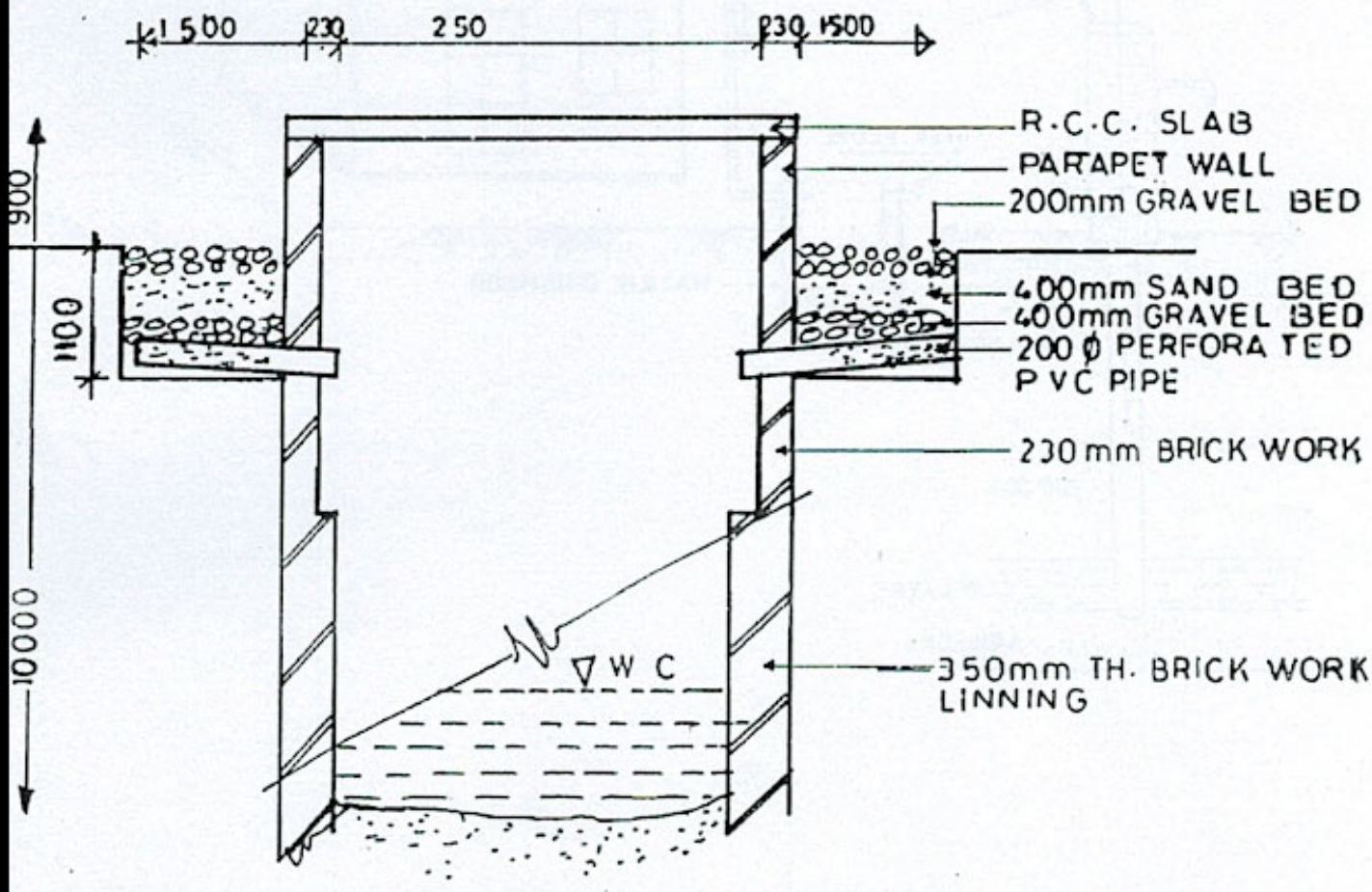
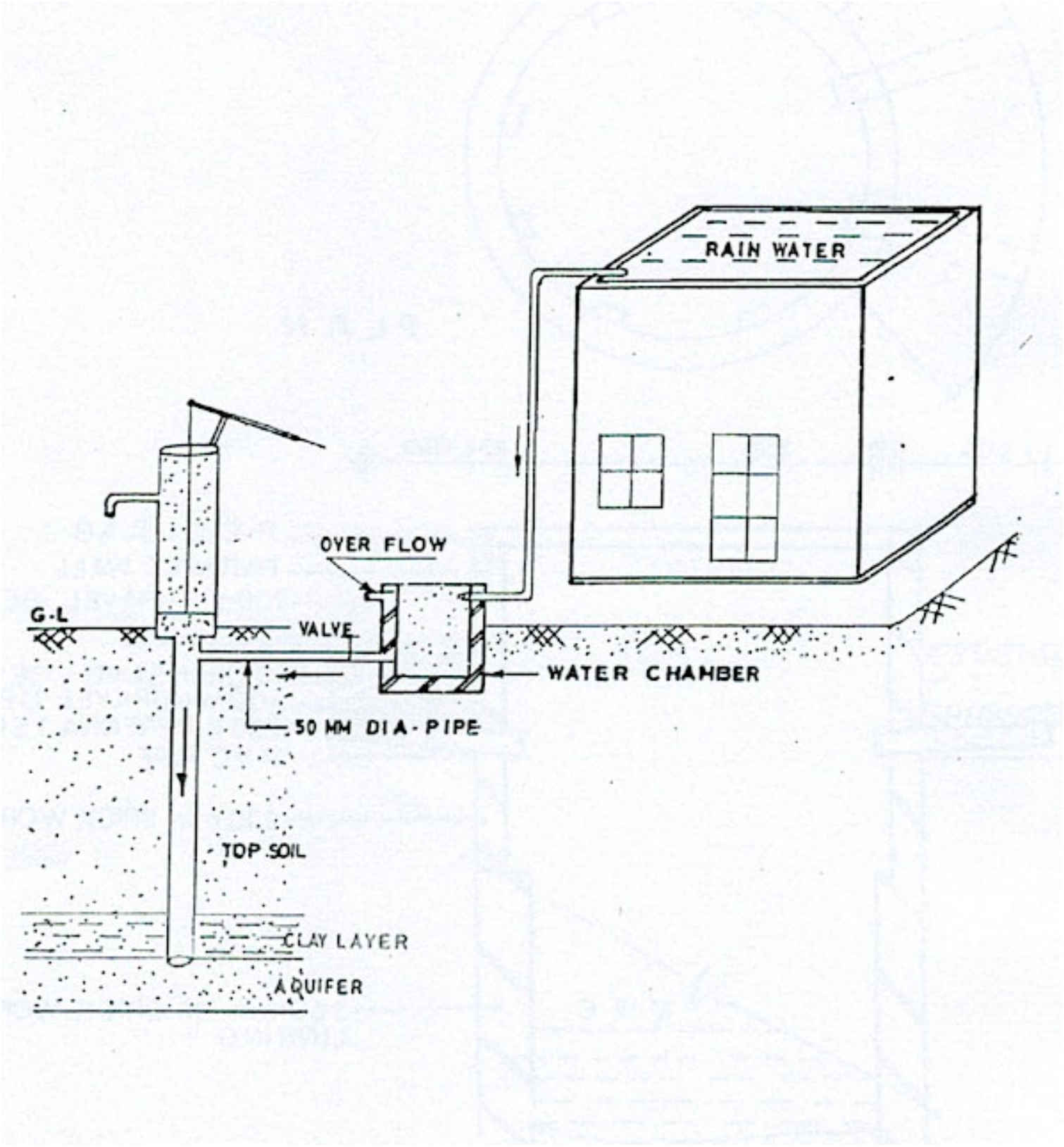
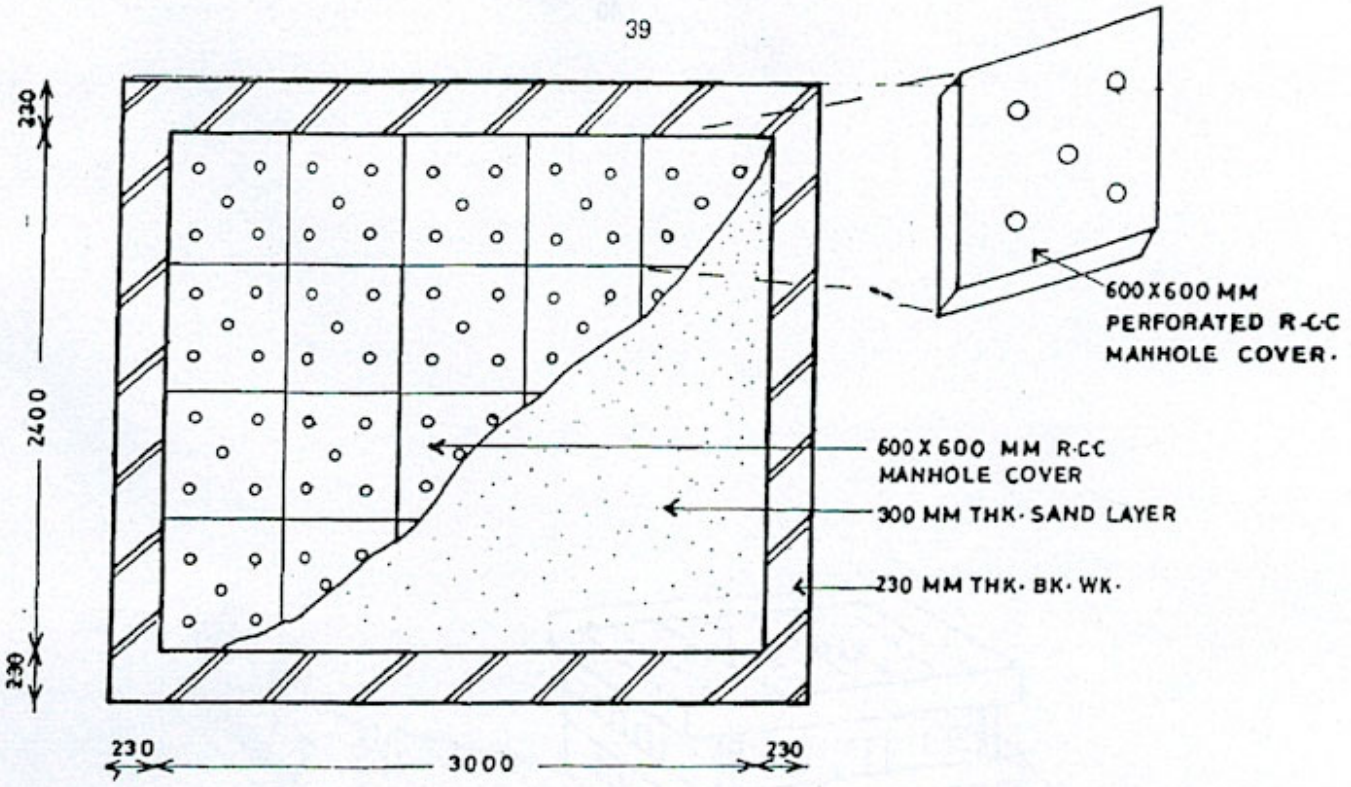


SECTION

Drg-10: Details of recharge dugwell


RAIN WATER
OVER FLOW
G.L
VALVE
WATER CHAMBER
50 MM DIA-PIPE
TOP SOIL
CLAY LAYER
AQUIFER



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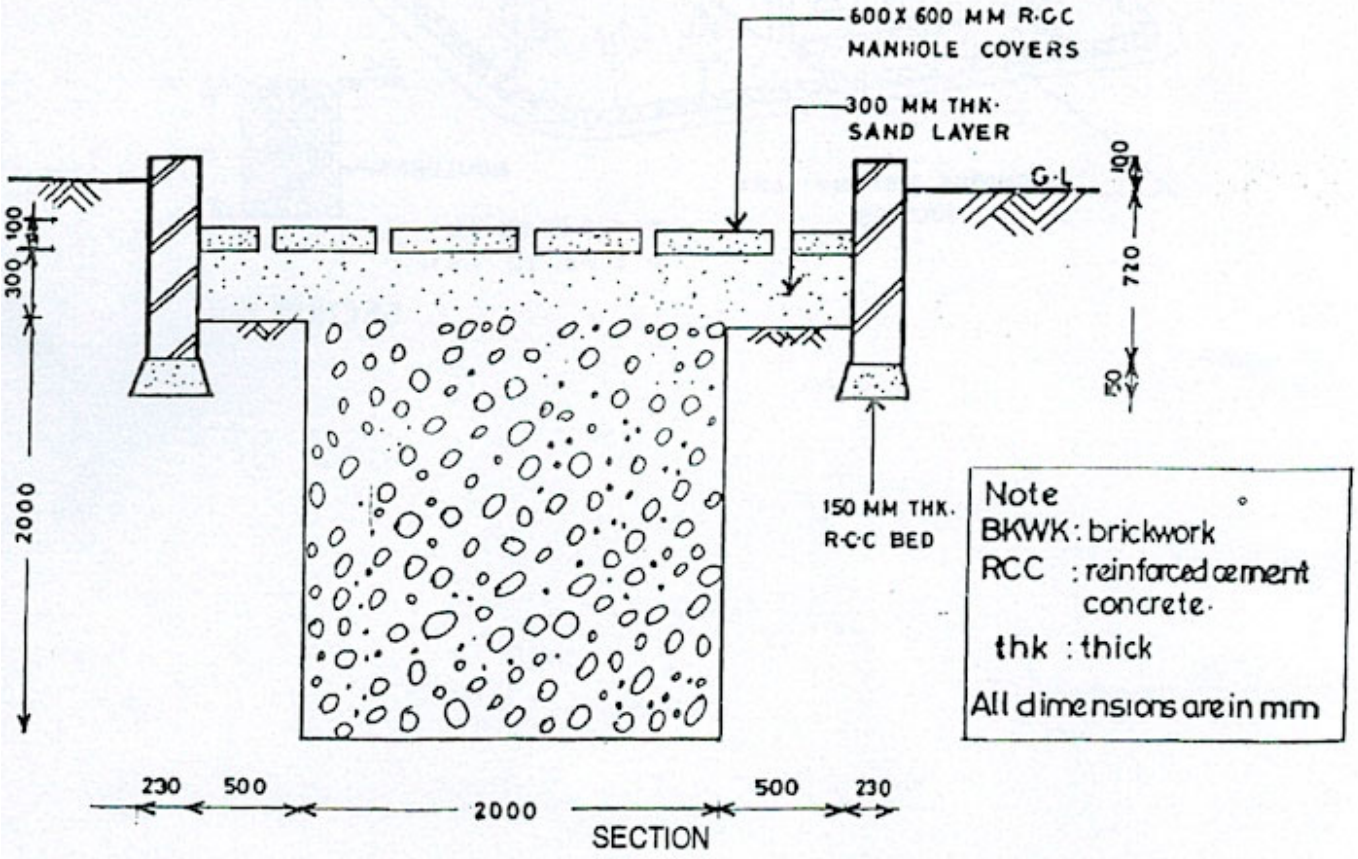

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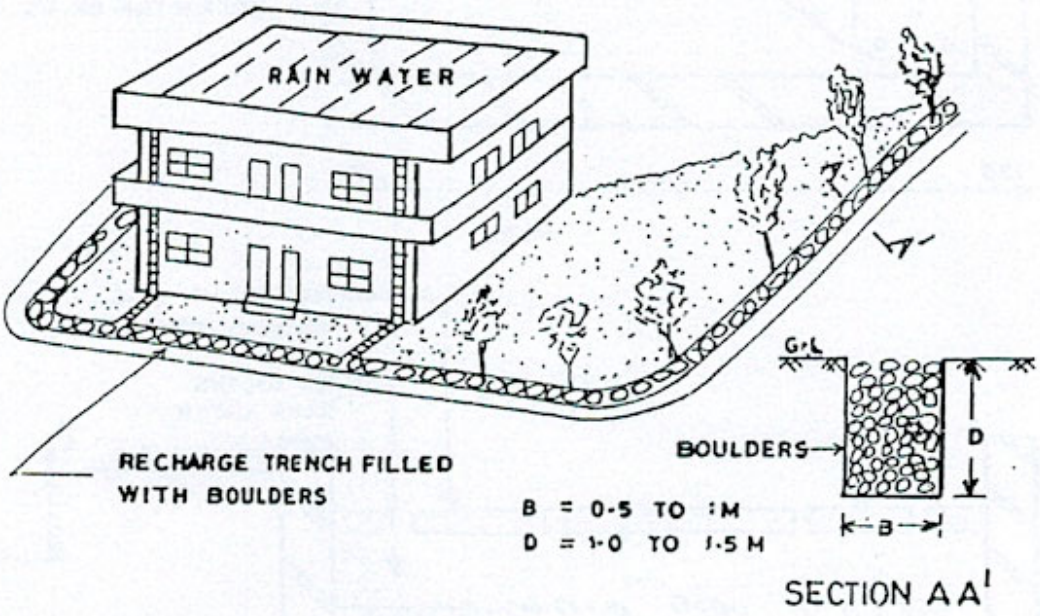
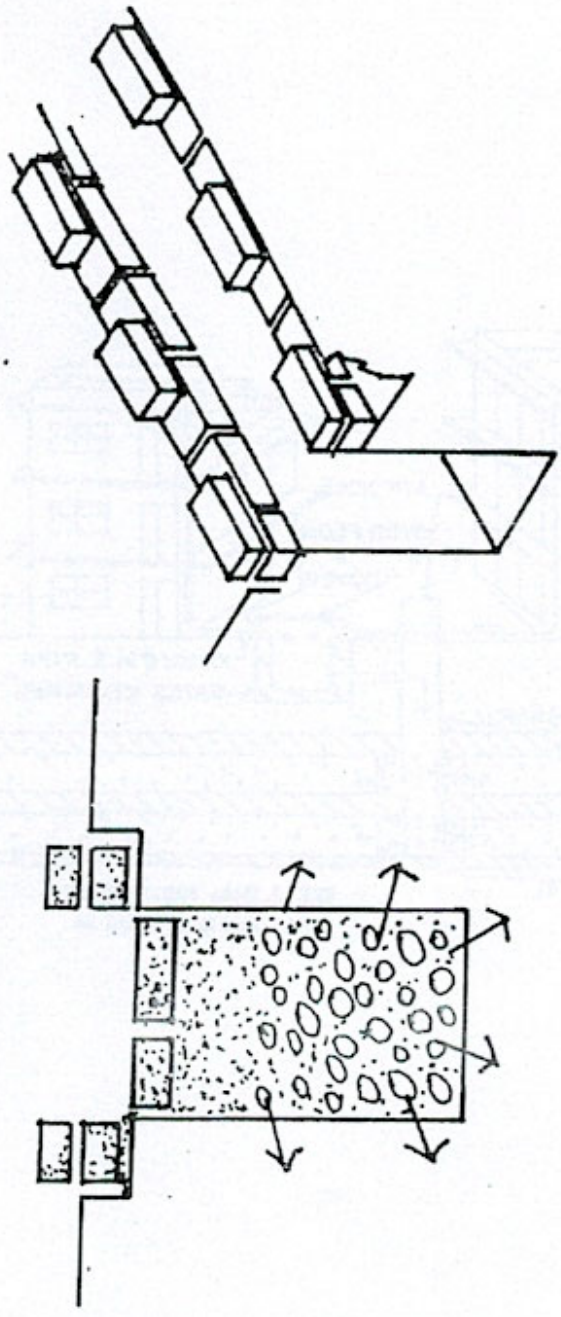
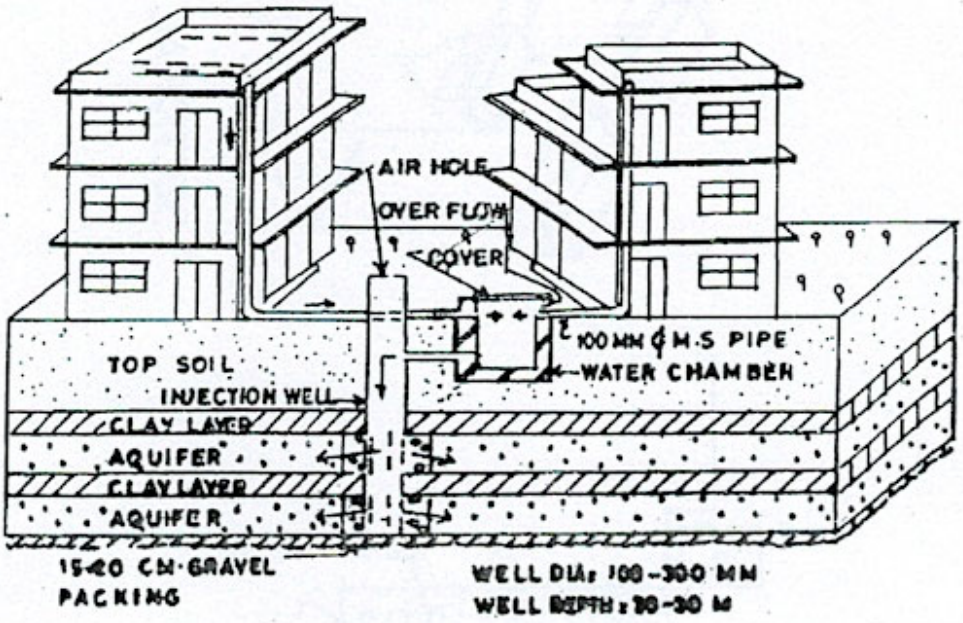
Drg-12: Details of recharge pit



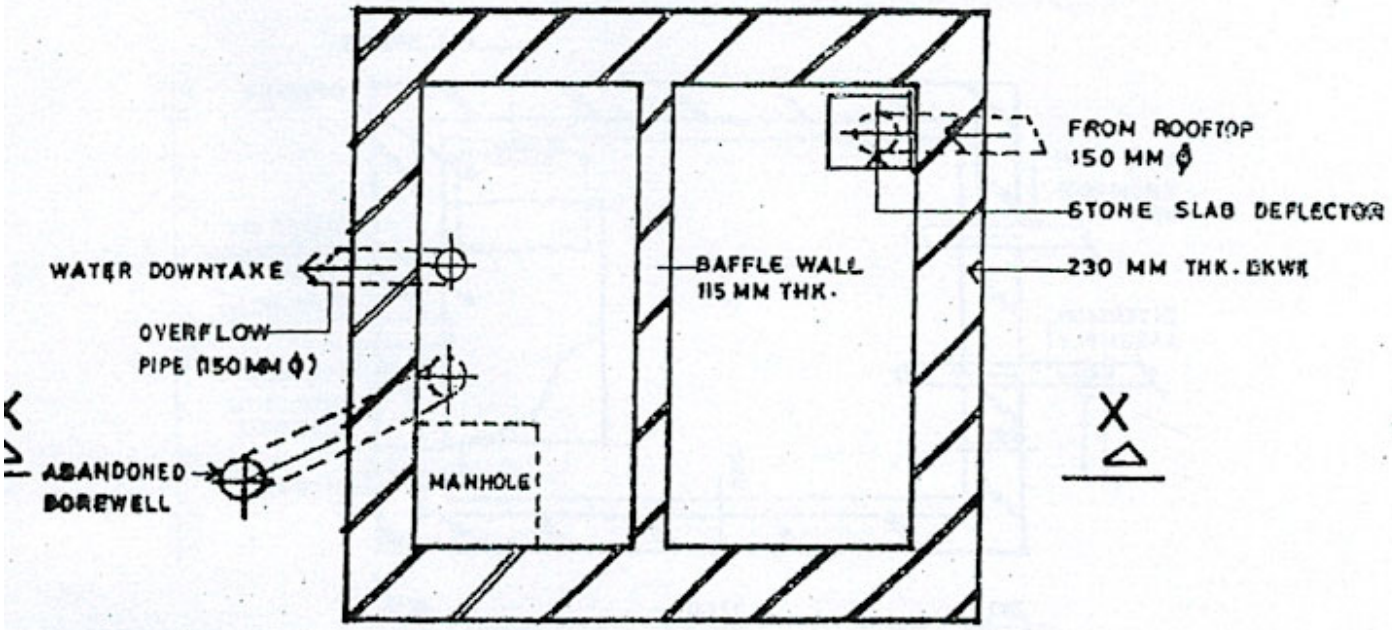
Drg-13: Recharge through trench



Drg-14: Details of recharge trench

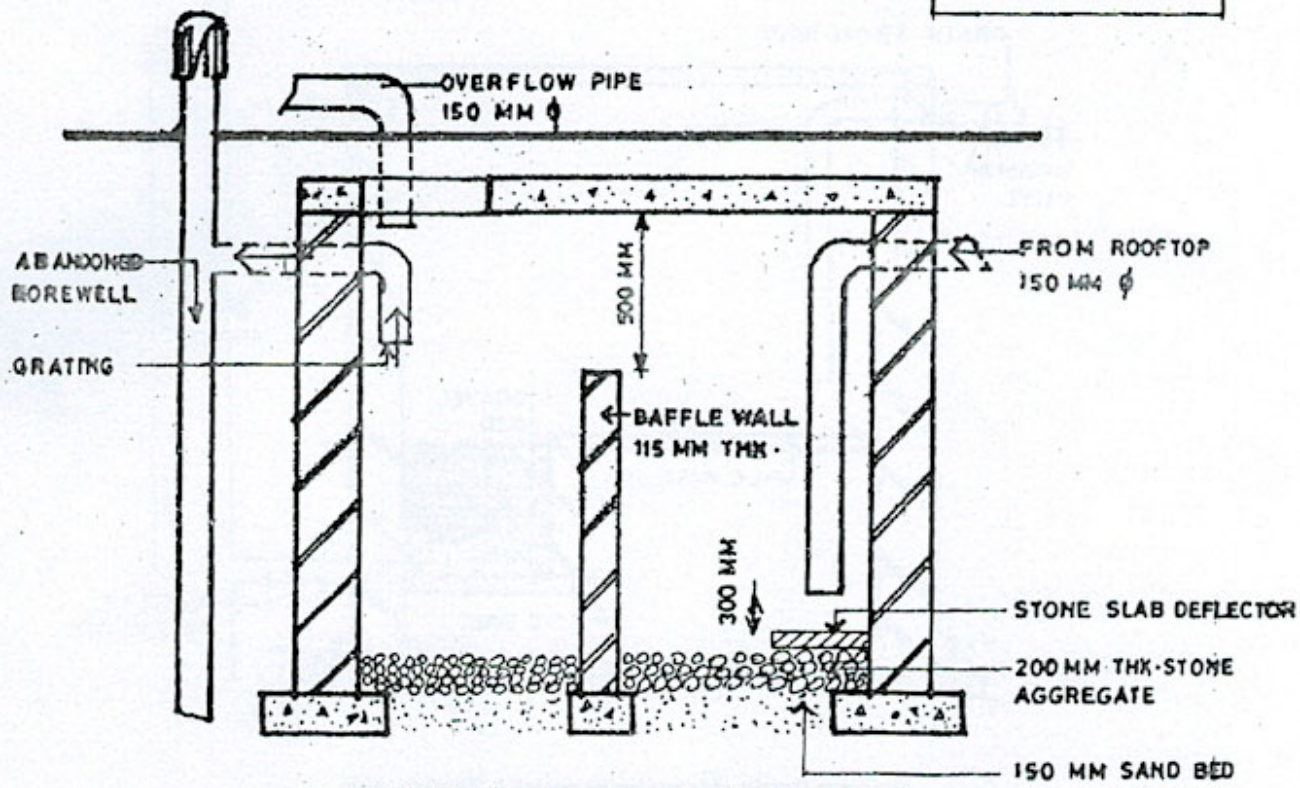


Drg-15: Gravity head recharge tube well



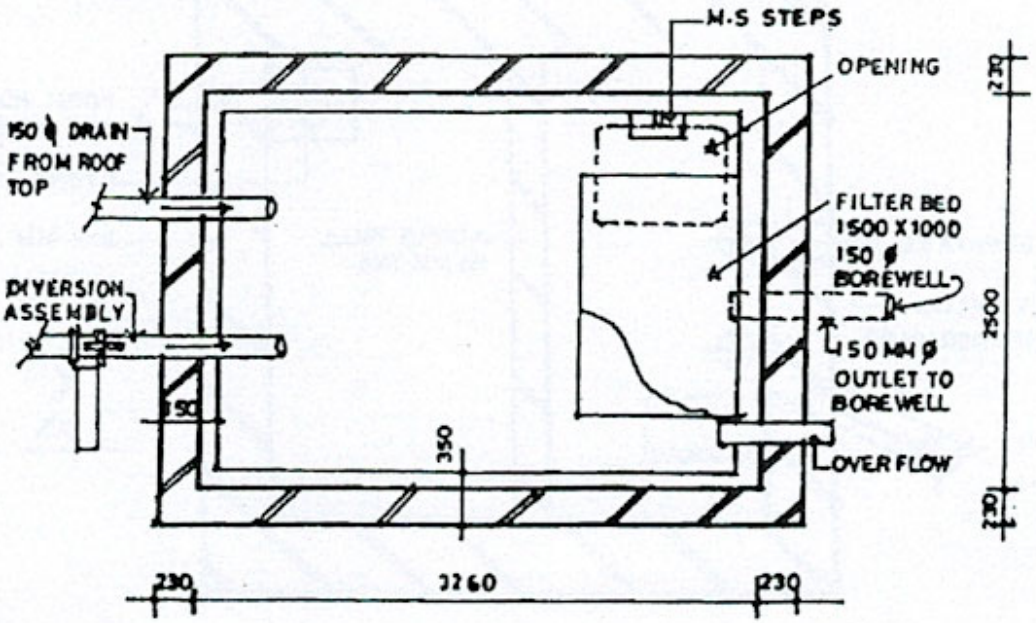
PLAN

Note:
BKWK: brickwork
ϕ : diameter
thk : thick



Drg-16: Details of recharge borewell and settlement tank

SECTION (X X)



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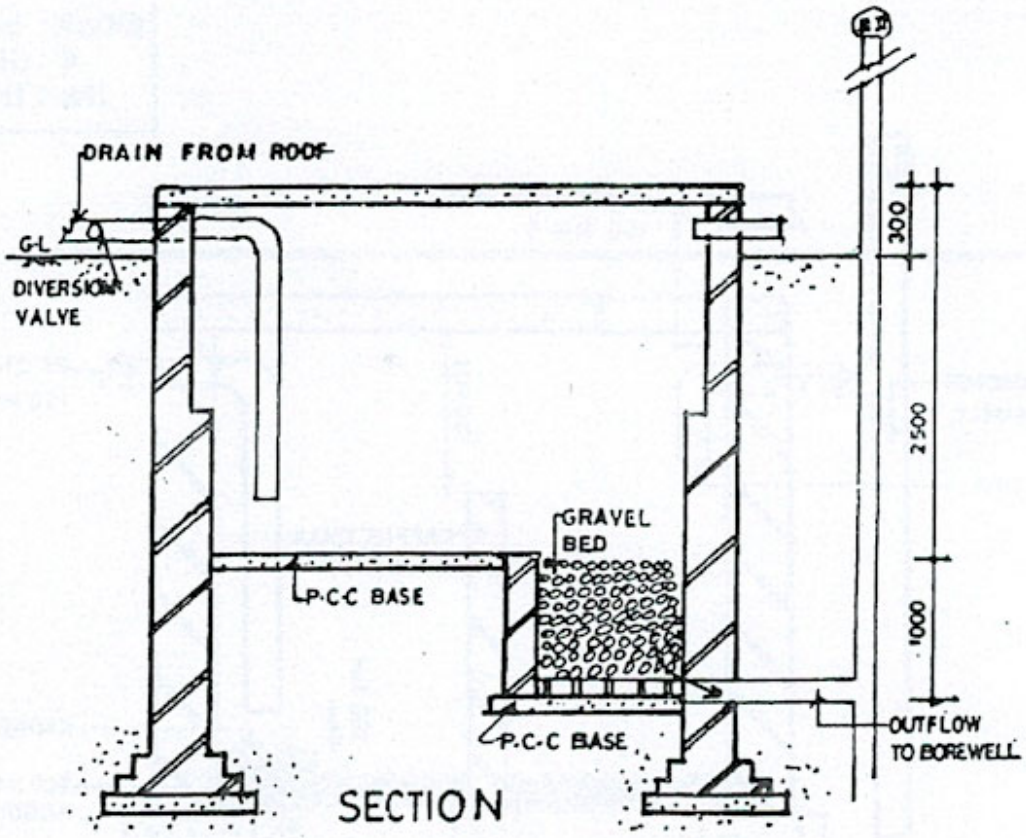

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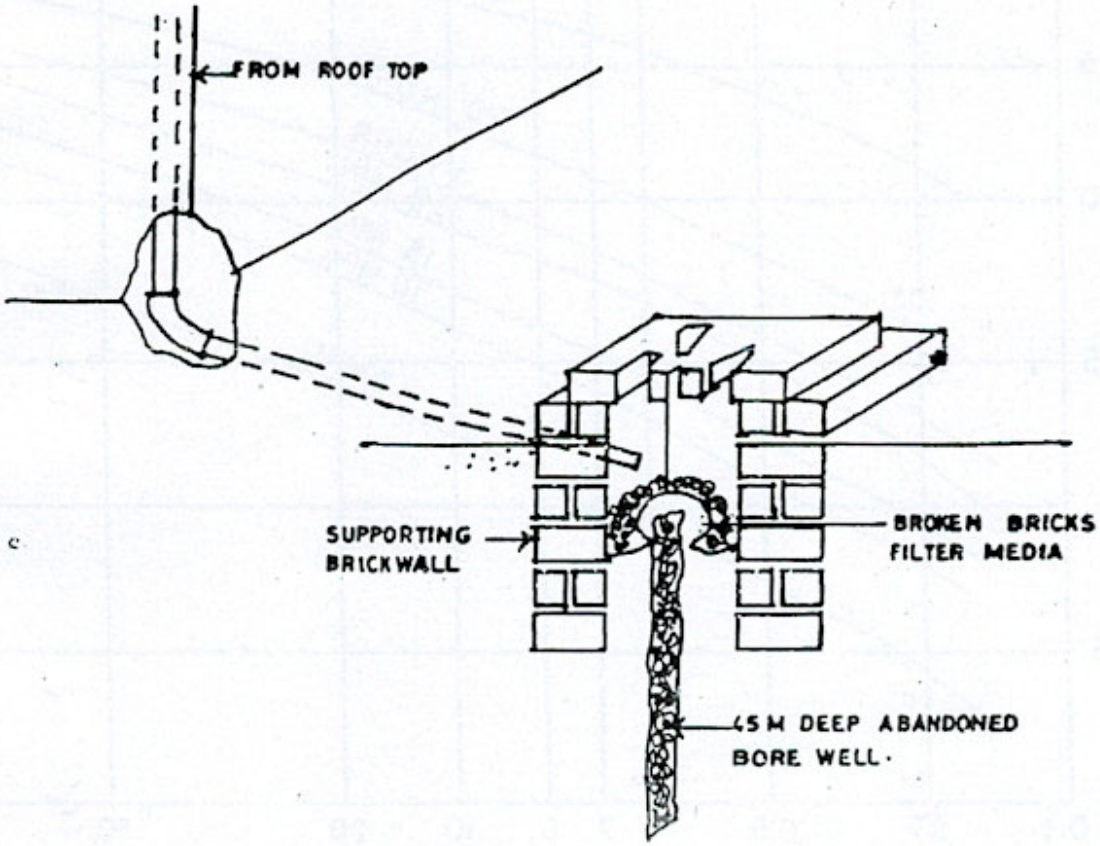
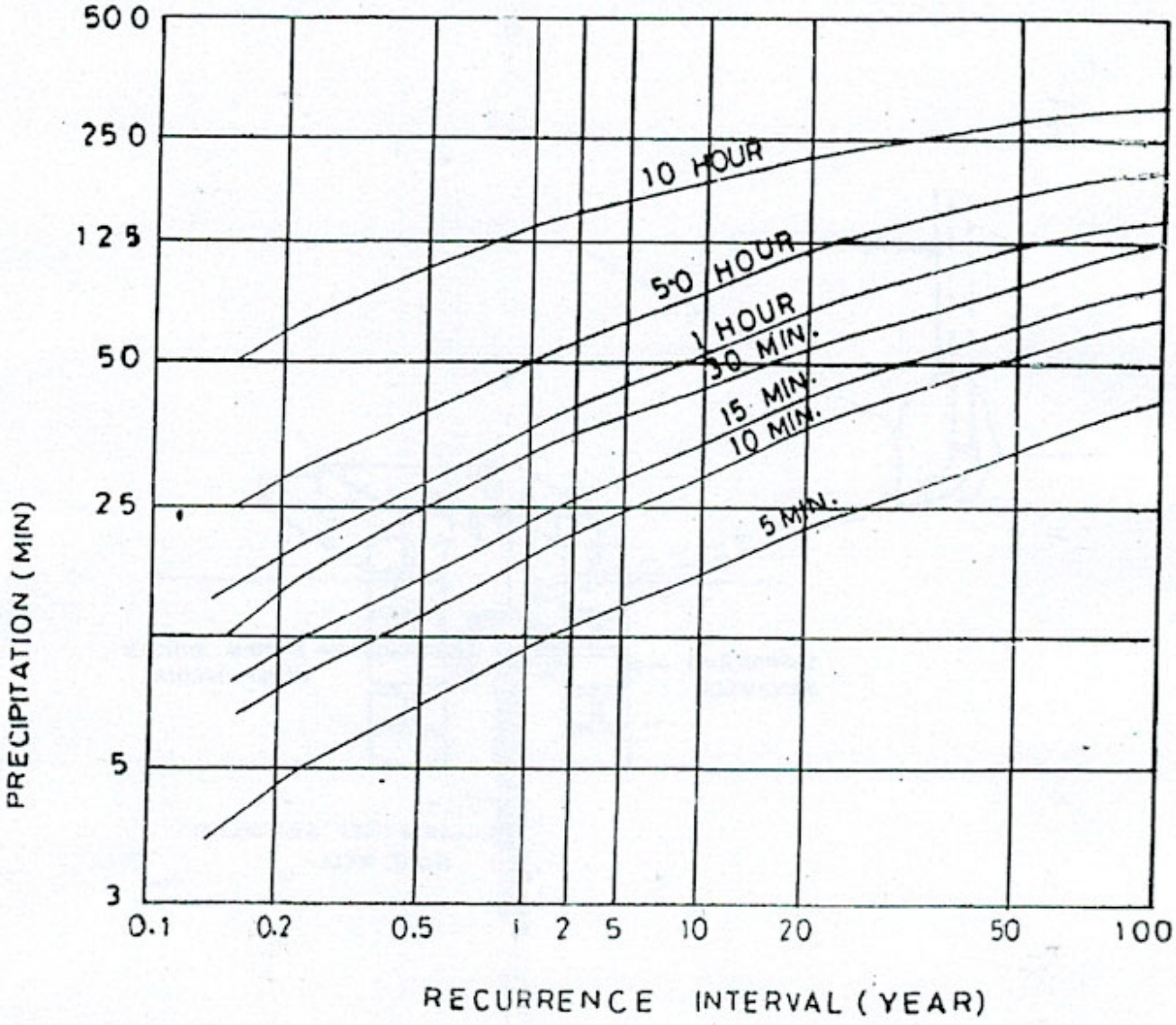
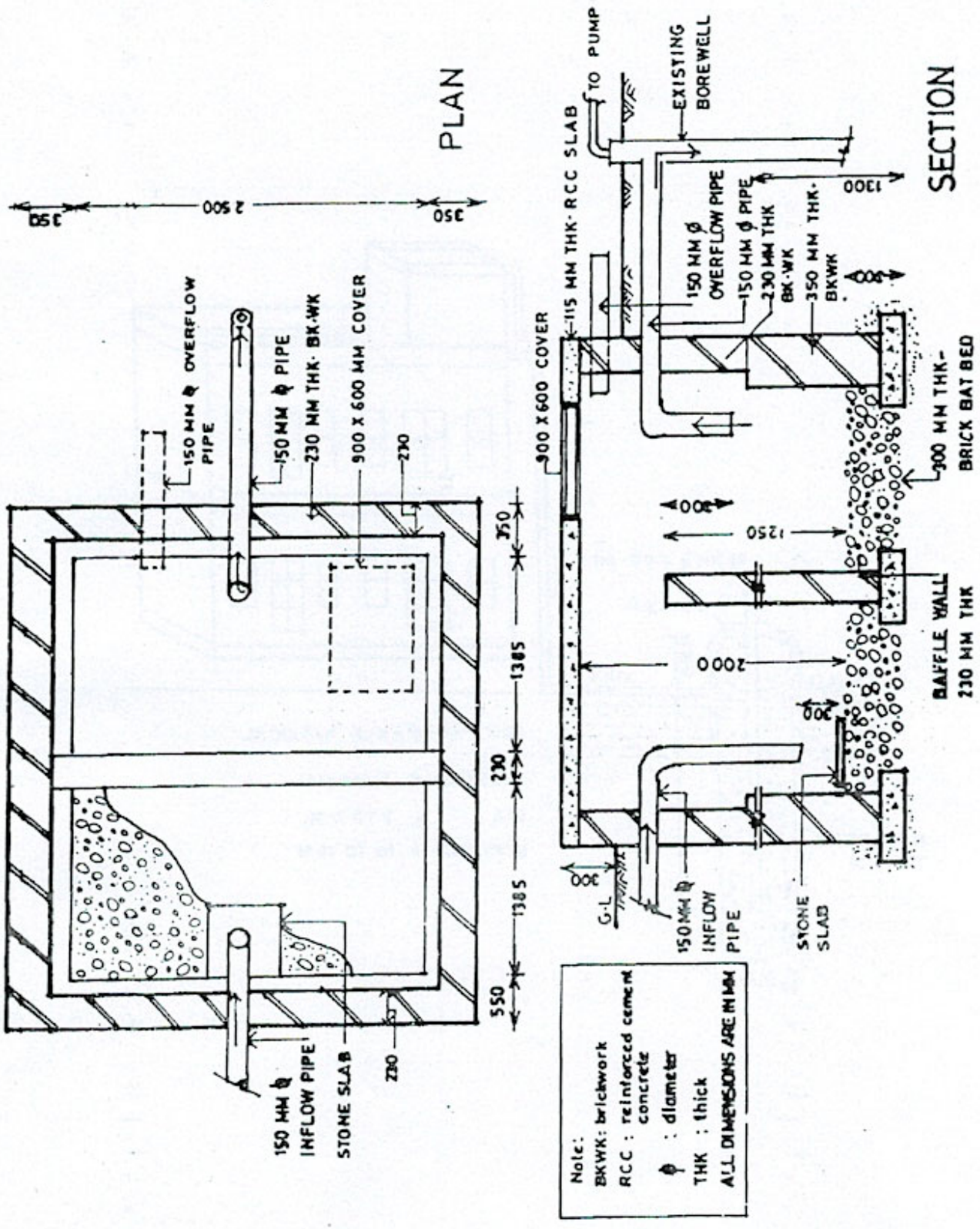
Drg-17: Details of recharge borewell & filtration tank



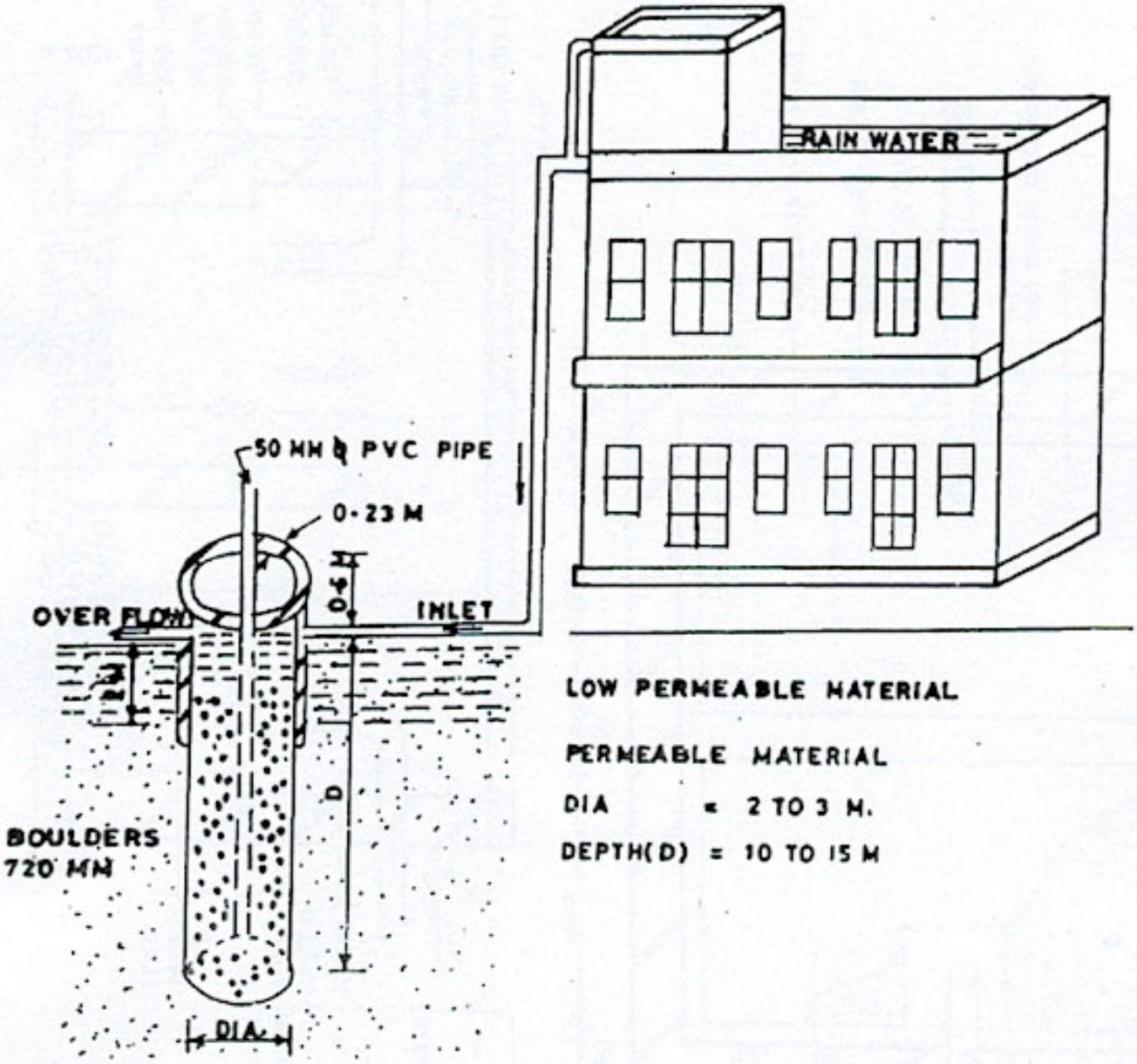
Drg-18: Detail of abandoned boerwell recharging



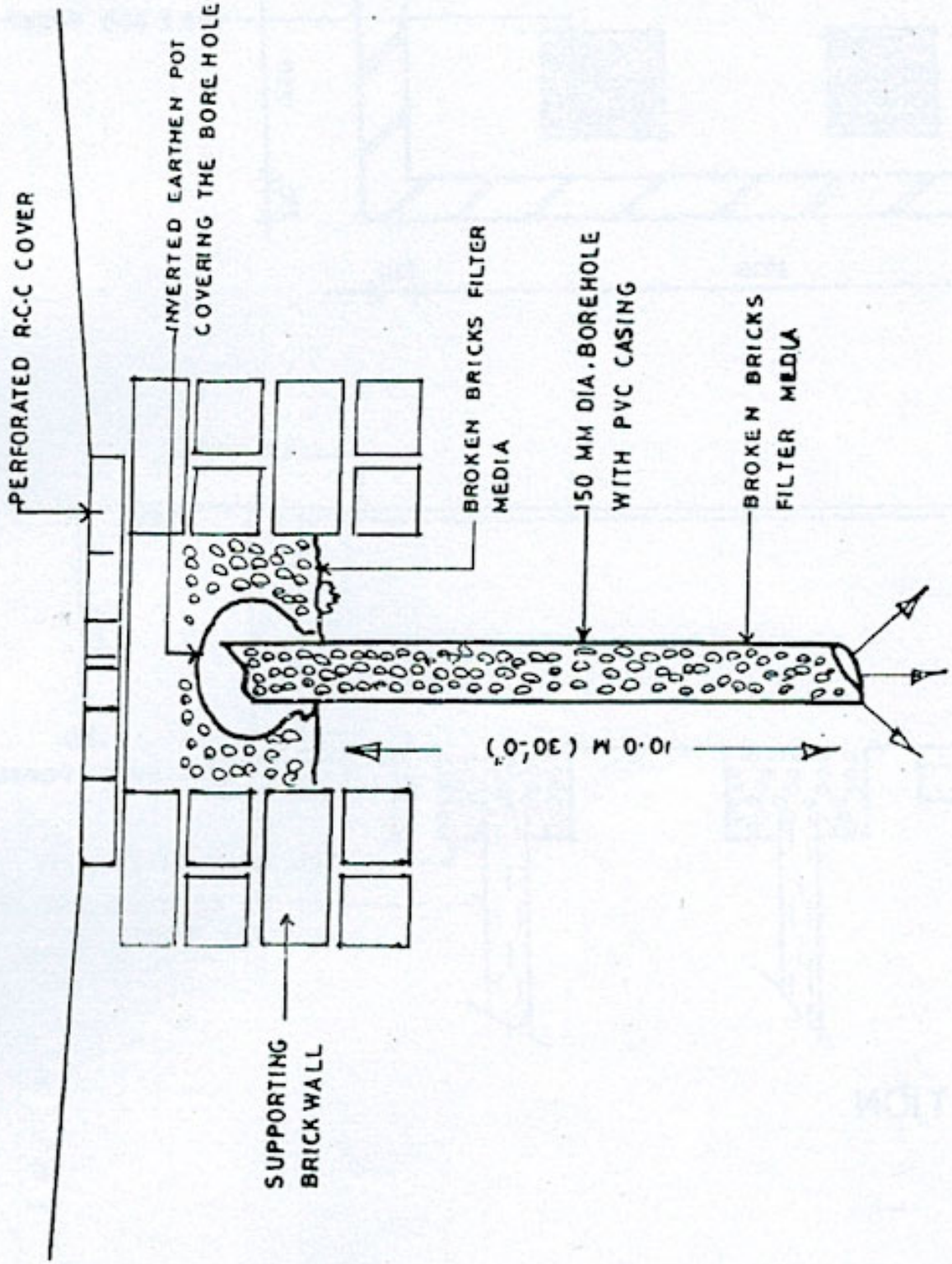
Graph No.1: Rain Fall Intensity – Duration – Frequency Relationship



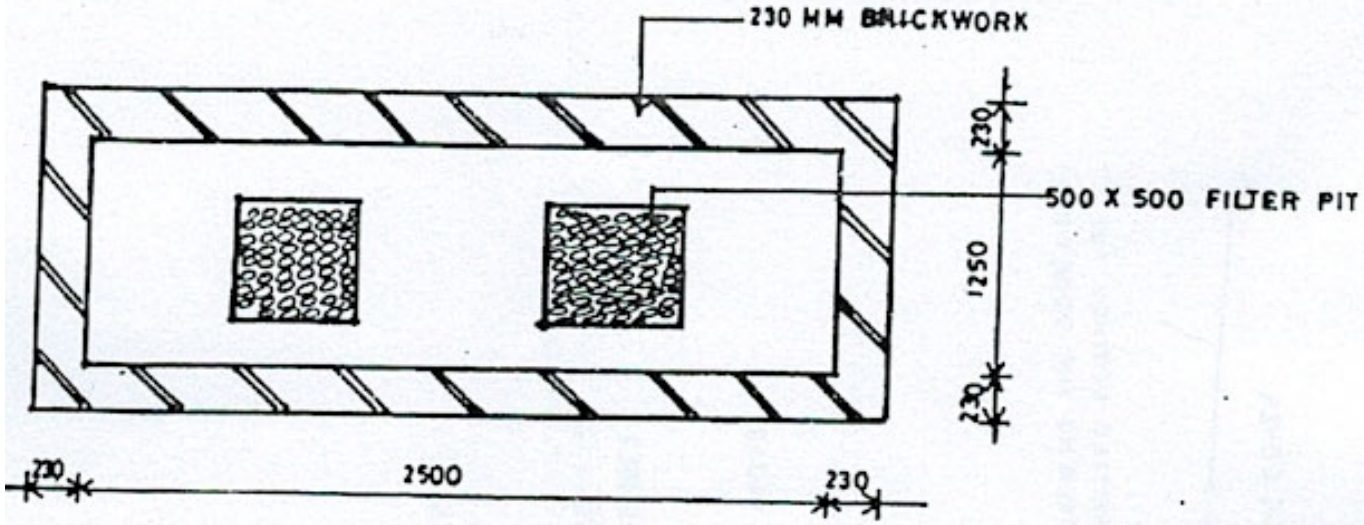
Drg-19: Details of recharge borewell & settlement tank



Drg-20: Recharge Shaft



Drg-21: Detail of soakway



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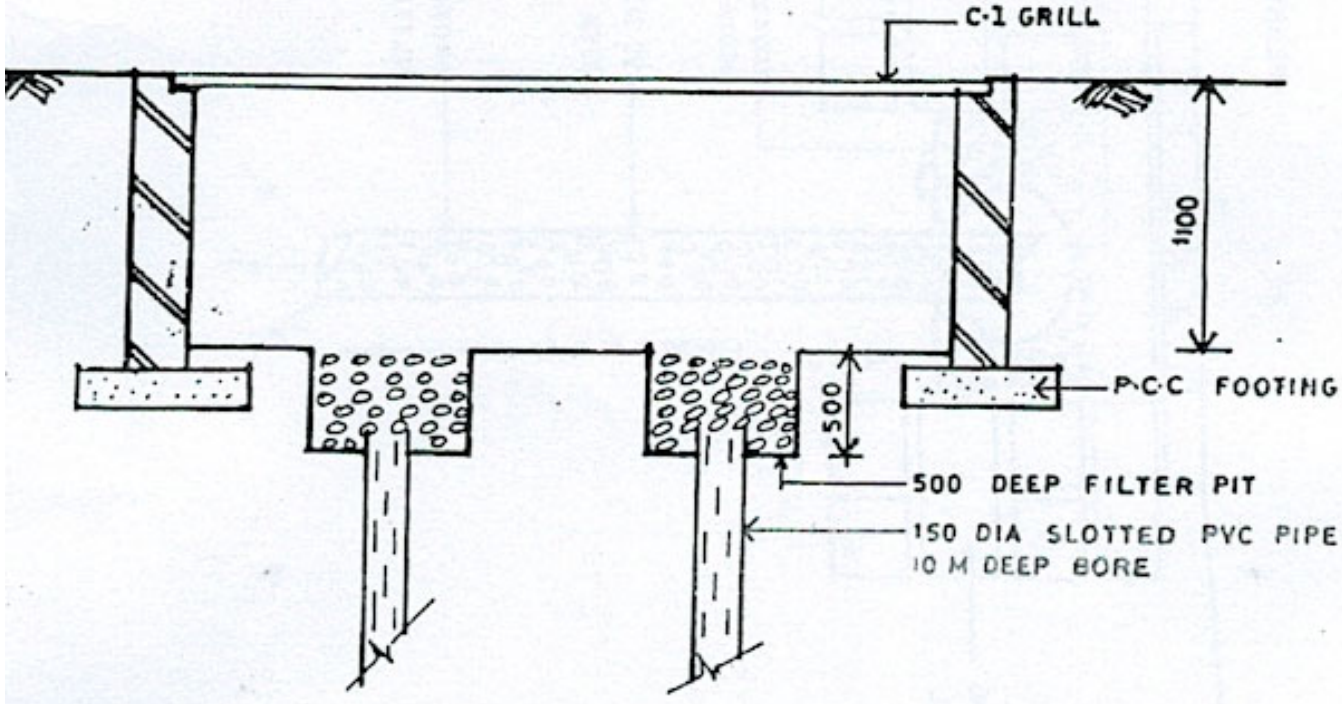


SECTION

Drg-22: Detail of recharge through & soakway

CHAPTER – 6

CASE STUDIES

Case No. 1 SPG Project at Dwarka (Papan Kala), New Delhi.

6.1.0 The Rain Water Harvesting & Conservation Techniques have been successfully executed in recently completed SPG Project at Dwarka, New Delhi. The details of items executed and the drawings followed are attached in Annexure - (Case Studies). Salient features of Artificial recharge to ground water are as under:

(i)	Average Annual rain fall	611.8 mm
(ii)	Total area	47.5 Hectre
(iii)	Depth to water level	5.75 m bgl
(iv)	Water available for recharge	112419 cubic metre/annum
(v)	Expected recharge	80,000 cubic metre/annum

6.1.1 Aims & Objectives:

The main objectives of the schemes are as follows:

(i) Augment the ground water recharge through surplus water available in the area.

(ii) To arrest the rate of decline of ground water levels.

(iii) To Monitor the effect and rate of ground water recharge

(iv) To develop the technology for artificial recharge is specially in urban areas and also quantify the volume of recharged water.

(v) To evaluate cost benefits of various recharge techniques adopted

(vi) To create awareness in the society for proper management of ground water resources.

6.1.2 Availability of water

Total area complex	=	47.48Hectare
Average annual rain fall is	=	611.8 MM
Total run off available for recharging the ground water	=	112419Cubicmetre per annum
Expected run off at hourly Rain fall intensity of 40mm / hour is	=	7350.06Cubic metre

S No.	Area Type	Area In Sqm	Normal rain fall in mtr. Year	Runoff co-efficient	Total runoff available in cubic mtr/ Annum	Runoff at hourly rain fall Intensity of 40 mm / hour
1	Roof Top	55227	0.6118	0.90	30409.09	1988.172
2	Roads	55559	0.6118	0.80	27192.80	1777.888
3	Paved Area	50000	0.6118	0.85	26001.50	1700.00
4	Parks & Green Belts	314000	0.6118	0.15	28815.78	1884.00
	Total:	474786			112419.16	7350.06

The ground water occurs in sandy silt horizon and predominantly kankar horizon which are potential aquifer zones in the area.

6.1.3 Type of artificial recharge structures proposed

Recharge trenches cum recharge wells are proposed. The design of these structures are given in Drawing No.23.

Recharge wells will be used for pumping wherever recharge source water is not available.

The pumping may take care of cleaning the silt which may enter the well during recharge.

6.1.4 Benefits of scheme:

(i) Proper utilisation of available run off

(ii) Arresting decline ground water and intrusion of brackish water in fresh water aquifers

(iii) Saving in energy for lifting of water.

(iv) To provide the sustainability to sum extend to the existing near by ground water structures.

6.1.5 Attributes of Ground Water:

(i) There is more ground water than surface water

(ii) Ground water is less expensive and economic source

(iii) Ground water is sustainable and reliable source of water supply

(iv) Ground water is relatively less vulnerable to pollution, high bacteriological purity, free of pathogenic organism, needs little treatment before use

(v) Ground water has no turbidity and colour, universally available

(vi) Ground water source can be instantly developed and used

(vii) Ground water has distinct health advantage as an alternative for lower sanitary surface water.

(viii) There is no conveyance losses in ground water based supplies

(ix) Ground water has low vulnerability to drought

(x) Ground water is key to life in arid and semi - arid regions

(xi) Ground water is source of dry weather flow in rivers and streams.

Case No. 2 Scheme for Artificial recharge to ground water at NH IV area, Faridabad (Haryana)

Normal annual Rain fall 564.3 mm

Normal Monsoon Rainfall 487.4 mm in on an average 21.8 days

Geological formation – alluvial and quartzite

Depth to water level – About 26 mtr below ground level.

6.2.1 Purpose:

(I) To recharge the available runoff which accumulates around quarters and creates inconvenience to the residents

(II) To arrest the decline of the ground water levels in the area

(iii) To create awareness in the society for proper management of rain water through harvesting.

(iv) Hydrology – The area is characterized by alluvial under lain by quartzite. Sand mixed with hampers in alluvium acts as very good repository for ground water. Depth to water level in the area is about 26 m below ground level.

6.2.2 Availability of surface water:

The annual normal rain fall of the area is 564.3 mm, out of which 487.4 mm occurs during monsoon period in on an average 21.8 days. The runoff availability for each block, playground and for market area is assessed as below:

S.No.	Area Description	Area contributing run off (sqm)	Runoff availability (cubic metre)
1	Type IV Qrs	189.04 x 35=6616	90x35=3150
2	Type V Qrs	312.82x13=4067	150x13=1950
3	Type VI Qrs	459.5x4=1838	220x4=880
4	Play Ground	151500	6000
5	Market area	6050	1700
	Total	**170071**	**13680**

Thus about 13680 cum runoff is available annually for recharge to ground water.

6.2.3 Artificial recharge structures:

The structures should be constructed only at those places where water accumulates during monsoon period The proposed recharge structures may be constructed at lower elevations keeping the topography into consideration.

6.2.4 Benefits of scheme:

(i) Proper utilisation of the available run off which accumulates around the quarters

(ii) To increase soil moisture

(iii) Sustaining the green areas

(iv) Arresting the declining ground water level

(v) Provide sustainability to the existing ground water absorption structures in the area.

Structures I, 2,3 (Ref. Drawing No. 24 to 26) Recharge pit with Bore

Structure – 4 (Lateral shaft with bore wells) (Ref. Drawing No.27)

Case No. 3 Salient feature of artificial recharge at Sewa Bhawan, RK Puram, New Delhi.

Average Annual rain fall	712.2 mm
Average Monsoon rain fall	605.2 mm
Geological formation	Older alluvial
Depth to water level	16 – 20 m bgl.
Water available for recharge	4500 cum
Expected recharge	4000 cum
Recharge structures proposed	4 recharge trench with injection wells. See Drawing No.28 & 29.

Case No. 4 Salient Features of Artificial Recharge proposal at HUDCO Place, Andrews Ganj, New Delhi.

1	Total Campus area	11.61 hectare
2	Normal Annual rainfall	712.2 mm
3	Normal Monsoon rain fall	605.2 mm
4	Geological formation	Alluvium

5	Depth to water level	About 24 m bgl
6	Water available for recharge	50350 cum
7	Recharge structure proposed	Trench cum bore wells – 7
8	Specification of Filter Material	(See Drawing No.30 & 31).
	a) Coarse Sand	1.5 to 2 mm size
	b) Gravel	5 to 10 mm size
	c) Boulders	Rounded and 5 to 20 cm
9	Depth & Dia of Recharge wells	32 m & 12" (303 mm)
10	Design of Recharge wells	

S. No.	Depth range	Assembly
1.	0.00 to 0.,50 m agl	303 mm dia MS blank pipe
2.	0.00 to 1.5 m bgl	303 mm dia MS blank pipe
3.	1.5 to 2.5 m bgl	303 mm dia slot pipe of 3 mm size
4.	2.5 to 10.00 m bgl	303 mm dia M.S. blank pipe
5.	10.00 to 18.00 m bgl	303 mm dia MS slot pipe of 1.59 mm size
6.	18.00 to 20.00 m bgl	303 mm dia blank pipe
7.	20.00 to 30.00 m bgl	303 mm dia slotted pipe of 1.59 mm size
8	30.00 to 32.00 m bgl	303 mm dia blank pipe with bail plug

11. The main objectives of the scheme :

(I) To augment the ground water recharge through surplus water available in the area.

(II) To arrest the decline of the ground water levels in the area.

(III) To create awareness in the society for proper management of ground water resources.

12. Hydrology

The area is a plain country having a very gentle northerly slope. The general elevation of the area is 214 mtr above Mean Sea level. The area is underlain by alluvial soil consisting of mostly clay silt mixed with kankar with occasional Badarpur Sand and Gravel. The thickness of alluvial layer varies between 70 mtr – 100 mtr below G.L. Depth of water level in the area is about 24 mtr. Bgl.

13. Availability of surface Water

Structure No.	Area in Sqm	Runoff Cum
1	11772	5220.00
2	9300	4251.00
3	13273	3618.00
4	9640	4486.00
5	11250	5045.00
6	11250	5046.00
7	49615	22684.00
Total	**116100**	**50350.00**

14. Artificial recharge structure

To harness the available runoff, 7 recharge trench cum bore,wells are proposed. The location and design of these structures are given in Drawing No. 30 to 31.

15. Benefits of the Scheme

(i) Proper utilisation of available run off

(ii) To increase soil moisture

(iii) To sustain green areas

(iv) To arrest the declining ground water level

(v) To provide sustainability to the existing ground water abstraction structures in the area.

Case No. 5 Ground Water recharging works at Dewas

Recharging of ground water table depends upon the rain intensity total rainfall, coefficient of permeability of soil and time available for run water to percolate into the ground. The rainfall is very limited soil is very impervious, percolation of rain water is very limited. As per report of CGWB rate of vertical percolation is 0.3 cm/ day hence it is essential to make previous vertical drains or to tape rain water direct to the ground water table for recharging. The existing soil was black cotton soil.

6.5.1 Harvesting of Roof Water (Ref Drawing No.32)

Roof drainage pipe connected to pipes and these pipes connected to tank or tube wells. The PVC/RCC pipes of various dia have been used based on surface area of roofs. When Water taken to the land no filtration has been done, when outlet is connected to the tube well, a filter bed of sand and aggregate has been used for filtration of water and bottom of the filter bed has been connected to the tube well.

6.5.2 Drain Water Harvesting (Ref Drawing No.32)

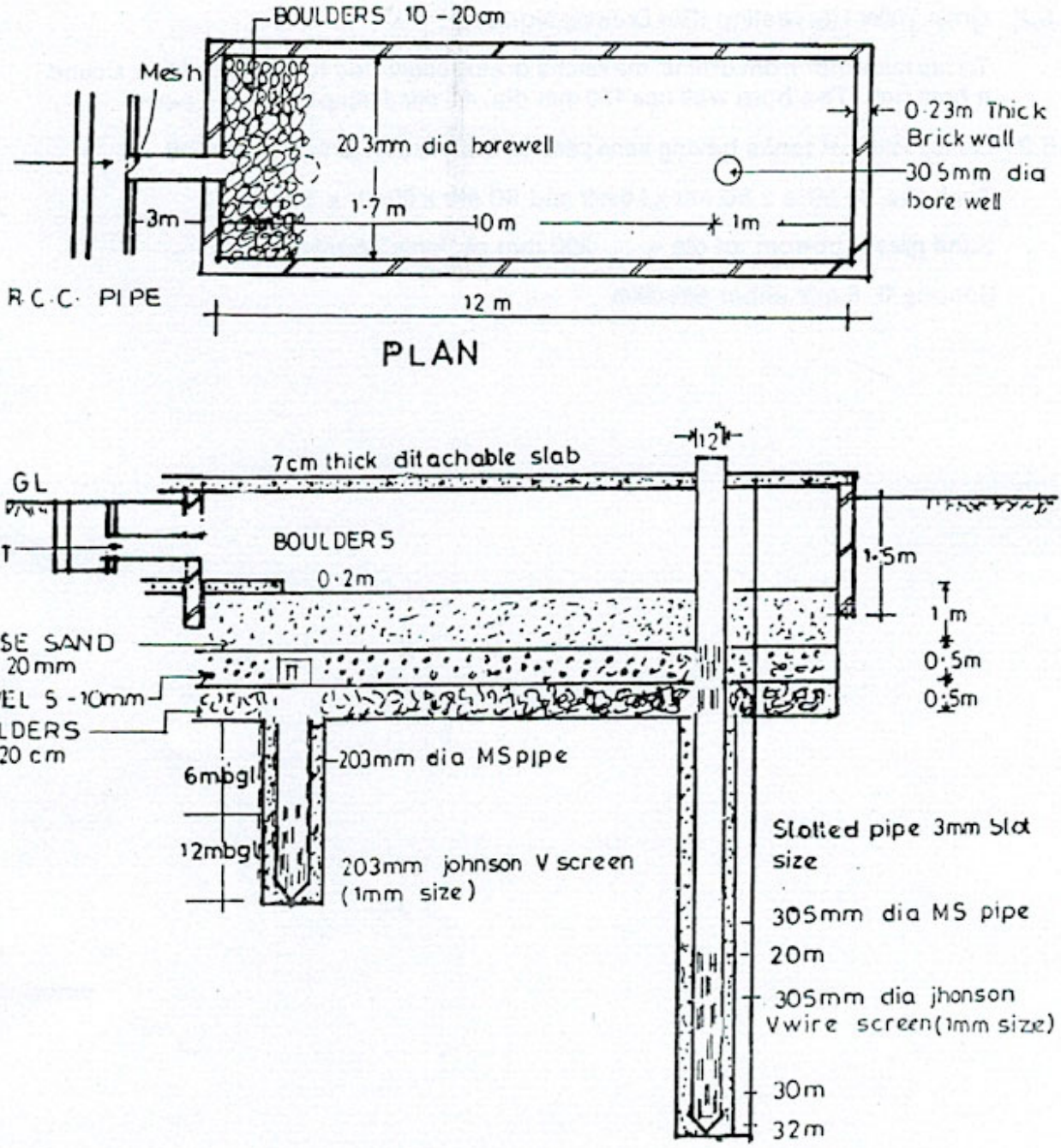
To tap rain water from drains, the katcha drains connected to designed filter around a bore well. The bore well has 150 mm dia, 45 mtr deep perforated pipes:

6.5.3 Construction of tanks having sand piles at bottom (Ref Drawing No.33)

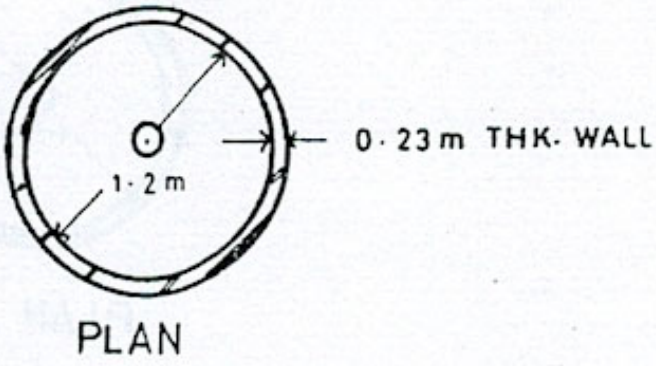
Tank size 60 mtrs x 50 mtr x 1.6 mtr and 90 mtr x 60 mtr x 1.5 mtr.

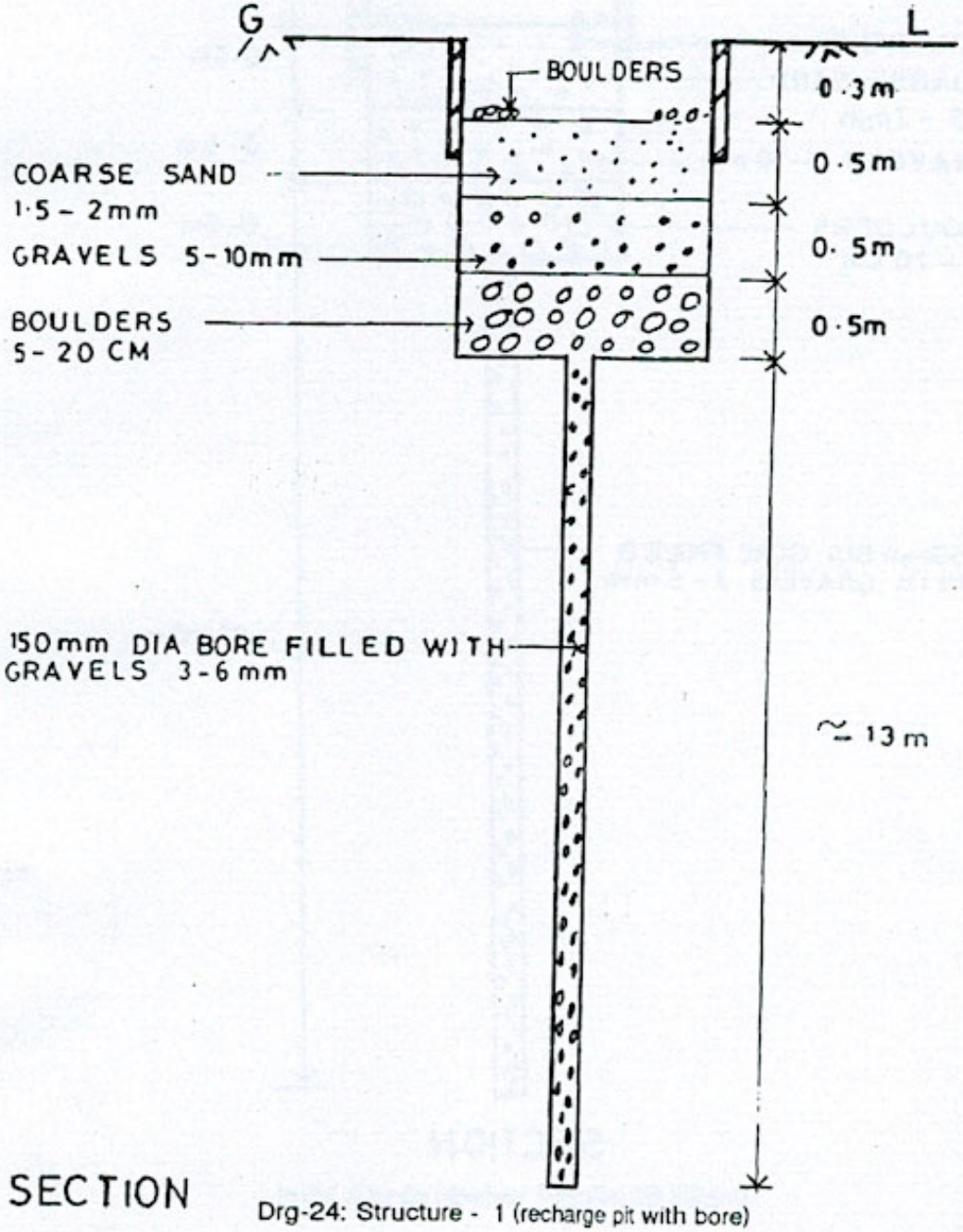
Sand piles at bottom of dia – 300 mm of Depth 3.5 mtr at a

Spacing @ 5 mtr either direction.

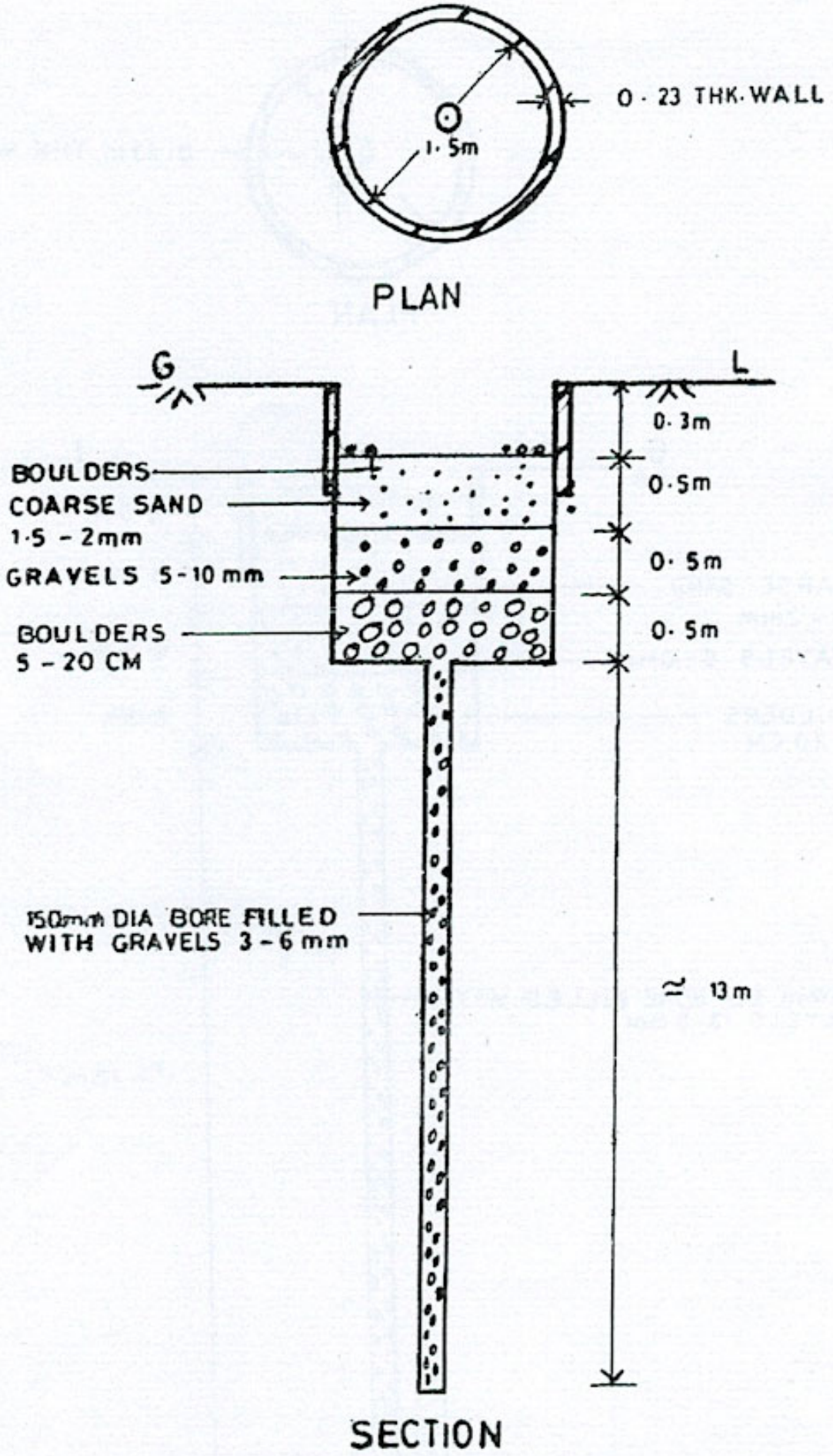


Drg-23: Sign of recharge trench cum recharge wells

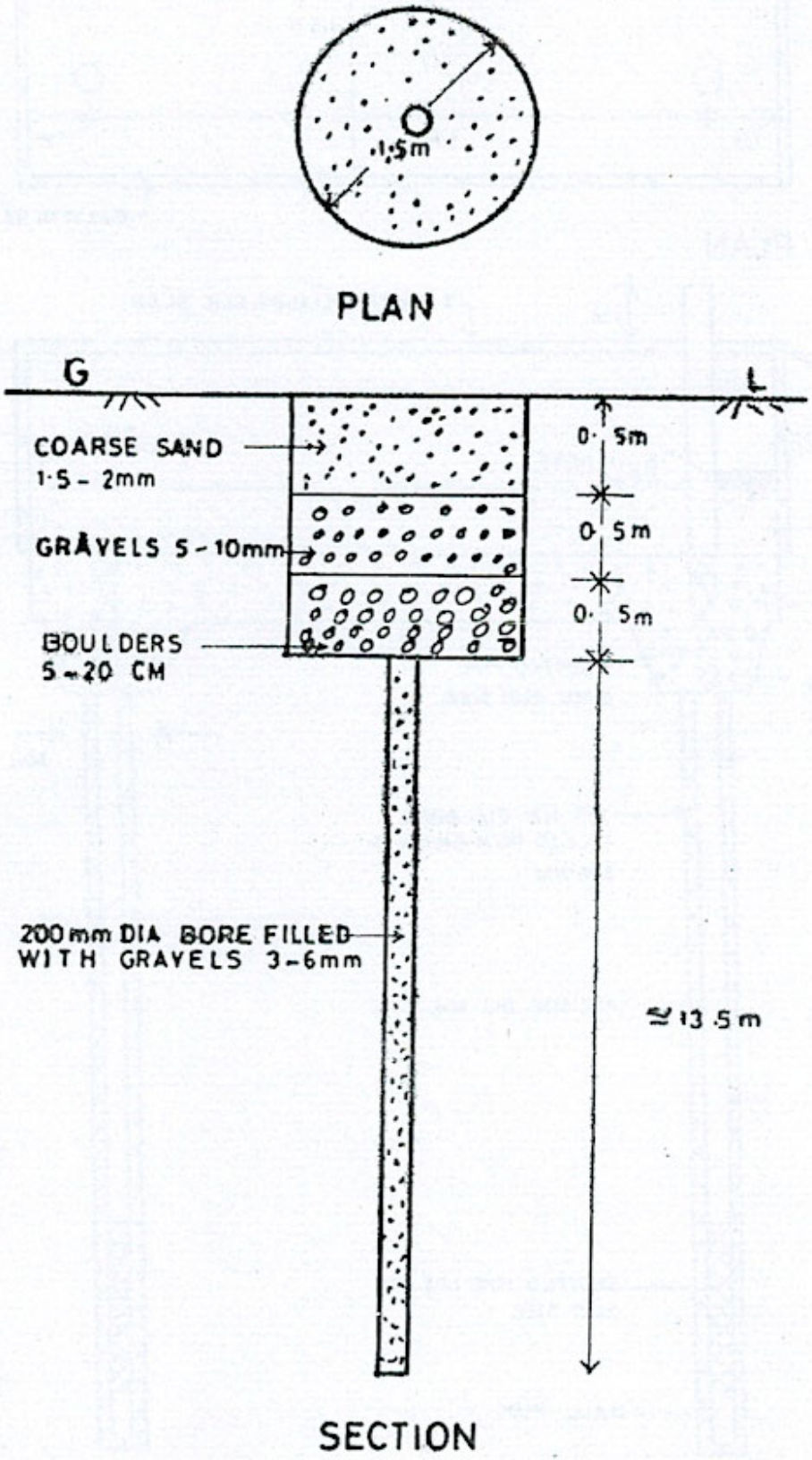




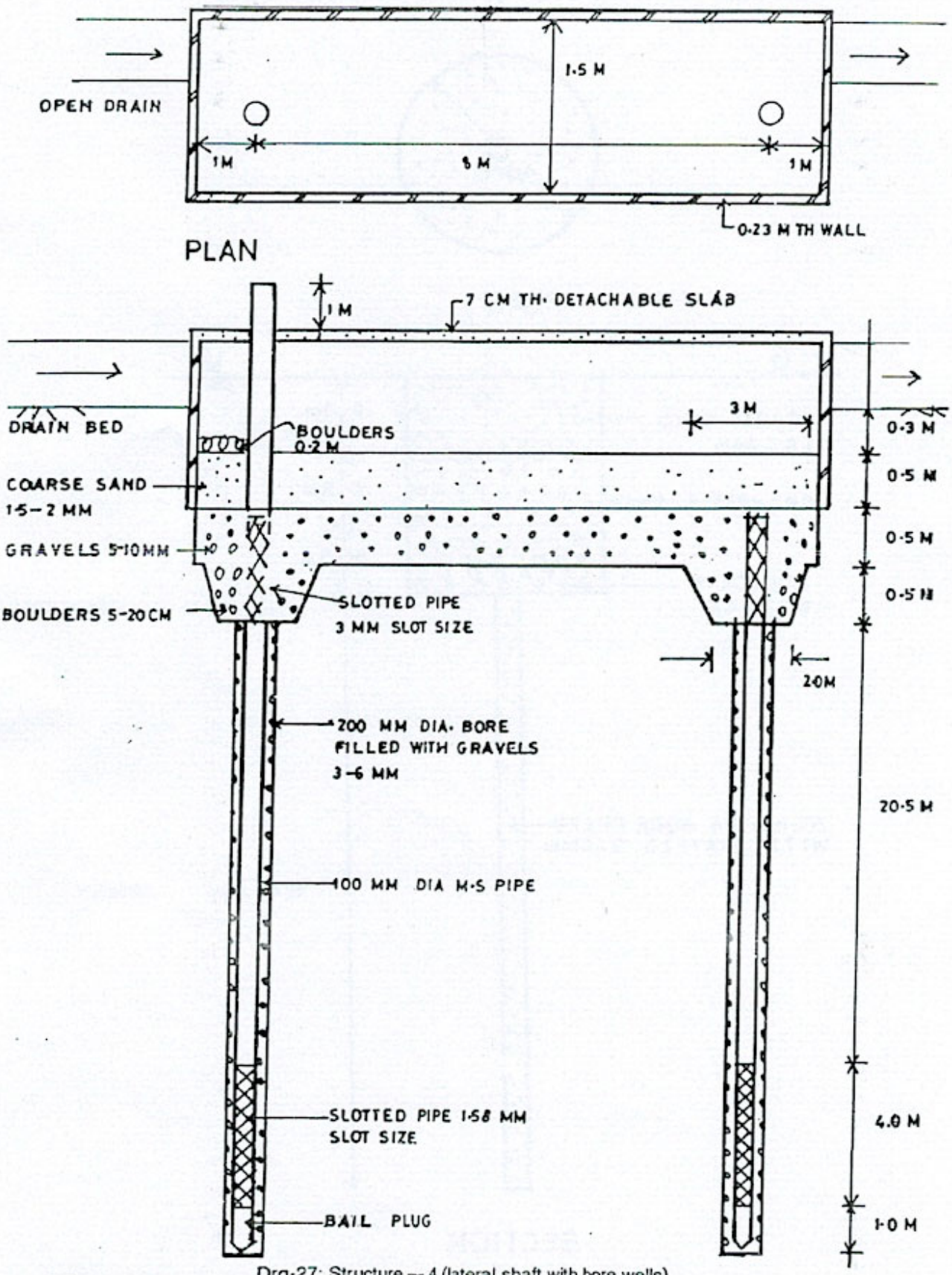
Drg-24: Structure - 1 (recharge pit with bore)



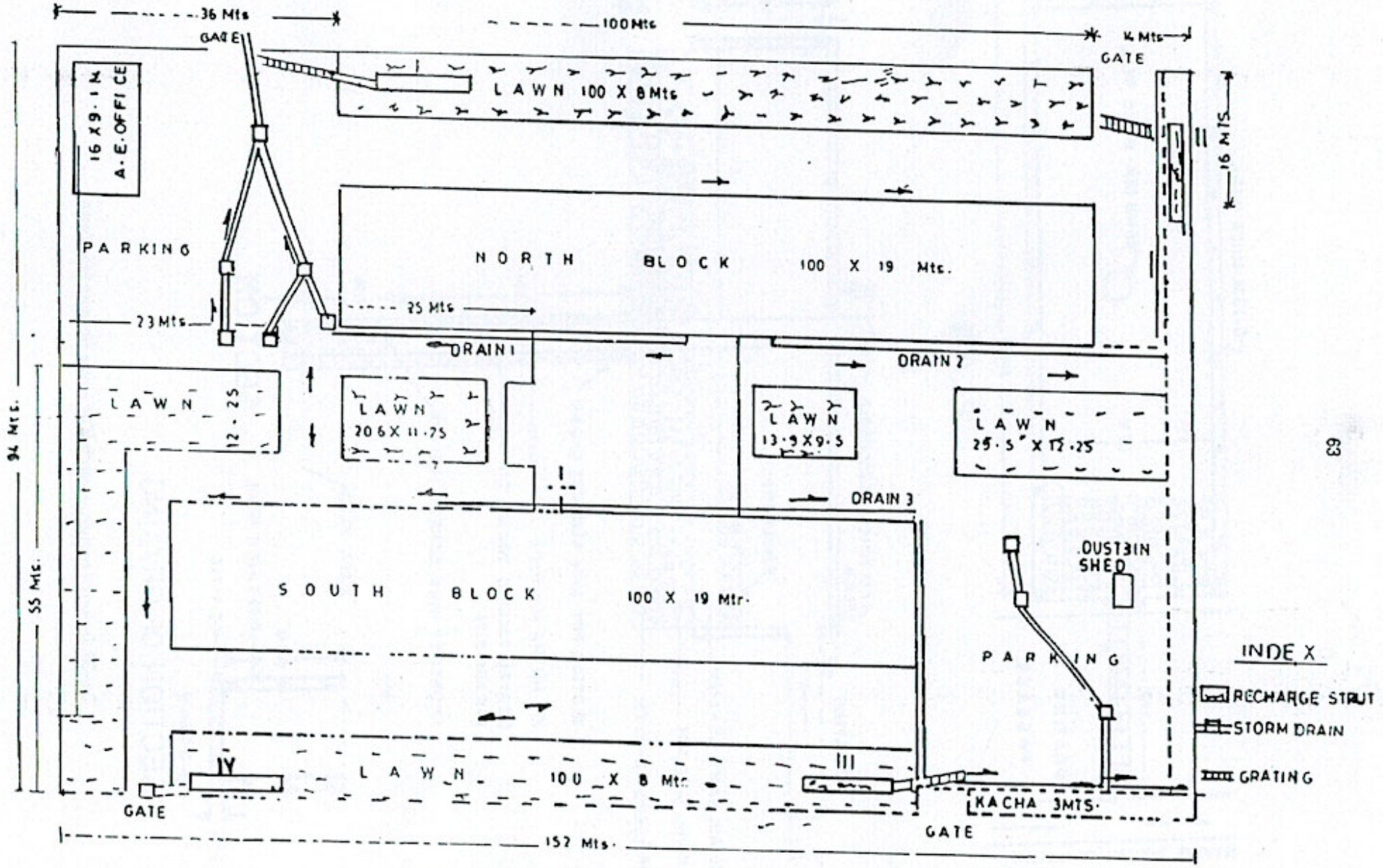
Drg-25: Structure-2 (recharge pit with bore)



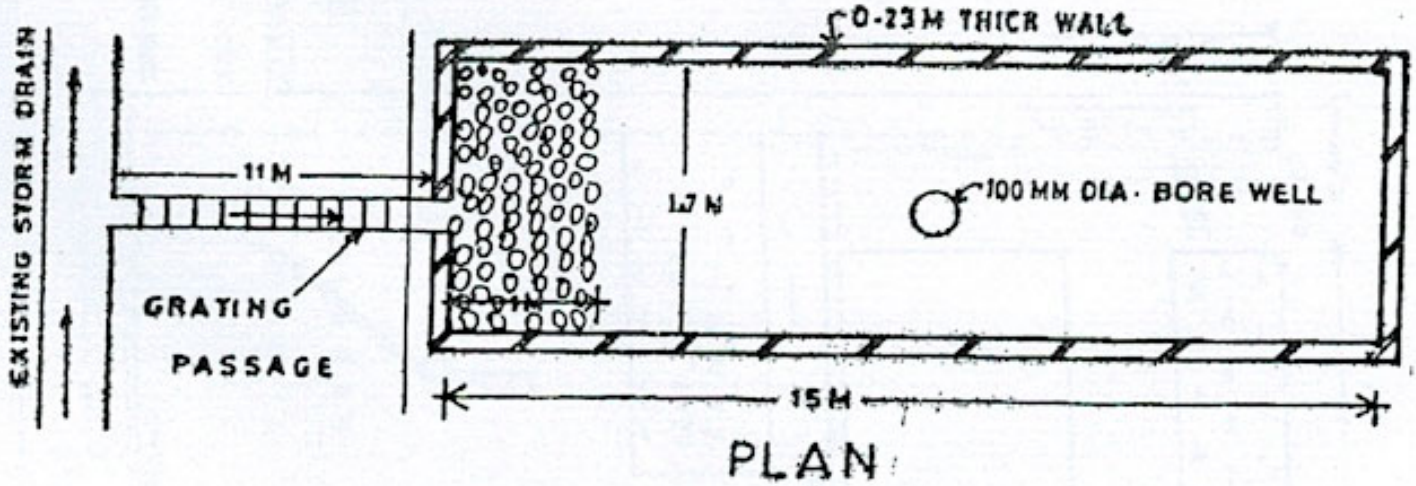
Drg-26: Structure — 3 (recharge pit with bore)



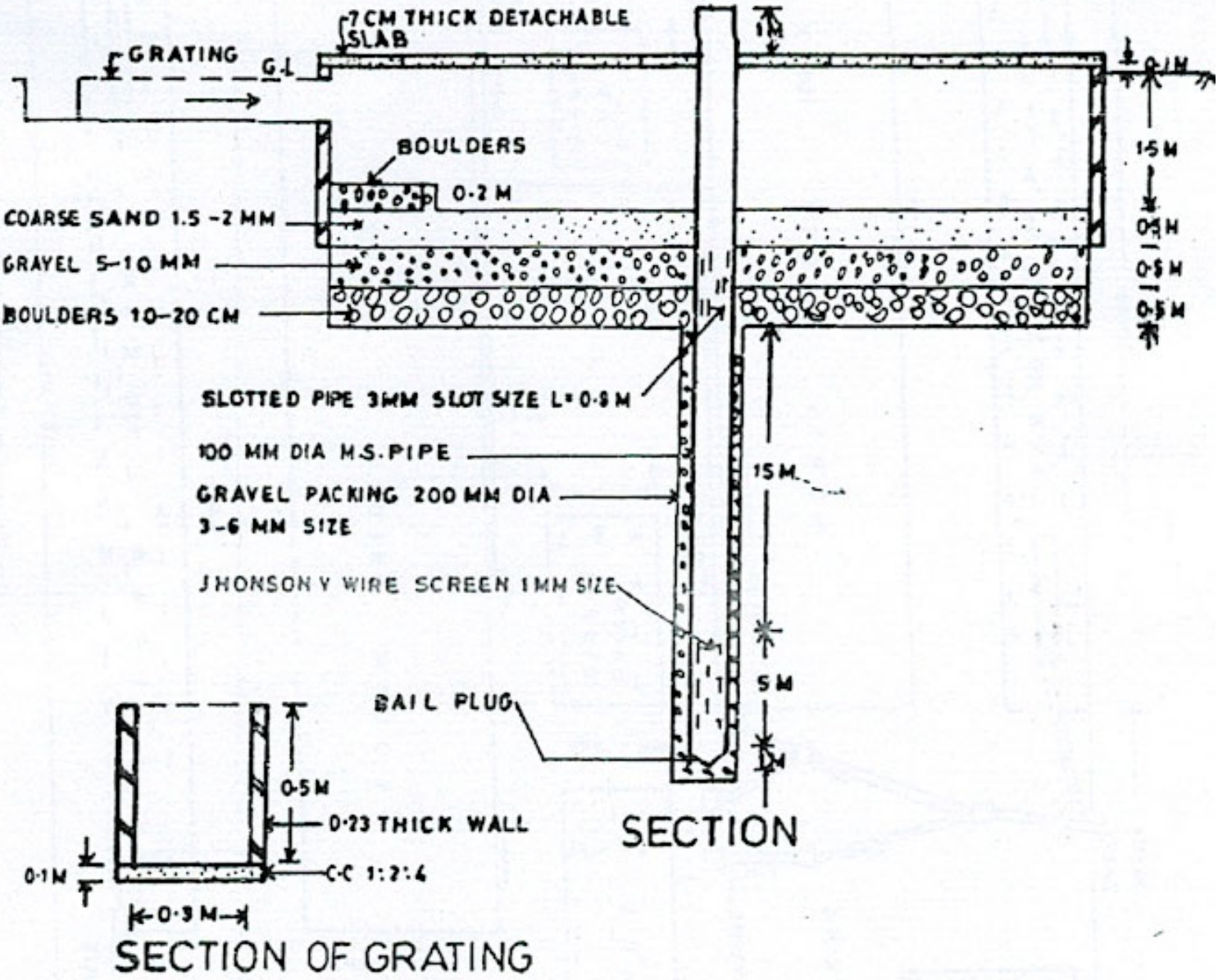
Drg-27: Structure — 4 (lateral shaft with bore wells)



Drg-28: Location of recharge structuers at sewa bhawan R.K. Puram



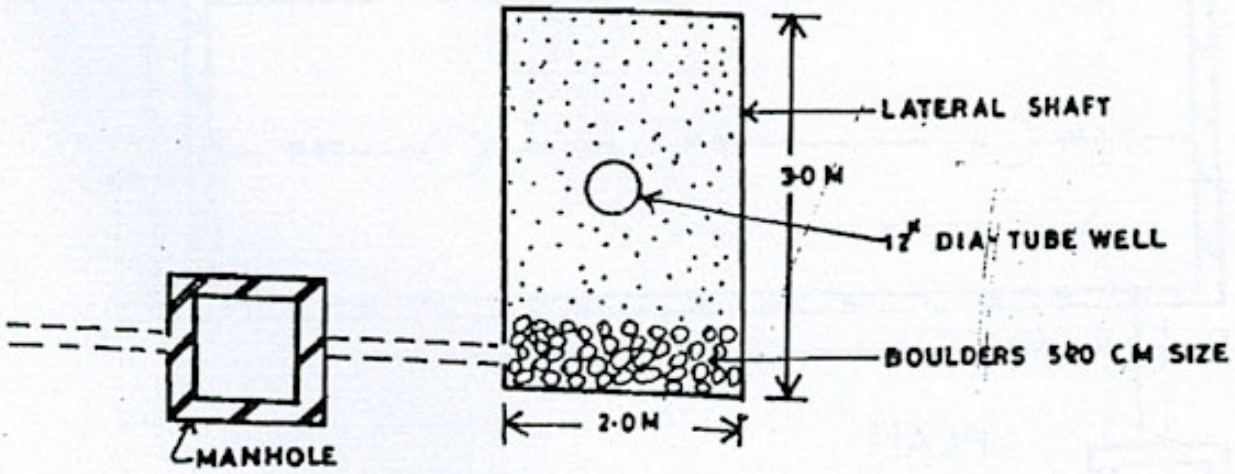
PLAN



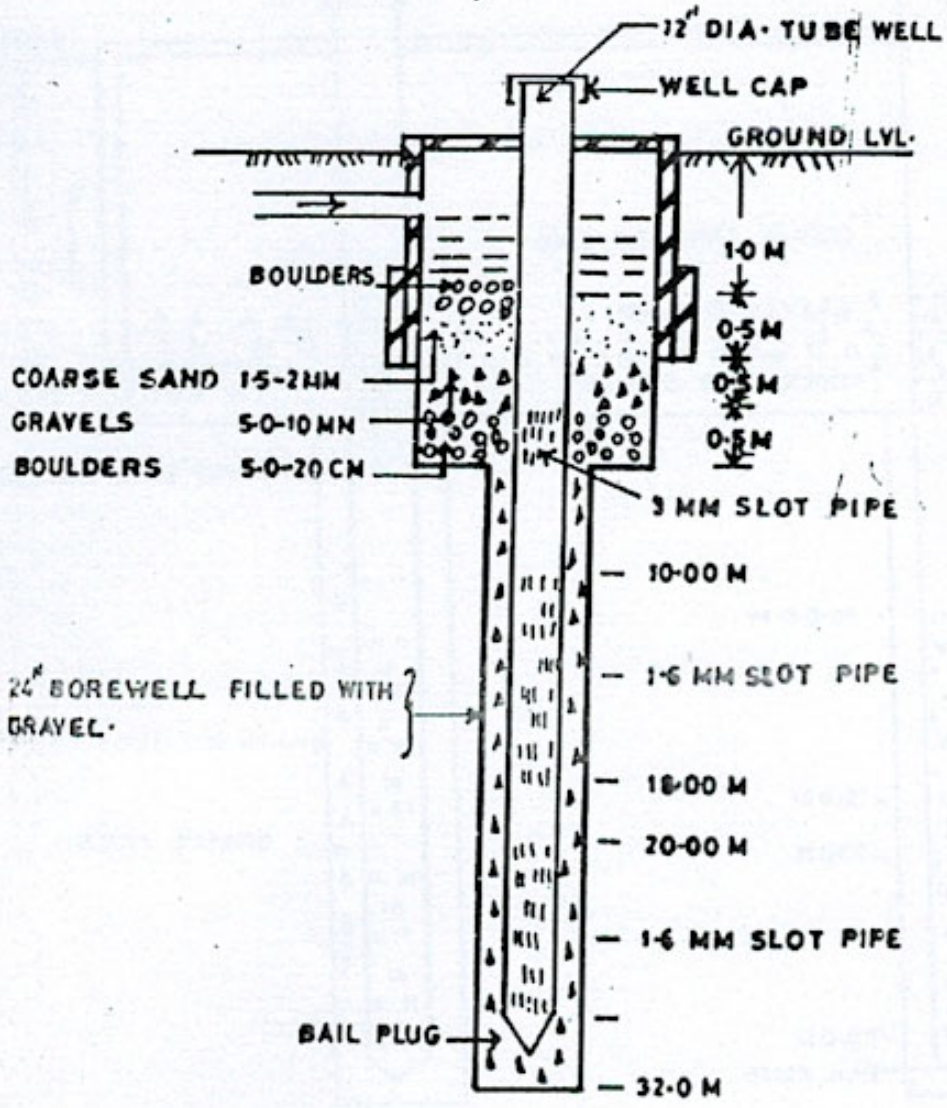
SECTION

SECTION OF GRATING

Drg-29: Design of recharge trench 1. (at sewa bhawan New Delhi)

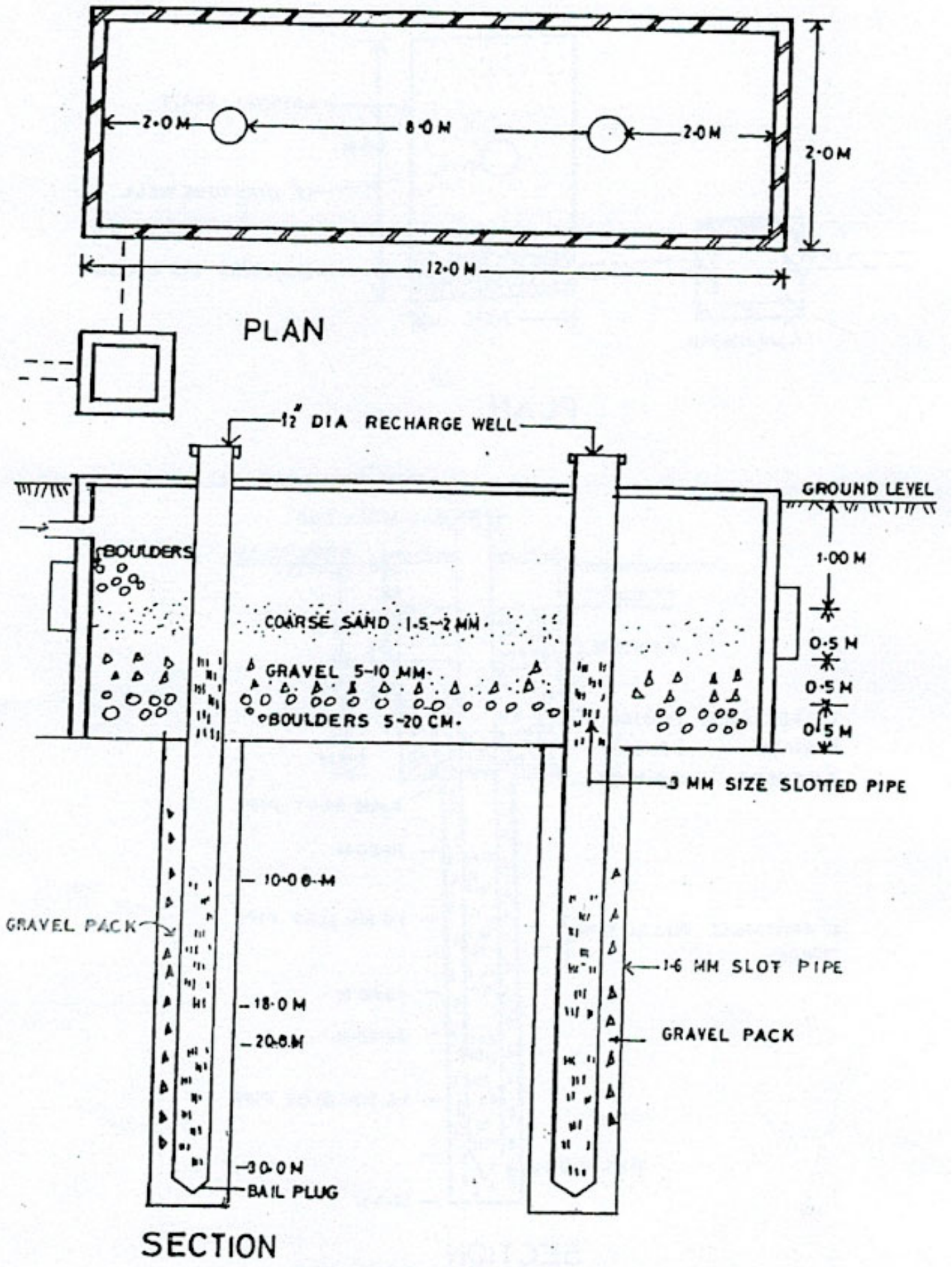


PLAN

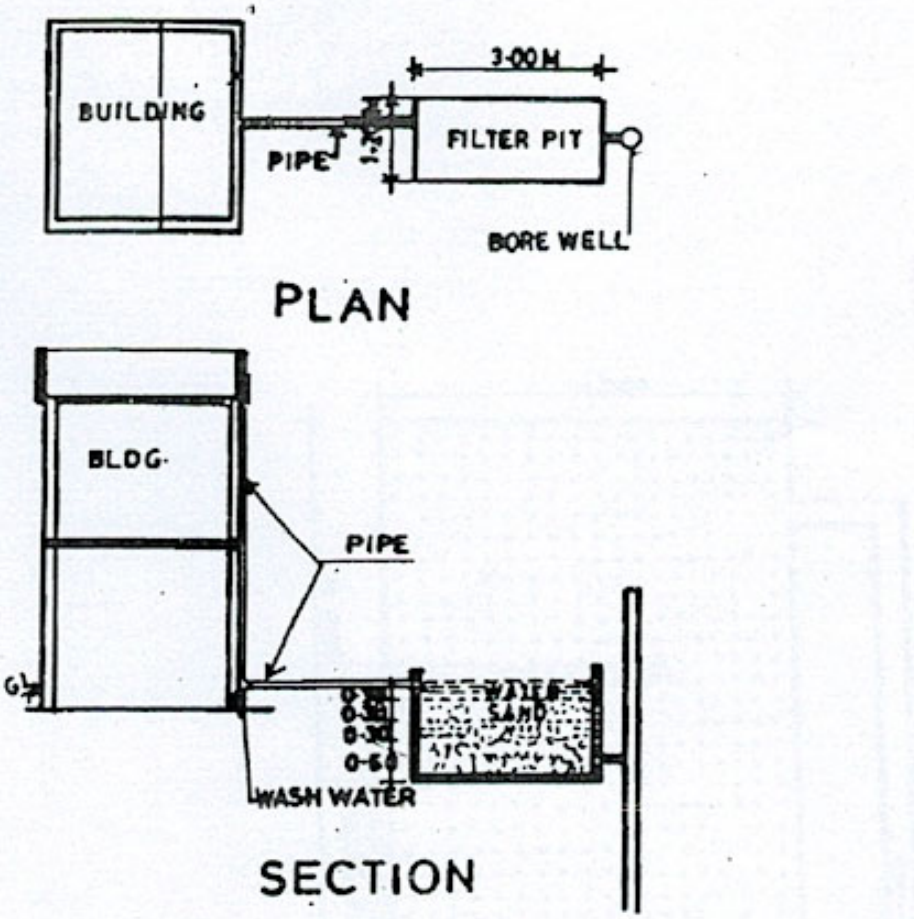


SECTION

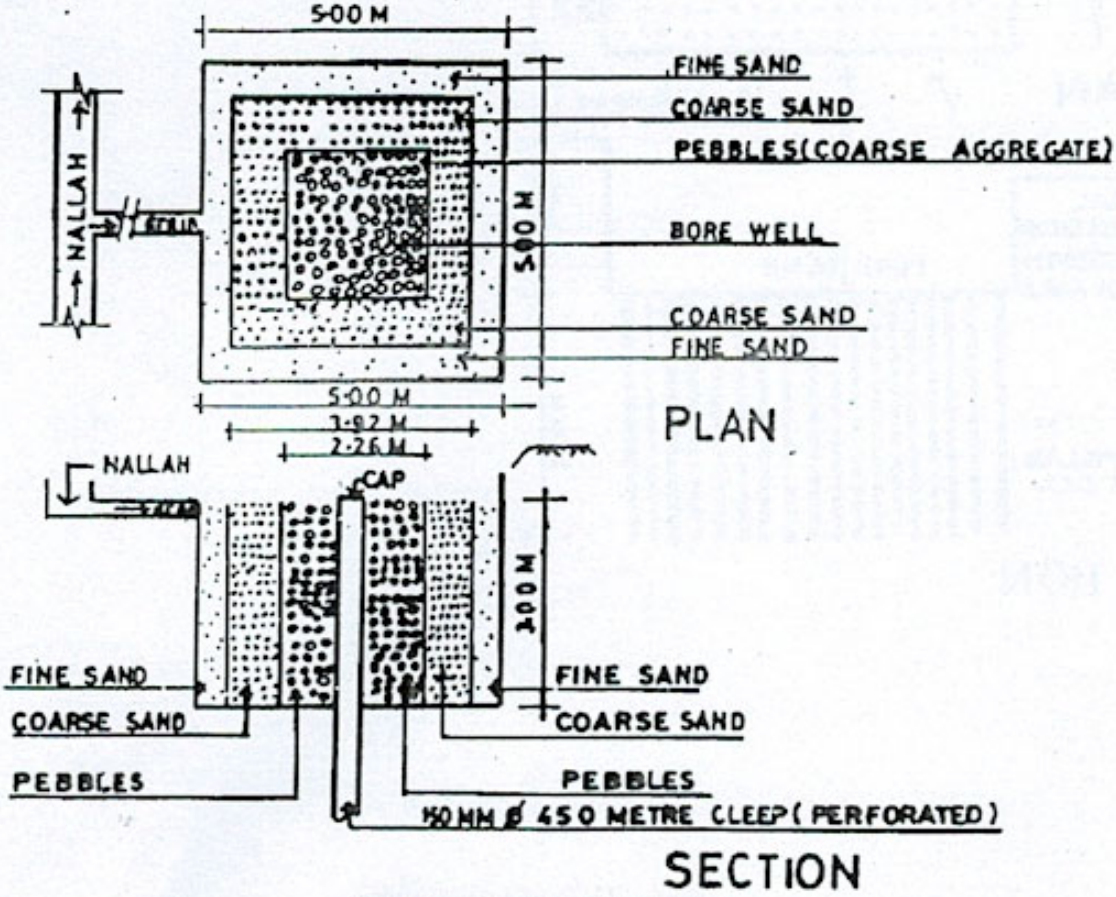
Drg-26: Design of lateral shaft 1,2,4,5&6



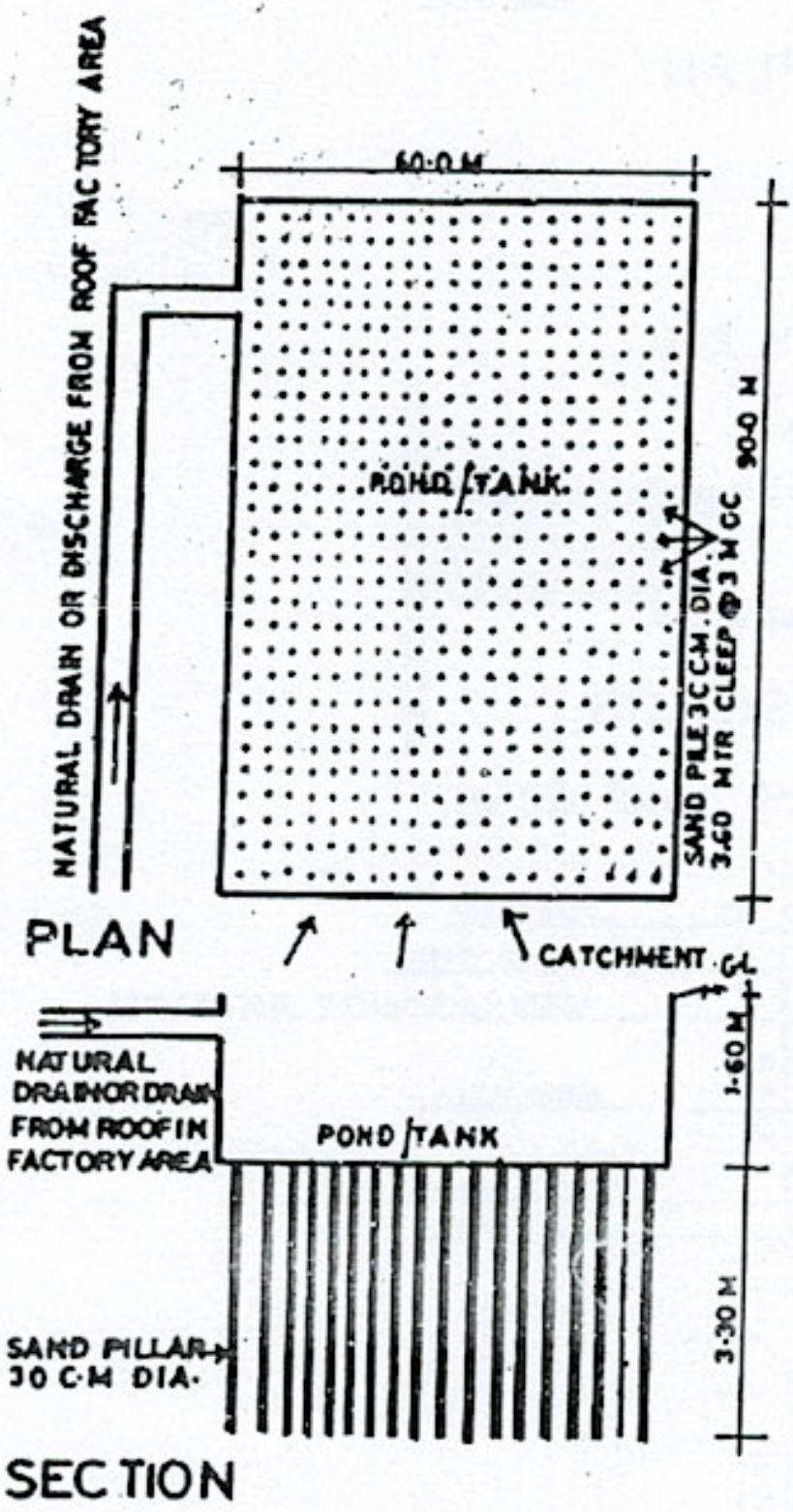
Drg-31: Design of lateral shaft 3 & 7



Harvesting of Roof Water



Drg-32: Drain water harvesting



Drg-33: Drain water harvesting with ponds/tanks

Concise

CPWD MANUAL

ON

RAIN WATER HARVESTING

RAIN WATER HARVESTING

0.0 Introduction

Rainwater harvesting is a technique recognized to conserve naturally available pure water through rainfall. In view of scarcity of potable water largely seen in most of the Metropolitan towns and also in areas not frequented by adequate rainfall, a necessity has been felt by the Govt of India to conserve natural water resource by this technique. Accordingly Central Govt has issued modifications in Unified Building Byelaws 1983 vide notification issued vide no 11001 1/9/93-DDV (Pt) DDIB dated 28.7.2001 (Annexure) making Rainwater Harvesting mandatory for buildings on plot size of 100 sqm. and above.

1.0 Definition

Rainwater harvesting is a system to

- Recharge the acquifer by rainwater through an artificial system at a rate more than that obtained under conditions of natural replenishment and/or
- Collect and store rain water.

2.0 Artificial Recharge of the Aquifer.

2.1 Techniques employed are:

2.1.1 Pits

Recharge pits are constructed for recharging the shallow aquifers. These are constructed 1 to 2 m. wide and 2 to 3 m. deep which are back filled with boulders, gravels and coarse sand.

2.1.2 Trenches

These are constructed when the permeable strata is available at shallow depths. Trench may be 0.5 tol m. wide, 1 to 1.5 m. deep and 10 to 20 m. long depending on the availability of water and the permeability of soil strata. These are back filled with filter materials.

2.1.3 Dug Wells

Existing dug wells may be utilized as recharge structure and water should pass through filter media before putting into dug well.

2.1.4 Hand Pumps

The existing hand pumps may be used for recharging the shallow/deep aquifers, if the availability of water is limited. Water should pass through filter media before diverting it into hand pumps.

2.1.5 Recharge Wells

Recharge wells of 100 to 300 mm. diameter are generally constructed for recharging the deeper aquifers and water is passed through filter media to avoid choking of recharge wells.

2.1.6 Recharge Shafts

For recharging the shallow aquifers, which are located below clayey surface, recharge shafts of 0.5 to 3 m. diameter and 10 to 15 m. deep are constructed and back filed with boulders, gravels & coarse sand.

2.1.7 Lateral Shafts With Bore Wells

For recharging the upper as well as deeper aquifers lateral shafts of 1.5 to 2 m. wide & 10 to 30m. long depending upon availability of water with one or two bore wells are constructed. The lateral shafts are back filled with boulders, gravels & coarse sand.

2.1.8 Spreading

When permeable strata starts from top then this technique is used. Spread the water in streams/Nalas by making check dams, nala bunds, cement plugs, gabion structures or a percolation pond may be constructed.

3.0 Collect and Store Rain Water

Underground or Surface storage tank connected to the roof top or similar water collection system with piping and storage pit through graded filter and charcoal. The under ground or surface water storage tank, to store treated rainwater, could also be connected with the water supply and distribution system as an alternative source of supply.

4.0 Criteria Necessitating Rain Water Harvesting

4.1 Artificial Recharge of the Aquifer.

Under any one or more of the following conditions, rain water harvesting by artificial recharge can be resorted to:

4.1.1 Ground water table is continuously getting lowered in identical months of the year when compared with past.

4.1.2 The source of supply is ground water drawn from tube wells or dug wells.

4.1.3 Quality of ground water is poor and it needs to be improved by artificial recharge. This is also necessary where possibility of intrusion of saline water is there, as is the case in coastal regions.

4.1.4 Permeable acquifer is available at shallow to moderate depth.

4.1.5 Depth of ground water table from the natural ground level from structural considerations is more than

a. 3 metres in case of load bearing construction,
b. 5 metres in case of framed construction with single basement
c. 8 metres in case of framed constructions with double basement

4.1.6 Sufficient depth of ground water table (more than 8 metres) for sub surface storage is available.

4.1.7 Where rate of evaporation is very high as is the case in dry and arid areas.

4.1.8 Adequate space for surface storage is not available, which is more common in urban areas.

4.2 Collect and store rain water:

Under the following circumstances, the rainwater could be collected and stored for future use.

4.2.1 Depth of ground water table is very deep.

4.2.2 Quality of ground water is very poor and unfit for human consumption. Simultaneously, it is also assessed that recharge to the ground water reservoir is not likely to improve its quality due to the nature of sub soil strata.

4.2.3 Annual rainfall is far lower than the requirement of water for human consumption.

4.2.4 Enough roof top area or clean water collection system is available.

4.2.5 Sufficient rainwater storage capacity that could be provided either in the form of impervious surface or underground tank or ground surface storage system in the form of impervious check-dams, ponds, etc

5.0 Data for Design of Artificial Recharge of the Aquifer

Following data is generally essentially required for design of system of artificial recharge of the aquifer.

i. Average annual rainfall
ii. Average monsoon rainfall.
iii. Period of monsoon.
iv. Maximum hourly rate of rainfall
v. Bore log of sub soil with soil properties at least up to the lowest ground water table.
vi. The depth of ground water level during the leanest season.
vii. Possible recharge structure types, as stated in para 3.0 above, that could be provided.
viii. Contoured lay out plan of the area.
ix. Chemical analysis of available ground water during leanest season.

6.0 Design of Artificial Recharge of the Acquifer

The rain water harvesting system by artificial recharge of the aquifer shall be designed based on design data given in para 5.0 above and other considerations discussed herein above. The design shall be carried out considering that the system shall recharge the ground water without further contamination due to impurities and dissolved chemicals, if any, due to sources other than from rain.

MANUAL - 3

भारतीय मानक

छतों पर वर्षा जल संग्रहण — मार्गदर्शी सिद्धान्त

Indian Standard

ROOF TOP RAINWATER HARVESTING — GUIDELINES

ICS 13.060.10

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

May 2008

Price Group 7

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Ground Water and Related Investigations Sectional Committee had been approved by the Water Resources Division Council.

Rainwater harvesting is an option which has been adopted in many parts of the world where due to increase in population conventional water supply system has failed to meet the needs of the people. The term 'Water Harvesting' connotes collection and storage of rainwater and also other activities aimed at harvesting surface water, prevention of loss through evaporation and seepage.

Natural recharge to ground water has reduced due to shrinkage of open area consequent to increased urban activities. Ground water levels have registered a marked decline, unplanned disposal of waste has resulted in deterioration of ground water quality. In view of the gap between demand and supply there is an utmost need for adopting roof top rainwater harvesting and augmenting ground water storage.

The composition of the Committee responsible for the formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ROOF TOP RAINWATER HARVESTING — GUIDELINES

1 SCOPE

This standard lays down guidelines for roof top rainwater harvesting.

2 REFERENCE

The following standard contains provision, which through reference in this text constitutes provision of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard given below:

IS No.	*Title*
14476 (Part 6) : 1998	Test pumping of water wells — Code of practice: Part 6 Special tests

3 GENERAL

Roof top rainwater collection is one of the solutions for solving or reducing the problem of water availability, where there is inadequate ground water supply and surface sources are either lacking or insignificant. In this system, rainwater falling on roofs of houses and other buildings is collected through a system of pipes and semi-circular channels of galvanized iron or PVC and stored in tanks suitably located on the ground or underground for direct use or for recharging ground water aquifers. Urban housing complexes/residential buildings and institutional buildings have large roof area and are amendable for rainwater harvesting. This practice is in vogue at the individual household level in remote hilly areas with high rainfall and in some semi-arid areas in the plains.

4 ADVANTAGES OF ROOF TOP RAINWATER HARVESTING

a) One of the appropriate options for augmenting ground water recharge/storage in urban areas, where natural recharge has been considerably reduced due to increased urban activities and not much land is available for implementing any other artificial recharge measure. In rural areas also, roof top rainwater harvesting can supplement the domestic requirements.

b) Rainwater runoff, which otherwise flows through sewers and storm drains and is wasted, can be harvested and utilized.

c) Helps in reducing the frequent drainage congestion in urban areas where fast rate of urbanization has reduced availability of open surfaces.

d) Recharging of aquifers with harvested water improves the quality of ground water through dilution.

e) The harnessed rainwater can be utilized when needed at the time and place of scarcity.

f) The structures required for harvesting are simple, economical and Eco-friendly.

g) In coastal areas over extraction of ground water leads to saline water ingress. Therefore, recharging of ground water aquifer in such areas helps to control saline water ingress.

h) Storing of harvested water under ground through aquifer recharge, wherever feasible, is advantageous as such storage is not exposed to evaporation and pollution. Aquifers serve as a distribution system as well supplying water when required.

5 FACTORS DETERMINING TYPE/SYSTEM OF RAINWATER HARVESTING

5.0 There are many factors that determine the total quantity of rainwater that can be harvested in a particular area and the system that would be appropriate for efficiently harvesting this quantity. Some of these are given in **5.1** to **5.5**.

5.1 Rainfall Quantity

The total volume of rainwater available from any roof top surface is a product of total rainfall and the surface area of collection. A runoff coefficient is usually applied to account for infiltration, evaporation and other losses and it varies from 0.8 to 0.95. In order to estimate the average annual/monsoon runoff from rooftop area in any location, the average annual/monsoon rainfall data for the location need to be used and using Tables 1 and 2, the water availability for flat and sloping roof can be worked out.

5.2 Rainfall Pattern

Rainfall pattern as well as total rainfall, will often determine the feasibility of a rainwater harvesting system. In areas where rainfall occurs regularly in most parts throughout the year, implies that the storage requirement is low and hence the system cost will be

Table 1 Water Availability for a Given Roof Top Area and Rainfall (For Flat Roofs)
(*Clause* 5.1)

Sl No.	Roof Top Area m^2	Rainfall, mm												
		100	200	300	400	500	600	800	1 000	1 200	1 400	1 600	1 800	2 000
		Water availability (m^3)												
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
i)	20	1.6	3.2	4.8	6.4	8	9.6	12.8	16	19.2	22.4	25.6	28.8	32
ii)	30	2.4	4.8	7.2	9.6	12	14.4	19.2	24	28.8	33.6	38.4	43.2	48
iii)	40	3.2	6.4	9.6	12.8	16	19.2	25.6	32	38.4	44.8	51.2	57.6	64
iv)	50	4	8	12	16	20	24	32	40	48	56	64	72	80
v)	60	4.8	9.6	14.4	19.2	24	28.8	38.4	48	57.6	67.2	76.8	86.4	96
vi)	70	5.6	11.2	16.8	22.4	28	33.6	44.8	56	67.2	78.4	89.6	100.8	112
vii)	80	6.4	12.8	19.2	25.6	32	38.4	51.2	64	76.8	89.6	102.4	115.2	128
viii)	90	7.2	14.4	21.6	28.8	36	43.2	57.6	72	86.4	100.8	115.2	129.6	144
ix)	100	8	16	24	32	40	48	64	80	96	112	128	144	160
x)	150	12	24	36	48	60	72	96	120	144	168	192	216	240
xi)	200	16	32	48	64	80	96	128	160	192	224	256	288	320
xii)	250	20	40	60	80	100	120	160	200	240	280	320	360	400
xiii)	300	24	48	72	96	120	144	192	240	288	336	384	432	480
xiv)	400	32	64	96	128	160	192	256	320	384	448	512	576	640
xv)	500	40	80	120	160	200	240	320	400	480	560	640	720	800
xvi)	1 000	80	160	240	320	400	480	640	800	960	1 120	1 280	1 440	1 600
xvii)	2 000	160	320	480	640	800	960	1 280	1 600	1 920	2 240	2 560	2 880	3 200
xviii)	3 000	240	480	720	960	1 200	1 440	1 920	2 400	2 880	3 360	3 840	4 320	4 800

Table 2 Water Availability for a Given Roof Top Area and Rainfall (For Sloping Roofs)
(*Clause* 5.1)

Sl No.	Roof Top Area m^2	Rainfall, mm												
		100	200	300	400	500	600	800	1 000	1 200	1 400	1 600	1 800	2 000
		Water availability (m^3)												
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
i)	20	1.9	3.8	5.7	7.6	9.5	11.4	15.2	19	22.8	26.6	30.4	34.2	38
ii)	30	2.9	5.7	8.6	11.4	14.3	17.1	22.8	28.5	34.2	39.9	45.6	51.3	57
iii)	40	3.8	7.6	11.4	15.2	19	22.8	30.4	38	45.6	53.2	60.8	68.4	76
iv)	50	4.8	9.5	14.3	19	23.8	28.5	38	47.5	57	66.5	76	85.5	95
v)	60	5.7	11.4	17.1	22.8	28.5	34.2	45.6	57	68.4	79.8	91.2	102.6	114
vi)	70	6.7	13.3	20.0	26.6	33.3	39.9	53.2	66.5	79.8	93.1	106.4	119.7	133
vii)	80	7.6	15.2	22.8	30.4	38	45.6	60.8	76	91.2	106.4	121.6	136.8	152
viii)	90	8.6	17.1	25.7	34.2	42.8	51.3	68.4	85.5	102.6	119.7	136.8	153.9	171
ix)	100	9.5	19	28.5	38	47.5	57	76	95	114	133	152	171	190
x)	150	14.3	28.5	42.8	57	71.3	85.5	114	142.5	171	199.5	228	256.5	285
xi)	200	19	38	57	76	95	114	152	190	228	266	304	342	380
xii)	250	23.8	47.5	71.3	95	118.8	142.5	190	237.5	285	332.5	380	427.5	475
xiii)	300	28.5	57	85.5	114	142.5	171	228	285	342	399	456	513	570
xiv)	400	38	76	114	152	190	228	304	380	456	532	608	684	760
xv)	500	47.5	95	143	190	237.5	285	380	475	570	665	760	855	950
xvi)	1 000	95	190	285	380	475	570	760	950	1 140	1 330	1 520	1 710	1 900
xvii)	2 000	190	380	570	760	950	1 140	1 520	1 900	2 280	2 660	3 040	3 420	3 800
xviii)	3 000	285	570	855	1 140	1 425	1 710	2 280	2 850	3 420	3 990	4 560	5 130	5 700

correspondingly low and *vice versa*. Conversely, areas where total rainfall occurs during 1-2 months, the water collected during the monsoon has to be stored for use in remaining months throughout the year, which requires large storage structures as well as arrangement for some treatment.

5.3 Intensity of Rainfall

The maximum intensity of rainfall will decide the peak flow, which is to be harvested and depending upon the peak flow, the gutter size for sloping roof and diameter of drainage pipe has to be calculated.

5.4 Collection Surface Area

For roof top rainwater harvesting, the collection area is restricted by the size of the roof of the dwelling unit. Sometimes other surfaces such as terrace, balconies and other projections are used to supplement the roof top collection area.

5.5 Storage Capacity

The storage tank is usually the most expensive component of rainwater harvesting system. Hence a careful analysis is required for design of storage tank capacity.

6 STORAGE OF WATER IN A STORAGE TANK FOR DIRECT USE

6.1 Design of System Components

A roof top catchment system has three main components, namely, a roof, a guttering and first flush device and a storage tank:

a) *Roof* — In this system, only roof top is the catchment as shown in Fig. 1 and Fig. 2. The roofing should be of galvanized iron sheets (G.I.), aluminium, clay tiles, asbestos or concrete. In case of thatch-roof, it may be covered with waterproof LDPE sheeting. The roof should be smooth, made of non-toxic material sufficiently large to fill the tank with the available rainfall conditions. Existing roofs of houses and public buildings can be used for a roof top catchment system. In some cases enlarged or additional roofed structures can be built.

b) *Guttering and First-Flush Device* — Guttering is intended to protect the building by collecting the water running of the roof and direct it, via a downpipe, to the storage tank. Gutter is provided along the edge of the roof. It is fixed with a gentle slope towards down-pipe, which is meant for free flow of water to the storage tank. This may be made up of G.I. sheet, wood, bamboo or any other locally available material. The downpipe used should be at least 100 mm diameter and be provided with a 20 mesh wire screen at the inlet to prevent dry leaves and other debris from entering it. The gutter size may be worked out using any standard formula of hydraulics or using Table 3.

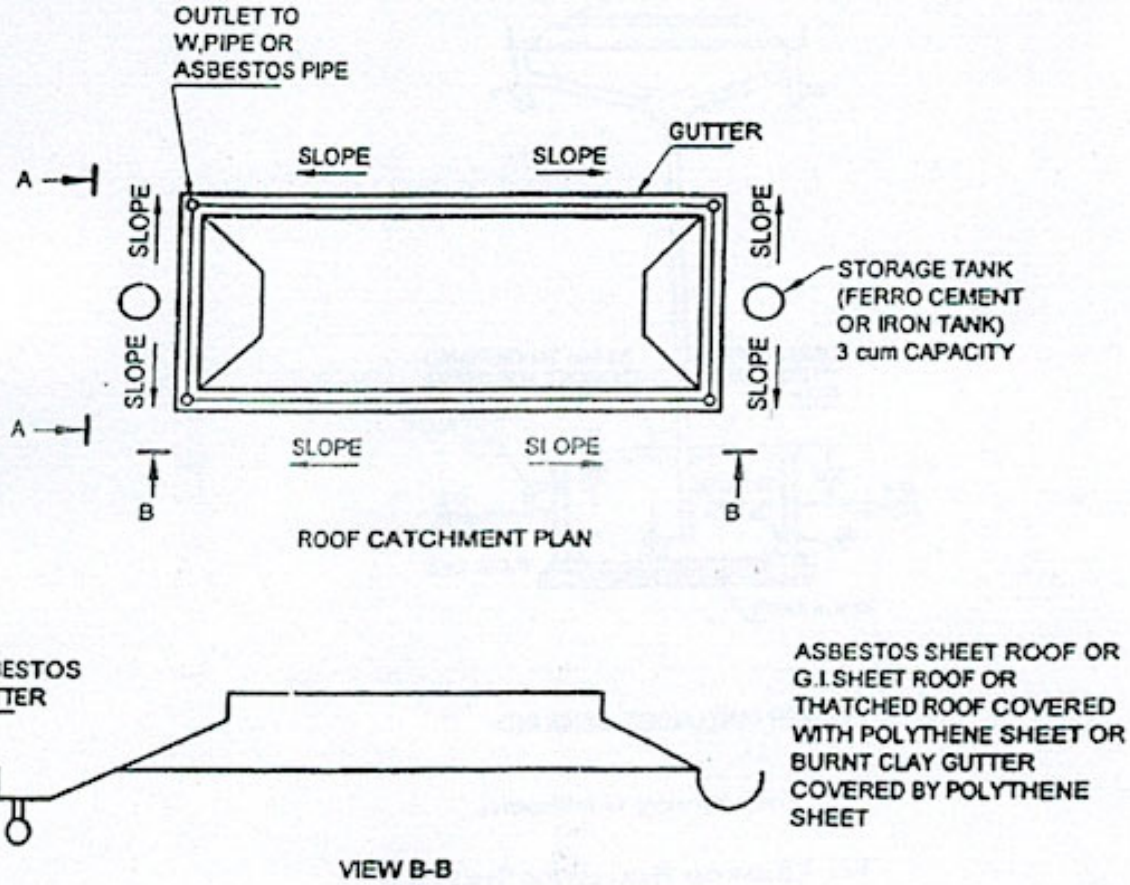


FIG. 1 RAINWATER HARVESTING SYSTEM

Table 3 Diameter of Gutter and Width of G.I. Sheet

[*Clause* 6.1(b)]

Sl No.	Roof Top Area		Rainfall Intensity, mm h													
			10	15	20	25	30	35	40	45	50	60	70	80	90	100
			Diameter (*D*) of Channel and Width (*W*) of G.I. Sheet (mm)													
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
i)	10	*D*	20	23	26	28	30	32	33	35	36	39	41	43	45	47
		W	51	56	60	64	67	70	72	74	77	81	84	88	91	93
ii)	20	*D*	26	30	33	36	39	41	43	45	47	50	53	56	58	61
		W	60	67	72	77	81	84	88	91	93	99	103	108	112	115
iii)	30	*D*	30	35	39	42	45	48	50	52	54	58	62	65	68	71
		W	67	74	81	86	91	95	99	102	106	112	117	122	127	131
iv)	40	*D*	33	39	43	47	50	53	56	58	61	65	69	72	76	79
		W	72	81	88	93	99	103	108	112	115	122	128	134	139	144
v)	50	*D*	36	42	47	51	54	58	61	63	66	71	75	79	82	86
		W	77	86	93	100	106	111	115	120	124	131	138	144	149	154
vi)	60	*D*	39	45	50	54	58	62	65	68	71	76	80	84	88	92
		W	81	91	99	106	112	117	122	127	131	139	146	152	158	164
vii)	70	*D*	41	48	53	58	62	65	69	72	75	80	85	89	93	97
		W	84	95	103	111	117	123	128	133	138	146	153	160	167	172
viii)	80	*D*	43	50	56	61	65	69	72	76	79	84	89	94	98	102
		W	88	99	108	115	122	128	134	139	144	152	160	167	174	180
ix)	90	*D*	45	52	58	63	68	72	76	79	82	88	93	98	102	107
		W	91	102	112	120	127	133	139	144	149	158	167	174	181	188
x)	100	*D*	47	54	61	66	71	75	79	82	86	92	97	102	107	111
		W	93	106	115	124	131	138	144	149	154	164	172	180	188	194
xi)	150	*D*	54	63	71	77	82	87	92	96	100	107	113	119	124	129
		W	106	120	131	141	149	157	164	170	176	188	197	207	215	223
xii)	200	*D*	61	71	79	86	92	97	102	107	111	119	126	132	138	144
		W	115	131	144	154	164	172	180	188	194	207	218	228	237	246
xiii)	250	*D*	66	77	86	93	100	105	111	116	121	129	137	144	150	156
		W	124	141	154	166	176	186	194	202	209	223	235	246	256	266
xiv)	300	*D*	71	82	92	100	107	113	119	124	129	138	146	154	161	167
		W	131	149	164	176	188	197	207	215	223	237	250	262	273	283
xv)	400	*D*	79	92	102	111	119	126	132	138	144	154	163	172	179	186
		W	144	164	180	194	207	218	228	237	246	262	276	290	302	313
xvi)	500	*D*	86	100	111	121	129	137	144	150	156	167	177	186	195	203
		W	154	176	194	209	223	235	246	256	266	283	299	313	326	339
xvii)	1 000	*D*	111	129	144	156	167	177	186	195	203	217	230	242	253	263
		W	194	223	246	266	283	299	313	326	339	361	381	400	417	433
xvii)	2 000	*D*	144	167	186	203	217	230	242	253	263	282	298	314	328	341
		W	246	283	313	339	361	381	400	417	433	462	489	513	535	556
xviii)	3 000	*D*	167	195	217	236	253	268	282	294	306	328	347	365	382	397
		W	283	326	361	391	417	441	462	482	501	535	566	594	620	644

NOTES

1 Provide minimum diameter of channel of 100 mm and width of sheet 176 mm.
2 Diameter to be limited to 300 mm and width of sheet 510 mm.

For all tanks having roof catchment, the first runoff of rainwater from the roof should be discarded. This helps keep the water potable because this first flush contains large quantities of dust, leaves and other impurities. This can also be prevented by installation of a gate valve at the end of down pipe at ground level.

c) *Tank* — Storage tank can be constructed underground or above ground. The underground tank may be of masonry or R.C.C. structure suitably lined with water proofing materials. The surface tank may be of G.I. Sheet, R.C.C., Plastic/HDP or Ferrocement Tank placed at elevation on a raised platform as shown in Fig. 3. Choice of the tank depends on locally available materials and space available. When the tank is constructed underground, at least 30 cm of the tank should remain above ground. Water

tanks using ferrocement technology come in different designs with volumes ranging between 2 m³ and 200 m³. For example, a free standing cylindrical tank can be built in sizes between 10 m³ and 30 m³, while a capacity of up to 200 m³ is possible with sub-surface covered tanks. The latter is economical when the capacity exceeds 50 m³.

An alternate design, avoiding framework, involves erecting a circular frame made of welded-mesh bars spaced at 15 cm and covered with chicken wire mesh (2.5 cm gauge) onto a reinforced concrete base. This is then covered on the outside with sacks or cloth and two coats of a 1.5 cm layer of mortar (1 part cement, 3 parts sand) and plastered along the inner walls to produce the tank wall. Two further coats of plaster are added, one on the outside after removing the sacks and one on the inside to provide a tank wall thickness of 5 cm. A waterproof coat of cement and water is then added to the tank's inner wall.

When the wall is complete, a wooden frame is constructed inside the tank to support the metal template made from old oil drums, which forms the mould for the domed roof. The roof is also reinforced with welded-mesh and chicken wire. For quality, the floor, walls and the roof need to be cured by moistening their surface for at least a week. This should start immediately after each component is ready.

To facilitate cleaning of the tank, an outlet pipe may be fitted and fixed in the tank at bottom level. The size of the tank will depend upon the factors such as daily demand, duration of dry spell, catchment area and rainfall.

The tank is provided with:

a) A manhole of 0.60 m × 0.60 m size with cover,
b) Vent pipe/overflow pipe of 100 mm diameter, and
c) Drain pipe of 100 mm diameter at bottom.

The withdrawal of water from the underground tank is

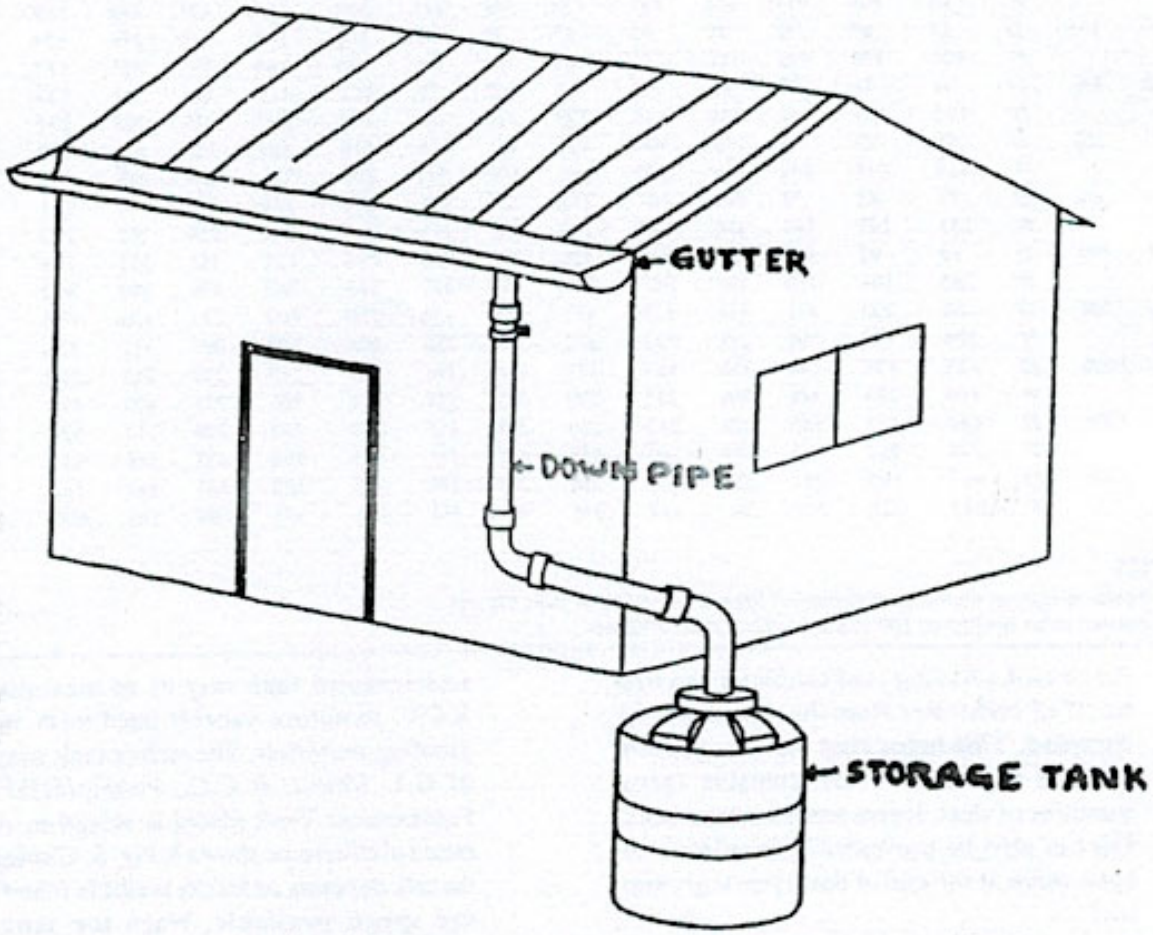


FIG. 3 STORAGE OF RAINWATER IN A HDPE TANK

done by installing a hand pump . In case of surface tank, taps may be provided. The overflow pipe should be connected to a drain/recharge pit.

Before the tank is put into use it should be thoroughly cleaned and disinfected with high dosage of chlorine. Since the water should remain stored for quite a long time, periodical disinfection of stored water is essential to prevent growth of pathogenic bacteria.

6.2 Site Assessment

Assessing the site conditions is the first step towards a sound system design. The five main site conditions to be assessed are:

a) Availability of suitable roof catchment,
b) Foundation characteristics of soil near the house,
c) Location of trees,
d) Estimated runoff to be captured per unit area of the roof, and
e) Availability and location of construction material.

6.3 Estimating the Size of the Required System

The size of the catchment area and tank should be enough to supply sufficient water for the users during the dry period. Assuming a full tank at the beginning of the dry season (and knowing the average length of the dry season and the average water use), the volume of the tank can be calculated by the following formula:

$$V = t \times n \times q$$

where

V = volume of tank, in litres;
t = length of the dry season (days);
n = number of people using the tank; and
q = consumption in litres per capita per day.

If, for example, 20 lpd (q) is agreed upon and a dry period of 100 days (t) is normally not exceeded, a storage volume of 10 m^3 would be required for a family of 5 members (n).

$V = 100\ (t) \times 5\ (n) \times 20\ (q) = 10\ 000$ litre or 10 m^3

The required catchment area (that is the area of the roof) can be determined by dividing the volume of the tank by the accumulated average rainfall volume (in litres) per unit area (in m^2) over the preceding wet months and multiplying this with the runoff coefficient, which varies from 0.8 to 0.95 depending upon type of roof.

6.4 General Design Features

Roof top water harvesting systems can provide good quality potable water, if the design features outlined below are taken into account:

a) The substances that go into the making of the roof should be non-toxic and chemically inert.
b) Roof surfaces should be smooth, hard and dense since they are easier to clean and are less likely to be damaged and release materials/fibres into the water.
c) Roof painting is not advisable since most paints contain toxic substances and may peel off.
d) No overhanging trees should be left near the roof.
e) Nesting of birds on the roof should be prevented.
f) All gutter ends should be fitted with a wire mesh screen to keep out leaves, etc.
g) Appropriate arrangement for discarding the first flow of rainfall should be made.
h) A hygienic soak away channel should be built at water outlets and a screened overflow pipe should be provided.
j) The storage tank should have a tight fitting roof that excludes light, a manhole cover and a flushing pipe at the base of the tank (for standing tanks).
k) There should be a reliable sanitary extraction device such as a gravity tap or a hand pump to avoid contamination of the water in the tank.
m) There should be no possibility of contaminated wastewater flowing into the tank (especially for tanks installed at ground level).
n) Water from other sources, unless it is a reliable source, should not be emptied into the tank through pipe connections or the manhole cover.

6.5 Management and Maintenance

Roof top catchment tanks, like all water supply systems, demand periodic management and maintenance to ensure reliable and quality water supply. If the various components of the system are not regularly cleaned, water use is not properly managed, problems are not identified or necessary repairs not performed, the roof catchment system will cease to provide reliable and good quality water.

Following is a time table of maintenance and management requirements that can provide a basis for monitoring and checking:

a) During the rainy season, the whole system (roof catchment, gutters, pipes, screens, first-

flush and overflow) should be checked before and after each rain and preferably cleaned after every dry period exceeding a month.

b) At the end of the dry season and just before the first shower of rain is anticipated, the storage tank should be scrubbed and flushed of all sediment and debris (the tank should be refilled afterwards with a few centimeters of clean water to prevent cracking). Ensure timely service (before the first rains are due) of all tank fixtures, including replacement of all worn screens and servicing of the outlet tap or hand pump.

6.6 Water Use Management

Control over the quantity of water abstracted from the tank is important to optimize water use. Water use should be managed so that the supply is sufficient to last through the dry season. Failure to do so will mean exhausting all the stored water. On the other hand, underutilization of the water source due to severe rationing should also be avoided.

7 RECHARGE OF HARVESTED RAINWATER INAQUIFERS

7.0 The runoff water collected from roof tops can artificially recharge and augment the depleting ground water resources especially in the urban areas, where the natural recharge has diminished considerably. The areas having depth to water table greater than 8 m below ground level and underlain by permeable strata are suitable for artificial recharge.

7.1 Design of Efficient Artificial Recharge Structures

The design involves consideration of data on hydrological and hydrogeological aspects and hydrometeorological parameters. The background information to be collected is as given below:

a) Layout plan of the area.
b) Demarcation of the roof, paved and open areas.
c) Delineation of storm water drains and flow of storm water.
d) Details of the existing ground water abstraction structures in and around the vicinity of the project site.
e) Computation of the runoff for recharge.

Apart from the above mentioned parameters, selection of appropriate recharge structure depends on the availability of space for construction of recharge structures and invert levels of storm water drains at inlets to recharge structures. While preparing the recharge scheme, depth and shape of the storage facility in recharge structure depends on the availability of runoff, depth of storm water drainage and space availability in an area. The recharge scheme as prepared may also be got vetted by appropriate authorities and experts to incorporate suggestions for improvement.

7.2 Recharge Structures

The most suitable recharge structures for roof top rain water harvesting are:

a) Recharge pits;
b) Recharge trenches;
c) Recharge through dry or operational dugwells;
d) Recharge through abandoned/existing tube wells; and
e) Recharge wells, etc.

7.2.1 *Recharge Pits*

a) In alluvial areas where permeable rocks are exposed on the land surface or at very shallow depth, recharge pits are suitable for artificial recharge of water collected from the roof tops.
b) The technique is suitable for buildings having a roof area of 100 m². The recharge pits are constructed for recharging the shallow aquifers.
c) Recharge pits may be of any shape and size and are generally constructed 1 to 2 m wide and 2 to 3 m deep which are backfilled with boulders (5-20 cm), gravels (5-10 mm), and coarse sand (1.5-2 mm) in graded form — boulders at the bottom, gravels in between and coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of the coarse sand layer and can easily be removed. For smaller roof area, pit may be filled with broken bricks/cobbles.
d) A mesh should be provided at the roof so that leaves or any other solid waste/debris are prevented from entering the pit and a desilting/ collection chamber may also be provided at the ground to arrest the flow of finer particles to the recharge pit.
e) The top layer of sand should be cleaned periodically to maintain the recharge rate.

7.2.2 *Recharge Trenches*

a) Recharge trenches are suitable for buildings having roof area of 200-300 m² and where permeable strata is available at shallow depths.
b) Trench may be 0.5 to 1 m wide, 1 to 1.5 m

deep and 10 to 20 m long depending upon availability of water to be recharged.

c) These are backfilled with boulders (5-20 cm), gravels (5-10 mm), and coarse sand (1.5-2 mm) in graded form — boulders at the bottom, gravel in between and coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of the sand layer and can easily be removed.

d) A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the trench and a desilting/collection chamber may also be provided on ground to arrest the flow of finer particles to the trench.

e) The top layer of sand should be cleaned periodically to maintain the recharge rate.

7.2.3 *Recharge Through Dry or Operational Dug Wells* (*see* Fig. 4)

a) Dry/operational dug wells if exist in the area may be utilized as recharge structures after cleaning and desilting the same.

b) Recharge water is guided through a pipe from desilting chamber to the bottom of the well or below the water level to avoid scouring of bottom and entrapment of air bubbles in the aquifer.

c) Recharge water should be silt-free. For removing the silt content, the runoff water should pass either through a desilting chamber or filter chamber.

d) Periodic chlorination should be done for controlling the bacteriological contamination in operational dug well.

e) Wire mesh filter should be provided just before the inlet to avoid entry of any foreign material, tree leaves, etc, in to the dug well.

7.2.4 *Recharge Through Abandoned/Existing Tube Wells* (*see* Fig. 5 and Fig. 6)

a) Abandoned/existing tube wells may be used as recharge structures.

b) The abandoned tube well should be properly developed before use as recharge structure.

c) PVC pipes of 10 cm diameter are connected to roof drains to collect rainwater.

d) The first roof runoff is drained through the bottom of drain pipe if existing tube well is used as recharge structure. After closing the bottom pipe, the rainwater of subsequent rain showers is taken through a 'Tee' to an online PVC filter in case of small roofs. If the roof area is larger, a filter pit may be provided. Rainwater from roofs is taken to collection/

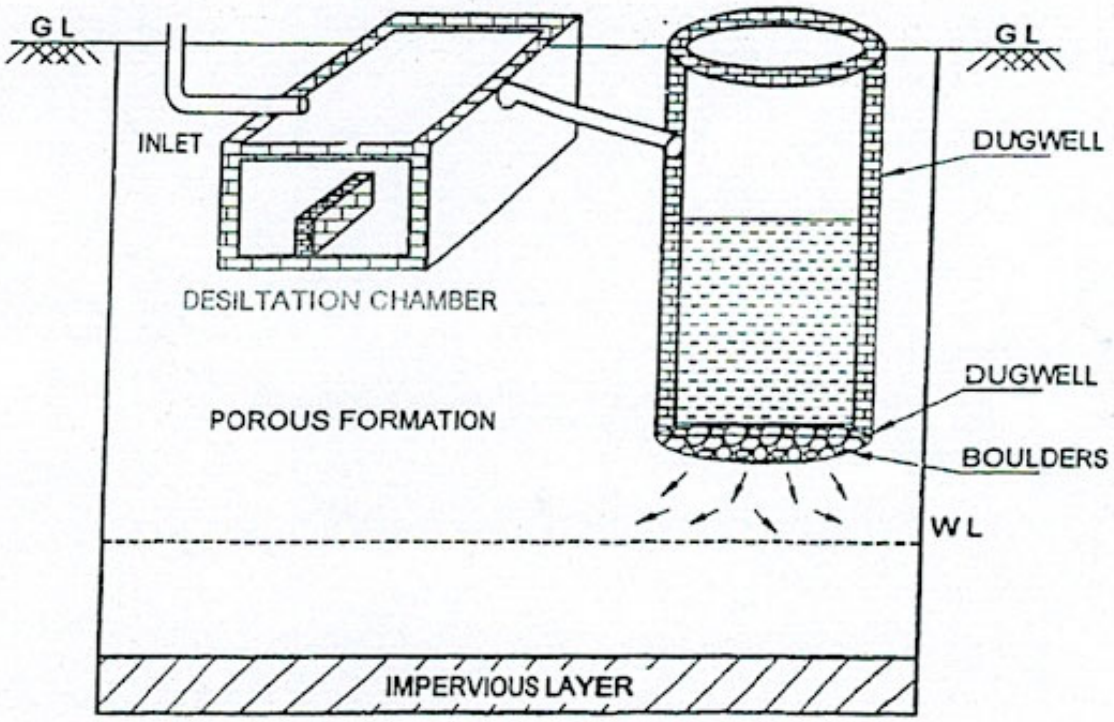


FIG. 4 RECHARGE THROUGH DUG WELL

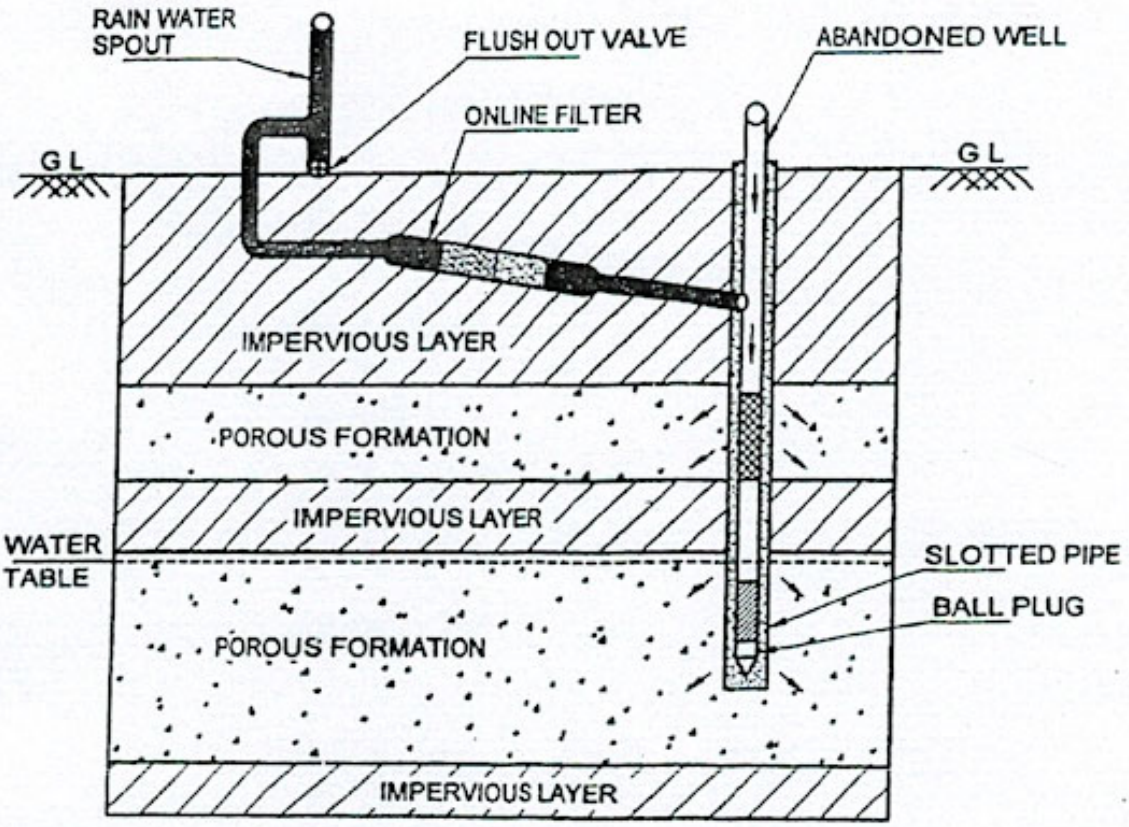
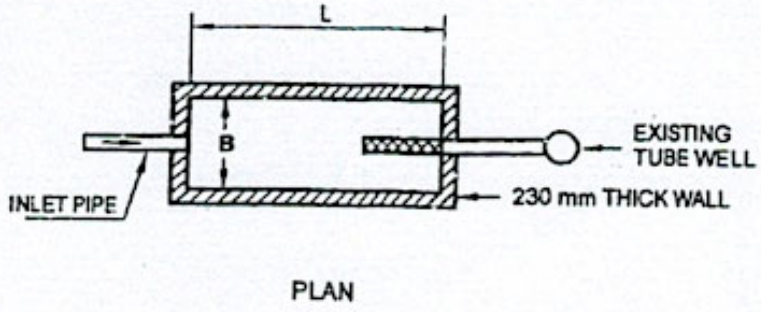


FIG. 5 RECHARGE THROUGH ABANDONED TUBE WELL



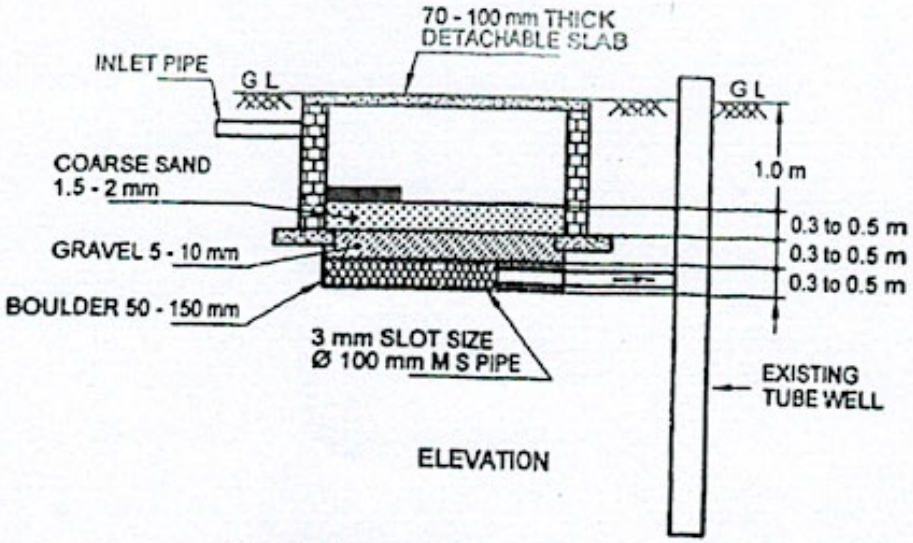


FIG. 6 RECHARGE THROUGH EXISTING TUBE WELL

desilting chambers located on ground. These collection chambers are interconnected as well as connected to the filter pit through pipes.

e) A connecting pipe with recharge well is provided at the bottom of the pit for recharging of filtered water through well.

f) Wire mesh filter should be provided just before the inlet to avoid entry of any foreign material, tree leaves, etc., in to the system.

7.2.5 *Recharge Wells* (*see* Fig. 7)

a) In areas where the aquifers are overlain by a considerable thickness of impervious formation, a new recharge tube well can be constructed for recharging the harvested rainwater.

b) It is used for recharging single/multiple aquifers.

c) A settlement-cum-storage tank is constructed near the tube well for settlement of silt particles and storage of excess water.

d) Roof top water is diverted to the settlement tank through pipes.

e) Clear water of storage tank is diverted to the recharge tube well for recharge.

f) It is suitable for recharging roof top rainwater of big buildings/blocks.

g) If runoff availability is less, then online filter may be used in the pipe line connecting roof water with recharge well.

7.2.5.1 *Construction of recharge well*

These are drilled by deploying the appropriate rig unit or by hand boring as per the site conditions and depth of the tube wells.

A well assembly of pipes with diameters varying from 100 to 250 mm may be lowered throughout the depth. Both M.S. and PVC pipes can be used. PVC pipes are rigid, light pipes in 6 or 9 m lengths available in all diameters. The main advantage of PVC pipes is their resistance to corrosion and slots of the pipes will not close with time. As the slotted pipes in recharge wells are in fluctuation zones of water levels, slots of M.S. pipes may become closed due to rusting. The main drawback of PVC pipes is that, these pipes can not be used in large diameter recharge wells. M.S. Pipes may be coated with bituminous coating to avoid rusting.

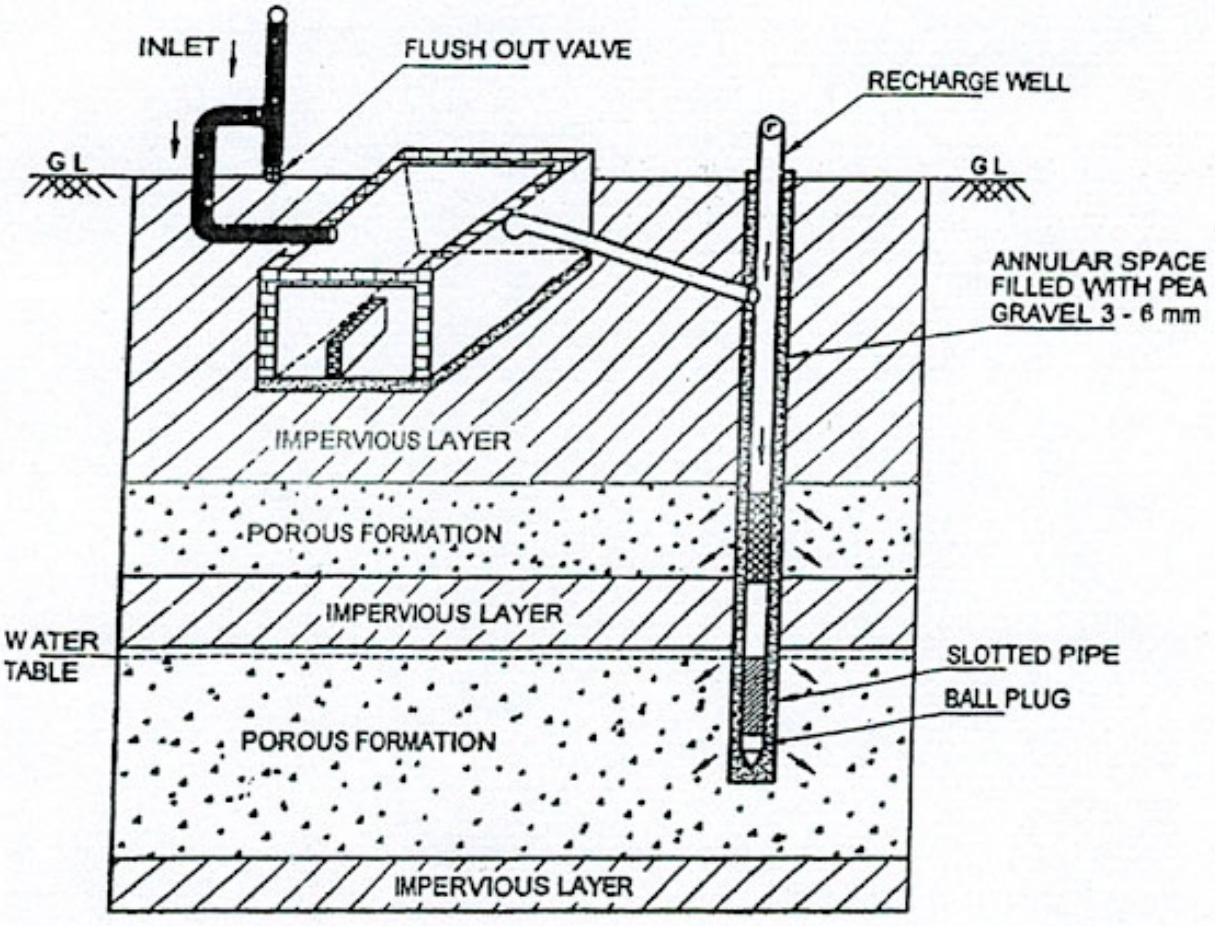


FIG. 7 RECHARGE THROUGH BORE WELL

After excavation of the recharge trench/shaft or filtration chamber is over, pipes should be rechecked and cleaned with wire brush. Depth sounding of recharge wells should be taken with tape to make sure that no silt or soil has gone into the recharge wells during the excavation of trench/shaft. Width of slots in recharge well should be in accordance with the aquifer system encountered. Slotted pipes should be placed against the aquifer or dried-up aquifers encountered in the recharge wells. A slotted pipe at the top of the recharge well will need to be placed to permit the entry of clean/clear water into the recharge well.

The annular space around the well assembly may be shrouded with appropriate size of gravel. The gravel should be washed so that it is silt-free. The recharge tube well should be developed by low capacity air compressor or by bailing method as required. The well may also be cleaned and developed by pouring the water from outside if required. The water levels of the tube well should be recorded and the well covered with cap with a provision to monitor the well in future. A vent pipe of about one inch diameter is also recommended which can act as escape for gases and for measuring the water levels. Once the recharge trench or shaft is constructed around the recharge tube well, recharge wells may be developed with hand bailers to avoid the disturbance of filter media.

7.2.5.2 *Recharge ability test*

To test the recharge ability of the tube well, a slug test may be conducted [*see* IS 14476 (Part 6)].

7.3 Filters

Generally, the following two types of filters are used :

a) *Online Filter*

1) This filter is used when availability of runoff as well as recharge rate of recharge well is less.
2) Manufactured from reinforced engineering plastic material.
3) Available in various sizes and flow rates ranging from 3 to 25 m^3/h.
4) Easy to open and clean.

b) *Purpose Built Filter*

1) The filter material recommended is coarse sand of 1.5 to 2 mm size at the top, followed by gravel of 5 to 10 mm size, and boulders of 5 to 20 cm at bottom. The thickness of each layer should be about 0.5 m. Coarse sand should be placed at the top so that the silt content that comes with runoff will be deposited on the top of the coarse sand/pea gravel and can easily be removed. For smaller roof area the pit may be filled with overburnt broken bricks/cobbles.
2) After excavation of filter chamber, boulders and gravel should be filled up first to the foundation of wall of the structure.
3) After filling of boulder and gravel, filter material should be covered with polythene/jute bags to avoid spilling of construction material, which may damage the filter bed. After the construction of walls, the polythene/jute bags should be removed and the sand/pea gravels filled up to the recommended depth as per the design.
4) Filter media should be free from silt and any other foreign material. Before putting the filter material into the chamber, filter material should be sieved and washed to remove all the finer material. During operation the scouring effect of flow of water into the structure should be checked upon and if flow is disturbing the filter media, the water can be released near the filter media. This can be done by providing an 'I' shape joint in the inlet pipe in trench.
5) Regular inspection of filter material is essential in recharge structures. Silt deposited on the filter media should be cleaned regularly. Once in a year the top 5-10 cm sand/pea gravel layer should also be scraped to maintain a constant recharge rate through filter material.
6) Growth of grass or bushes hampers the filtration rate of the chamber. The grass and bushes should be cleared regularly.

7.4 Maintenance of Catchment Area, Water Drains and Recharge Structures

a) The catchments should be neat and clean. The roof top/terrace of the building spaces around the buildings should not be used for dumping of unwanted items and scrap material.
b) The washing machine water having heavy dose of detergents should not be allowed to enter into the water drains which are connected with recharge structures.
c) Open water drains covered with perforated detachable RCC slabs are best as the maintenance of these drains is easy and pollution, especially bacteriological pollution, can be avoided. If the storm water drainage is through pipe system, provide manholes and

chambers at regular intervals as well as close to the suspected silt and waste accumulation places within the channel.

d) Protect the drainage system from tree leaves, polythene bags, plastic bottles and pouches of eatables.

e) Put up sign boards mentioning that the campus of building is equipped with rainwater harvesting system which is being recharged to the ground water system. Mention the ill effects and health impacts if the storm water drains are not properly maintained. Educate the staff maintaining the storm water drains to keep the drains neat and clean.

f) Provide wire mesh filter just before the inlet. Provide silt check wall within the drain bed at a convenient place. If more silt is expected provide check wall at regular intervals in the storm water drains.

g) The periodic removal of the material deposited on the surface be done by scraping the silt accumulated on top of the filter bed regularly.

h) Precaution should be taken to avoid domestic waste water entering into the recharge structures.

j) Recharge tube wells should be developed periodically by hand bailers to avoid clogging of the slots.

k) Before the arrival of monsoon, the roof top as well as drains should be properly cleaned.

m) Length and placement of the slotted pipe should be finalized after drilling of pilot hole for tube well.

n) Recharge water should be introduced into the structure at its lowest point to prevent erosion and disturbance of filter material.

p) A wire mesh should be placed at the entrance of recharge structures.

q) Periodic cleaning of collection chambers should be carried out to remove the plastic bags, leaves, etc, which may choke the entry of water recharge structures.

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Ground Water and Related Investigations Sectional Committee, WRD 3

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Organization	*Representative(s)*
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MANUAL - 4

Tehsil wise Rain Water Harvesting Structures in NCT Delhi

Sl No.	Tehsil	Recommended harvesting structures	Depth of recharge well (meter)	Remarks
	District: New Delhi			
1	Chanakyapuri	Trench with bore	18	
2	Connaught place	Only Trench	-	
3	Parliament Street	Trench with bore	18	
	District: North West			
4	Model Town	Only Trench	-	
5	Narela	Only Trench	-	
6	SaraswatiVihar	Only Trench	-	
	District: West			
7	Patel Nagar	Trench with bore	15	
8	Punjabi Bagh	Only Trench	-	
9	Rajouri Garden	Trench with bore	18	
	District: South West			
10	Delhi Cantt.	Trench with bore	25	
11	Najafgarh	Trench with bore	15	
12	VasantVihar	Trench with bore	35	
	District: North East			
13	Seelampur (North)	Only Trench*		
	Seelampur (South)	Only Trench	-	
14	Seemapuri	Only Trench	-	
15	Shahdara	Only Trench	-	
	District: East			
16	Gandhi Nagar	Only Trench*		
17	PreetVihar (East)	Trench with bore	15	
	PreetVihar (West)	Only Trench	-	
18	VivekVihar (East)	Trench with bore	15	
	VivekVihar (West)	Only Trench	-	
	District: North			
19	Civil Lines (North)	Only Trench*		
	Civil Lines (South)	Only Trench	-	
20	Kotwali	No Structure		
21	Sadar Bazar	No Structure		
	District: Central			
22	Daryaganj	Only Trench*		
23	Karolbagh (East)	Only Trench	-	
	Karolbagh (West)	Trench with bore	15	
24	Paharganj	Only Trench	-	
	District: South			
25	Defence Colony	Trench with bore	15-35	
26	HauzKhas	Trench with bore	50	
27	Kalkaji	Trench with bore	15-45	

*** Feasible where water level is more than 5 meter below ground level.**

Technical design of Roof Top Rain Water Harvesting and Artificial Recharge to Ground Water

A. Trench without Recharge well

Roof Top Area (Sq. m)	Highest Rainfall intensity (mtr/ hourly)	Run-off Coefficient	Runoff/hr (cu. m)	Annual Runoff (cu. m)	Size of recharge Structure (mtr)
a	b	c	d(aXbXc)	e(aX0.54Xc)	LXBXH
100	0.025	0.8	2.0	43.20	1.2X1.2X1.4
200	0.025	0.8	4.0	86.40	1.8X1.5X1.5
300	0.025	0.8	6.0	129.6	2.4X1.8X1.4
400	0.025	0.8	8.0	172.8	2.7X2.1X1.4
500	0.025	0.8	10.0	216	3.3X2.1X1.5

Note: Normal rainfall in Delhi: 611 mm,
Normal monsoon rainfall: 540 mm

Points to be taken into consideration for implementation of the above structures:

1. Valid for buildings without basements (Cellar) and for areas for alluvial formation where ground water level is more than 5 meter upto 15 meter below ground level. Buildings with basements should adopt rain water harvesting through storage tank.

2. Only the rain water from the roof top area has to be diverted to recharge structure through connection of down pipe.

3. Before the onset of the monsoon all the catchment area (roof top) considered for recharge is to be cleaned. The recharge structures are to be in operation during the monsoon season only so as to avoid any contamination.

4. A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the pit. By-pass arrangement be provided before the collection chamber to reject the first showers.

5. The depth of the inlet pipe should be within 10 cm below ground level for easy overflow through outlet pipe that has to be connected to storm water drain.

6. Based on site condition length and breadth of the recharge chamber may be altered keepings its volumetric capacity the same.

7. RCC slab thickness and reinforcement shall be dependent on structural loads. Access manhole frame and covers to be provided.

8. Filter media of 1.0 meter thick will be in three layers comprising of 0.4 meter thick layer of boulders (5-20cm) at the bottom, 0.3 meter thick layer of gravels (5-10cm) in the middle and 0.3 meter thick layer of coarse sand (1.5-2.0mm) at the top so that the silt content that will come with runoff will be deposited on the top and can easily be removed.

9. A 10 cm thick layer of pea gravels will be provided over the coarse sand layer of the filter media.

10. Prior to monsoon season the top most sand layer in the pit may be scrapped and replaces with the fresh and cleaned coarse sand.

11. Recharge chambers shall be checked and cleaned at 7 days interval or more frequently during rainy season.

B. Trench with Recharge well

Roof Top Area (Sq. m)	Highest Rainfall intensity (mtr/ hourly)	Run-off Coefficient	Runoff/hr (cu. m)	Annual Runoff (cu. m)	Size of recharge Structure (mtr)
a	b	c	d(aXbXc)	e(aX0.54Xc)	LXBXH
100	0.025	0.8	2.0	43.20	1.0X0.5X0.5
200	0.025	0.8	4.0	86.40	1.0X1.0X1.0
300	0.025	0.8	6.0	129.6	1.0X1.0X1.0
400	0.025	0.8	8.0	172.8	1.0X1.0X1.0
500	0.025	0.8	10.0	216	2.0X1.5X1.0

Points to be taken into consideration for implementation of the above structures:

1. Valid for all buildings and for both alluvial and hard rock formation where ground water level is more than 15 meter below ground level.

2. Only the rain water from the roof top area has to be diverted to recharge structure through connection of down pipe.

3. Before the onset of the monsoon all the catchment area (roof top) considered for recharge is to be cleaned. The recharge structures are to be in operation during the monsoon season only so as to avoid any contamination.

4. A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the pit. By-pass arrangement be provided before the collection chamber to reject the first showers.

5. The depth of the inlet pipe should be within 10 cm below ground level for easy overflow through outlet pipe that has to be connected to storm water drain.

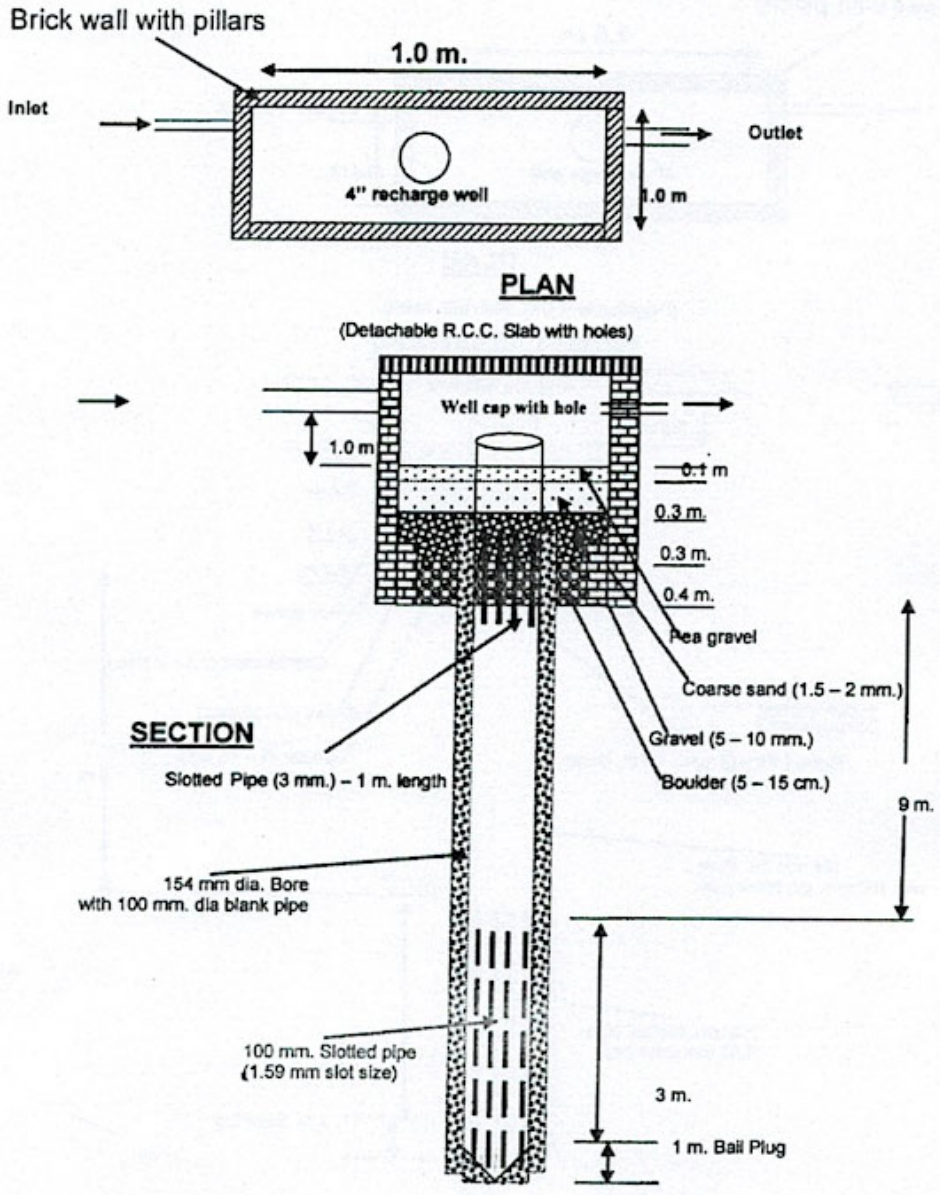
6. Based on site condition length and breadth of the recharge chamber may be altered keepings its volumetric capacity the same.

7. RCC slab thickness and reinforcement shall be dependent on structural loads. Access manhole frame and covers to be provided.

8. Filter media of 1.0 meter thick will be in three layers comprising of 0.4 meter thick layer of boulders (5-20cm) at the bottom, 0.3 meter thick layer of gravels (5-10cm) in the middle and 0.3 meter thick layer of coarse sand (1.5-2.0mm) at the top so that the silt content that will come with runoff will be deposited on the top and can easily be removed.

9. A 10 cm thick layer of pea gravels will be provided over the coarse sand layer of the filter media.

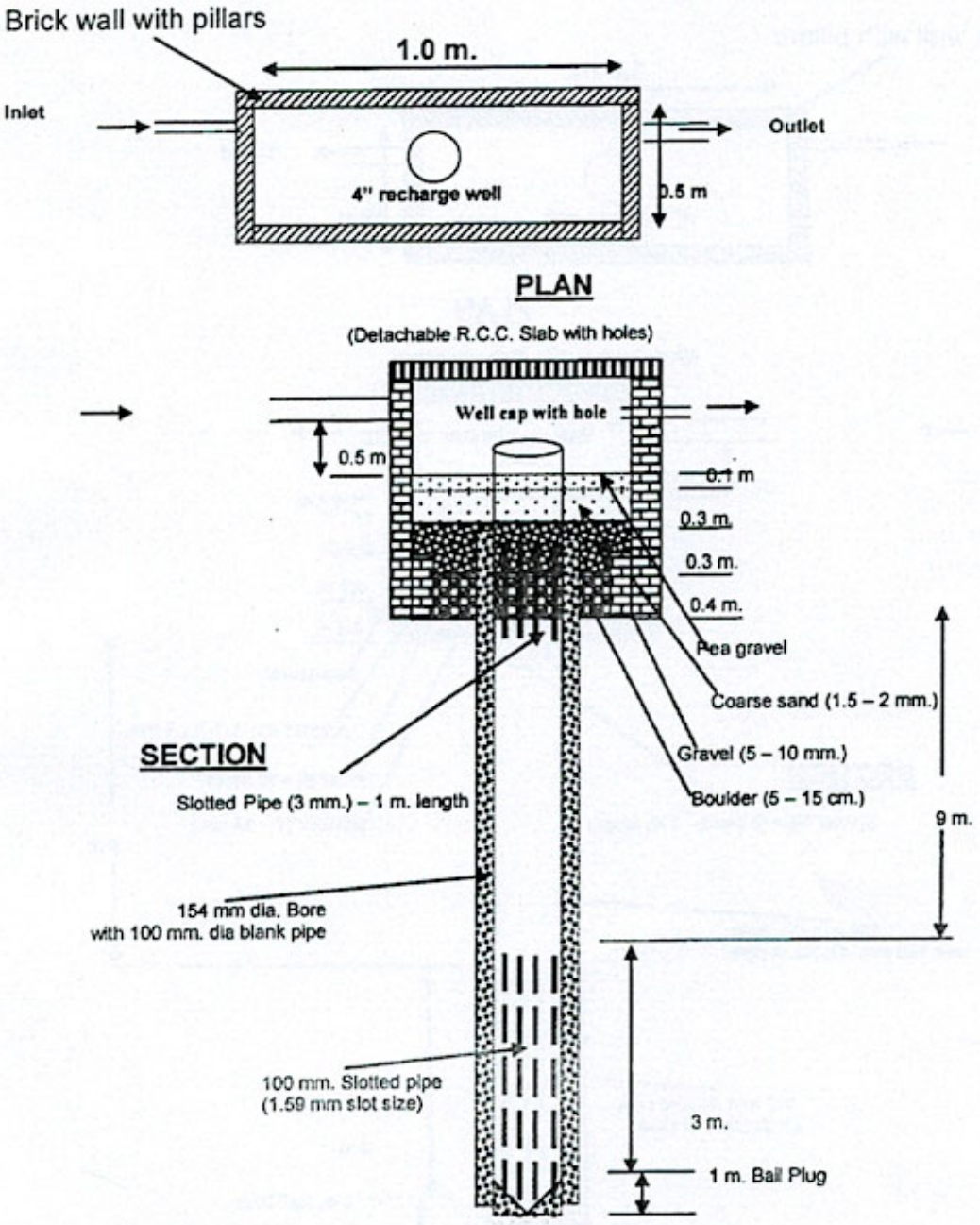
Trench with Recharge well
(Roof top area100-200 sq. m)



Note:

1. **Based on post monsoon depth to water level, the recharge well depth will change and should be kept 2to 3 meter above post monsoon water level.**
2. **The design is indicative; the actual design depends on site condition.**

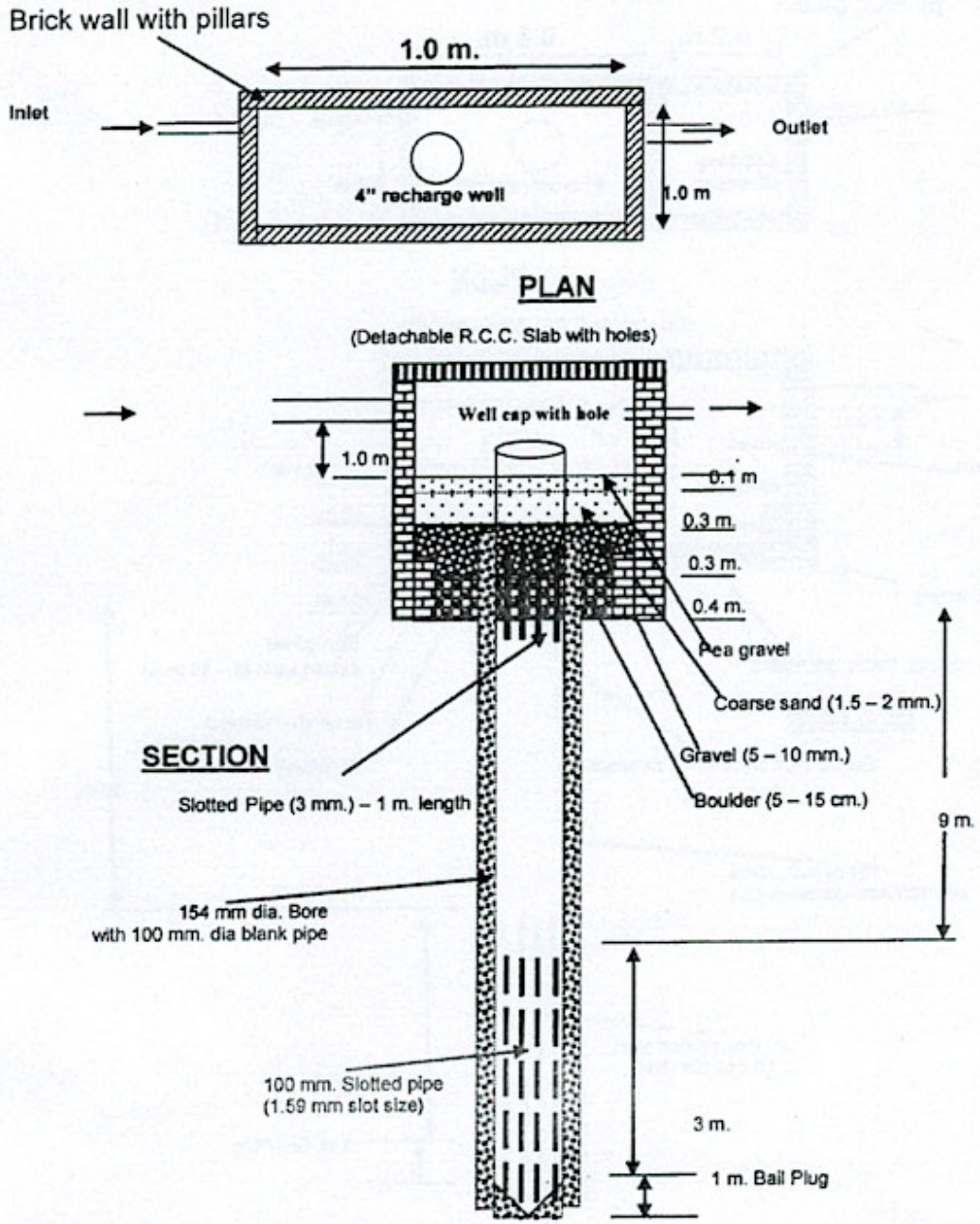
Trench with Recharge well
(Roof top area upto 100 sq. m)



Note:

1. **Based on post monsoon depth to water level, the recharge well depth will change and should be kept 2to 3 meter above post monsoon water level.**
2. **The design is indicative; the actual design depends on site condition.**

Trench with Recharge well
(Roof top area 200-300 sq. m)

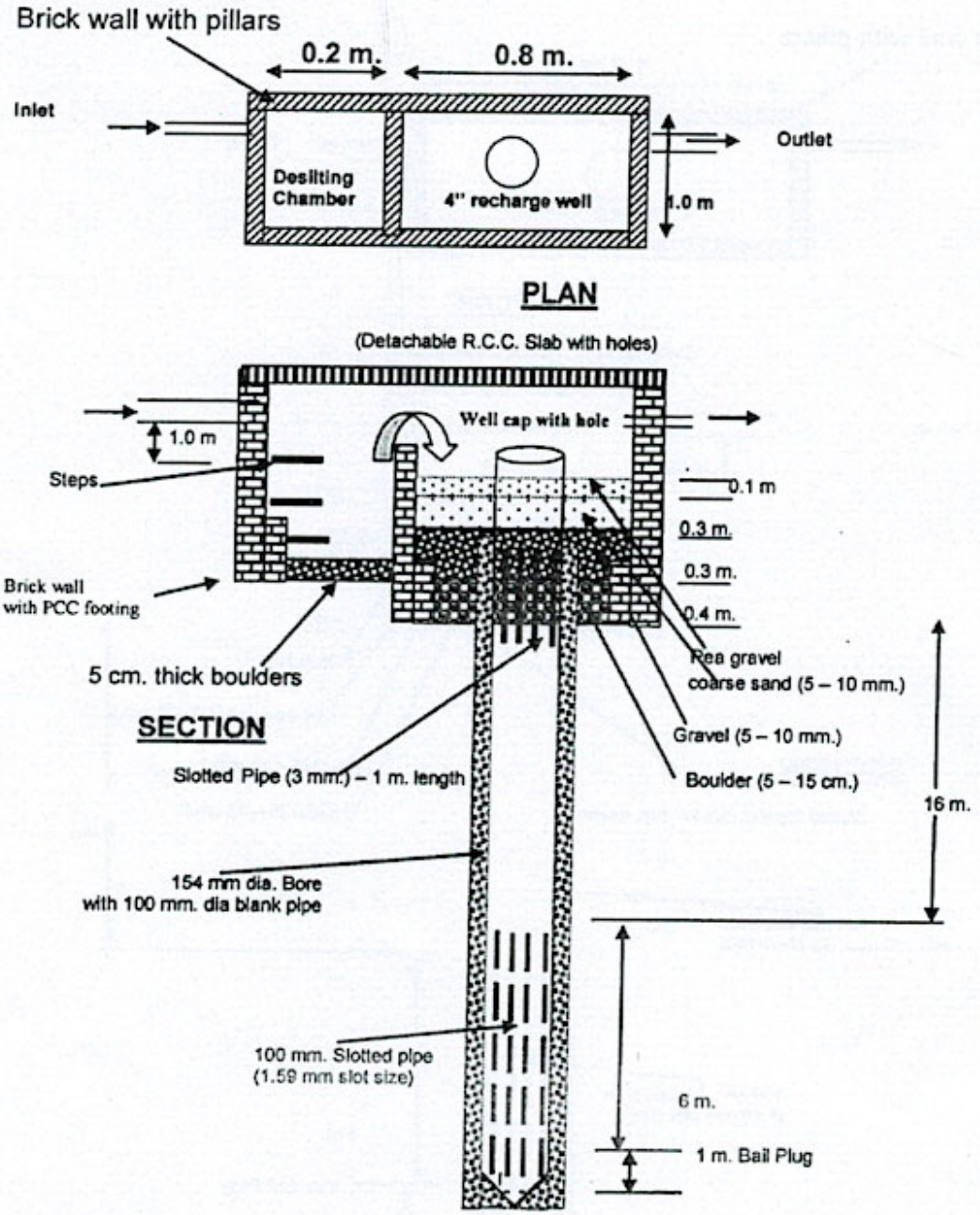


Note:

1. **Based on post monsoon depth to water level, the recharge well depth will change and should be kept 2to 3 meter above post monsoon water level.**
2. **The design is indicative; the actual design depends on site condition**

Trench with Recharge well & De-silting Chamber

(Roof top area 300-400 sq. m)

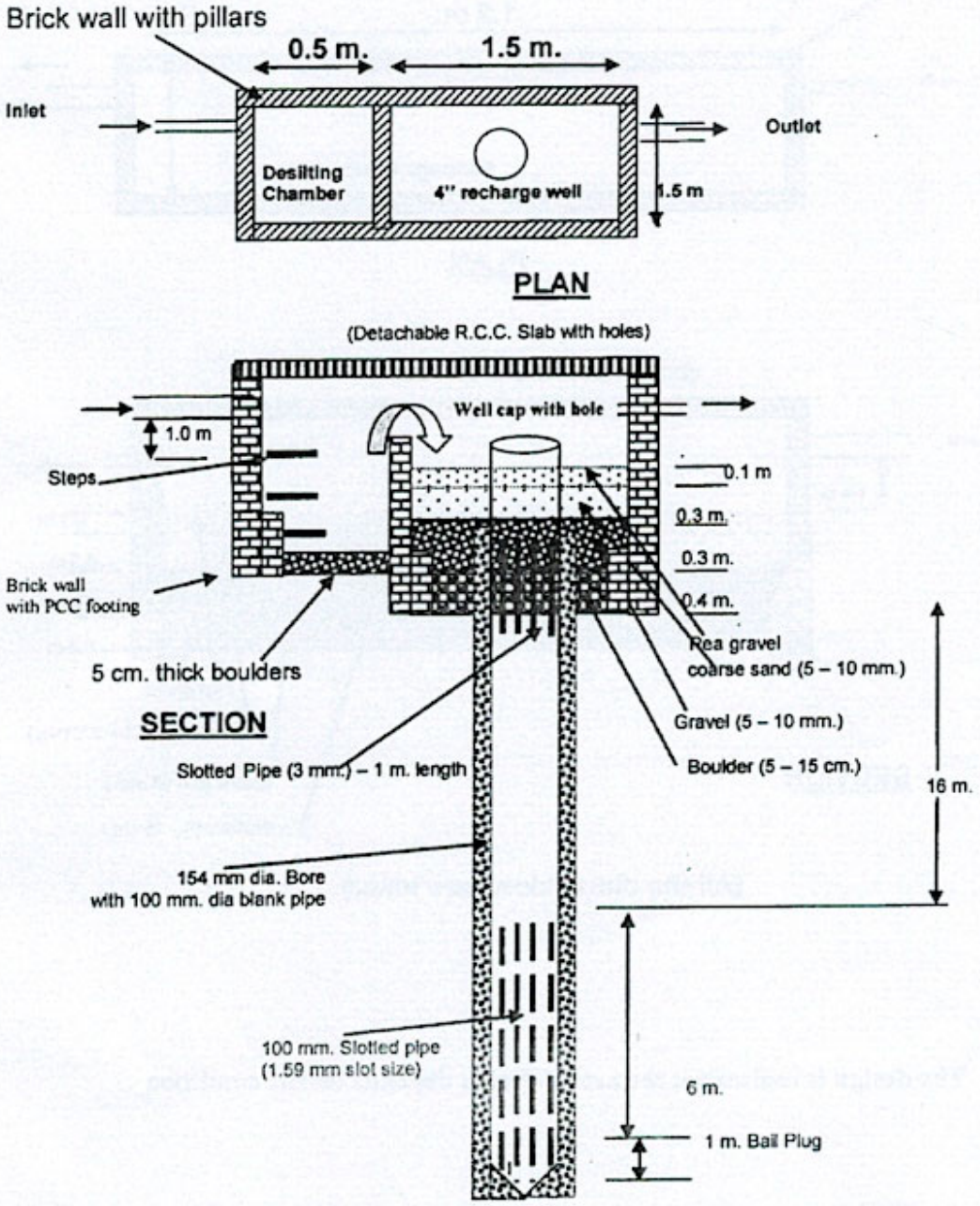


Note:

1. **Based on post monsoon depth to water level, the recharge well depth will change and should be kept 2to 3 meter above post monsoon water level.**
2. **The design is indicative; the actual design depends on site condition**

Trench with Recharge well & De-silting Chamber

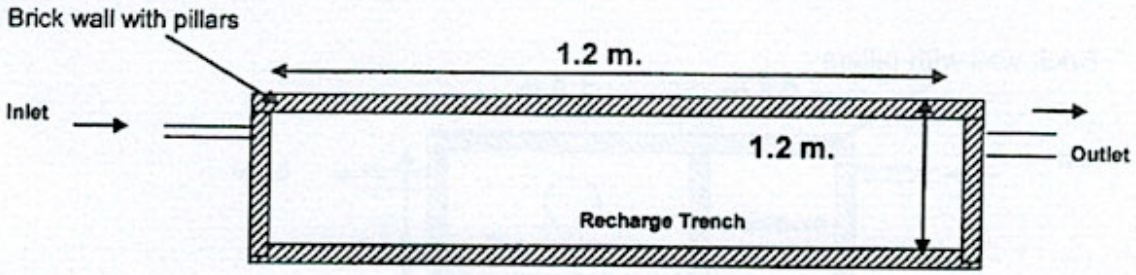
(Roof top area 400-500 sq. m)



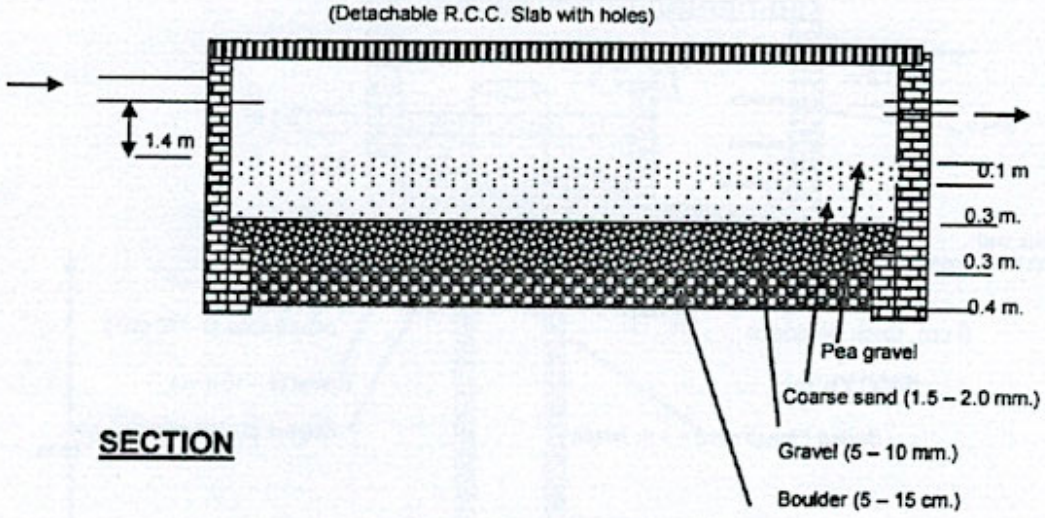
Note:

1. **Based on post monsoon depth to water level, the recharge well depth will change and should be kept 2to 3 meter above post monsoon water level.**
2. **The design is indicative; the actual design depends on site condition**

Recharge Trench (Roof Top area upto 100 sq. m.)



PLAN



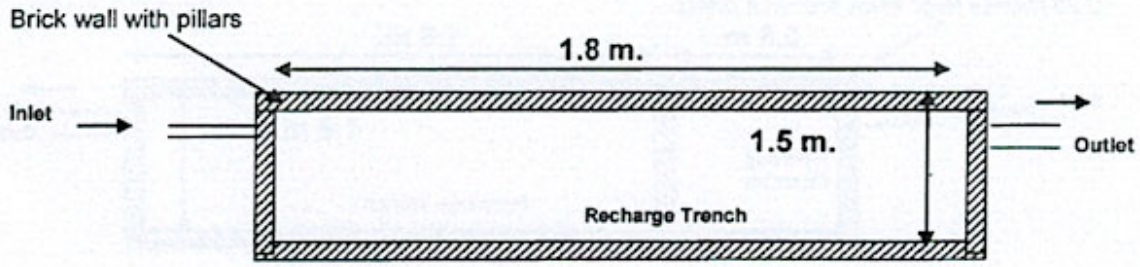
SECTION

(All the dimensions are inner)

Note:

1. The design is indicative; the actual design depends on site condition

Recharge Trench (Roof Top area 100-200 sq. m.)



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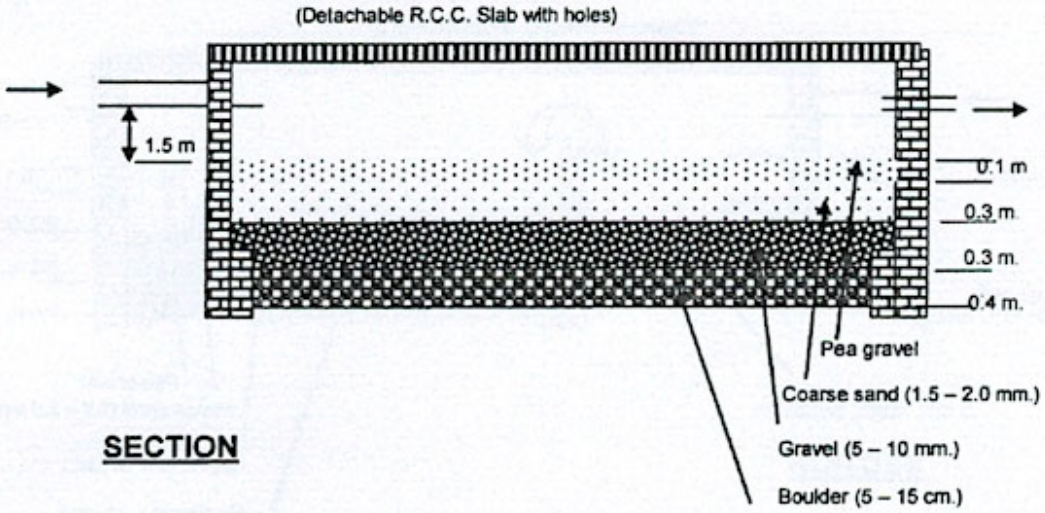


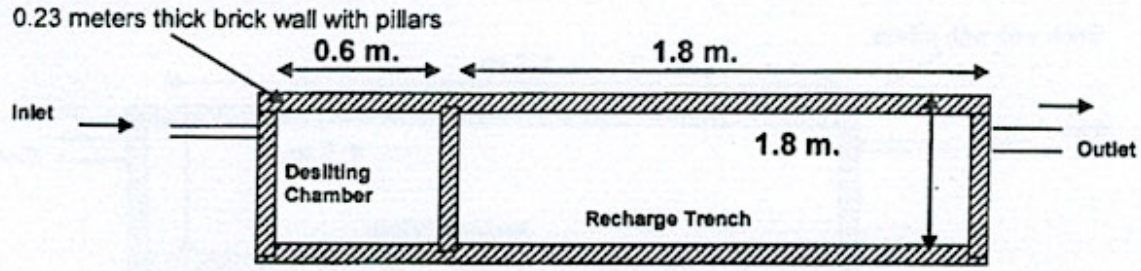
SECTION

(All the dimensions are inner)

Note:

1. **The design is indicative; the actual design depends on site condition**

Recharge Trench with Desilting Chamber (Roof Top area 200-300 sq. m.)



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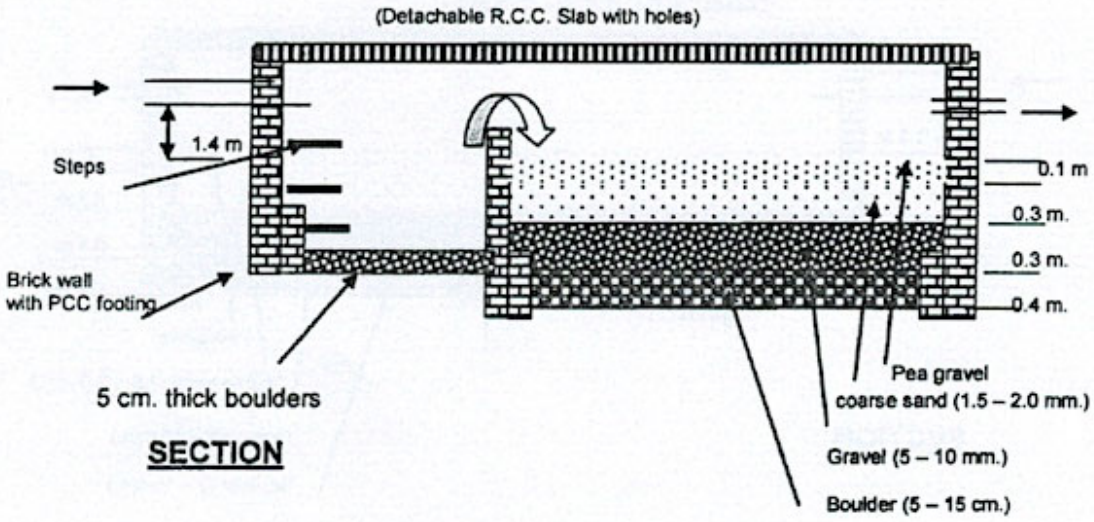


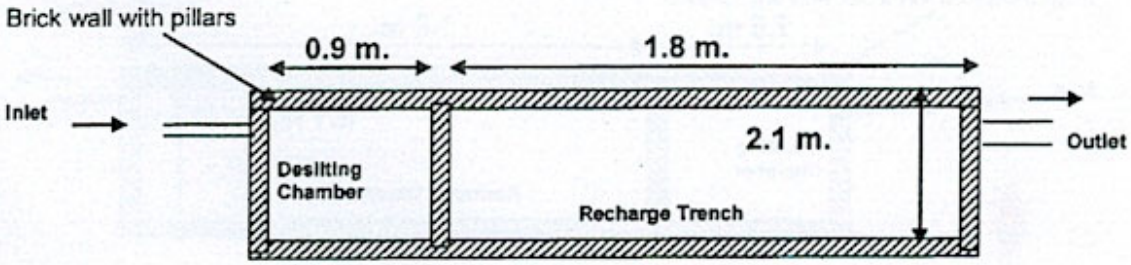
SECTION

(All the dimensions are inner)

Note:

1. The design is indicative; the actual design depends on site condition

Recharge Trench with Desilting Chamber (Roof Top area 300-400 sq. m.)



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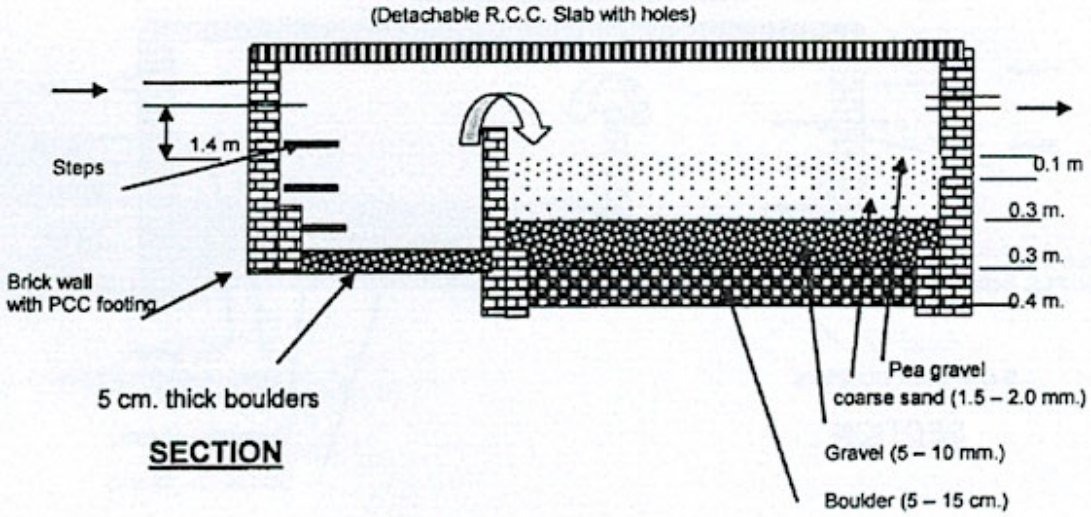


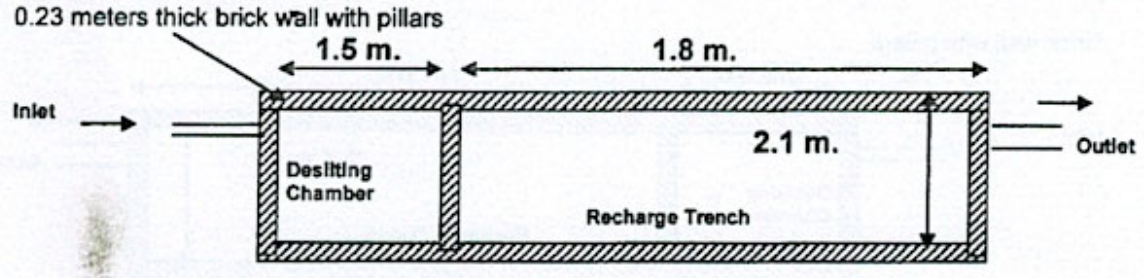
SECTION

(All the dimensions are inner)

Note:

1. **The design is indicative; the actual design depends on site condition.**

Recharge Trench with Desilting Chamber (Roof Top area 400-500 sq. m.)



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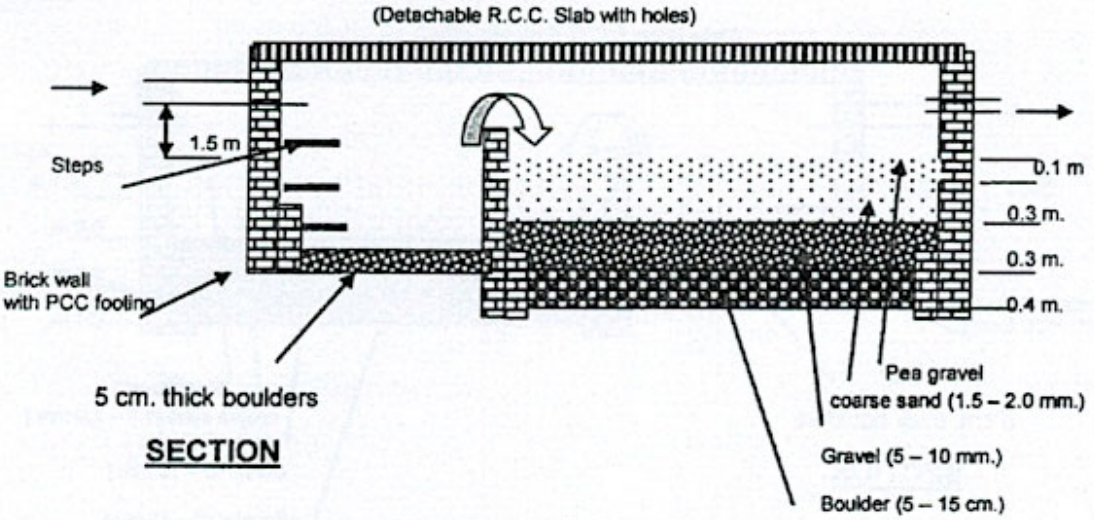


SECTION

(All the dimensions are Inner)

Note:

1. **The design is indicative; the actual design depends on site condition.**

STANDARD DESIGNS

FOR

ADOPTION OF ROOF TOP RAINWATER HARVESTING

IN DELHI

CENTRAL GROUND WATER BOARD
STATE UNIT OFFICE
NEW DELHI

INTRODUCTION

National Capital Territory (NCT) Delhi covers an area of 1483 Sq. Km. The Ground Water available in the territory is controlled by the hydrogeological situation characterized by occurrence of alluvial formation and hard rocks such as quartzite. The hydrogeological set up and the following distinct physiographic units further influence the ground water occurrence: (1) Older Alluvial Plain on the eastern and western side of the ridge. (2) Yamuna Flood Plain deposits. (3) Isolated nd nearly closed Chattarpur alluvial basin. (4) NNE-SSW trending Quartzite Ridge.

The high rate of population growth and high level of urbanization in NCT Delhi ha s resulted in over development of ground water resources. Thus in about 75% area of NCT Delhi ground water levels are declining at an alarming rate of 0.40 m per annum. In South and Southwest district the decline is high varying from 1 to 2 m/Yr. The annual replenishable ground water resources of the State is 0.31 bcm with a net annual ground water availability of 0.29 bcm. Ground water draft (as on 31st March 2009) is 0.40 bcm with a stage of ground water development of 138%. Out of the 27 assessment units (Tehsils) in the State, 20 have been categorized as over exploited, 05 semi critical and 02 have been categorized as safe from ground water development point of view.

In view of high state of ground water development, and depletion of ground water levels due to its over development Central Ground Water Authority (CGWA) had notified South and South-West district vide Public Notice No. 6 of 2000 dated 15.08.2000 and imposed prohibition and restriction for construction and installation of any structure for abstraction of ground water resources to avoid further depletion and deterioration of ground water quality. Subsequently the Hon'ble Lieutenant Governor had declared the whole NCT Delhi as notified on 31.03.2009 vide order No. F8 (348)/EA/Env/09/14433.

The normal annual rainfall of NCT Delhi is 611.8 mm out of which 81% of the annual rainfall is received during the monsoon months July, August and September. The rest of the annual rainfall is received as winter rain and as thunderstorm rain in the pre and post monsoon months.

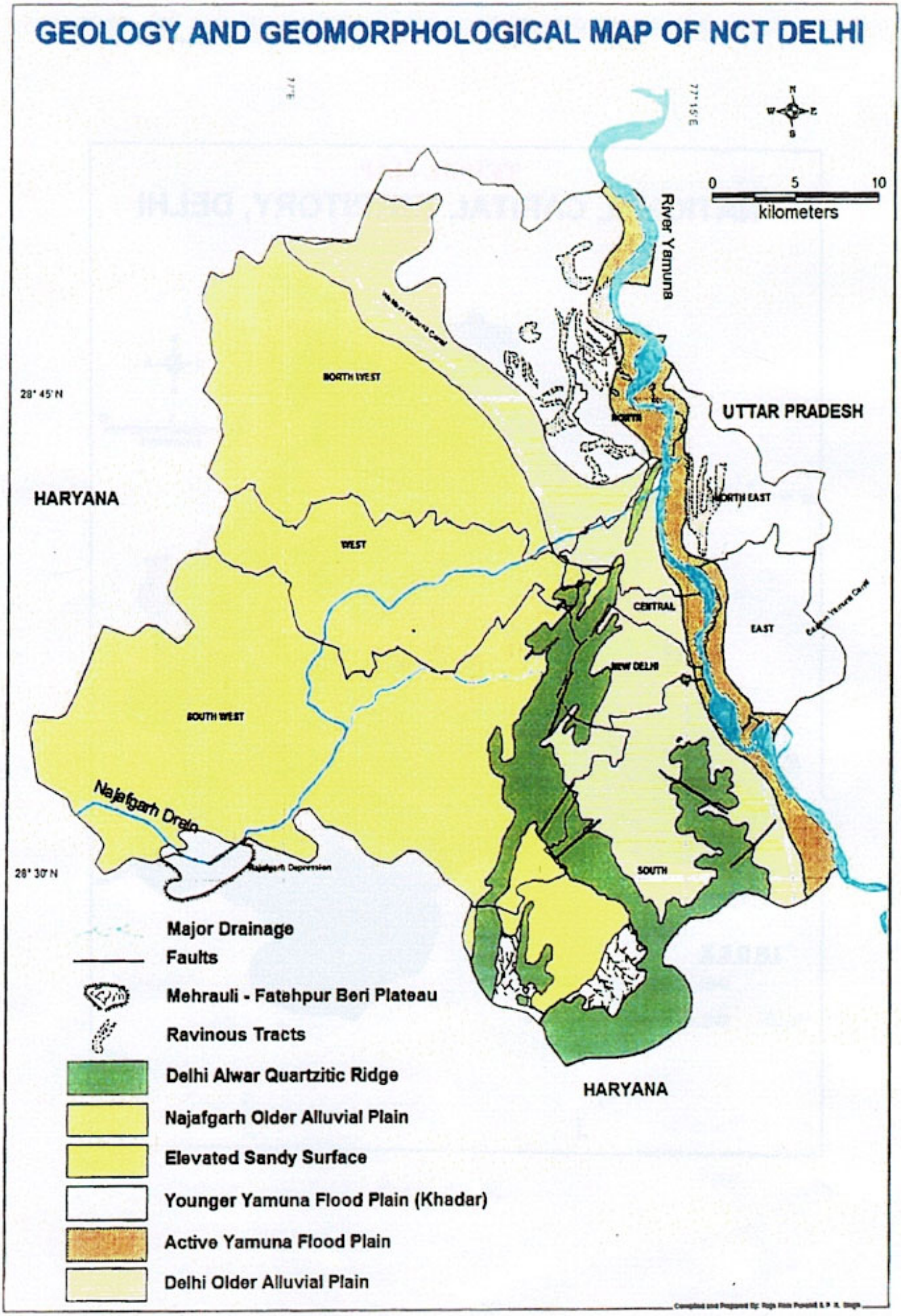
In order to increase the natural ground water resource rain water harvesting and artificial recharge to ground water has become increasingly important in ground water management. The subsurface geology, post monsoon depth to water level and declining ground water level conditions of the State indicate that the area is suitable for artificial recharge. The favorable aquifer zones down to depth of ground water level which is lying unsaturated presently may be suitable recharged through rain water harvesting.

For the convenience of general public standard designs of Rainwater Harvesting have been prepared and placed on CGWB website.

Permission to install various Artificial Recharge Structures and Recharge wells is governed by the prevailing rules and laws in the area.

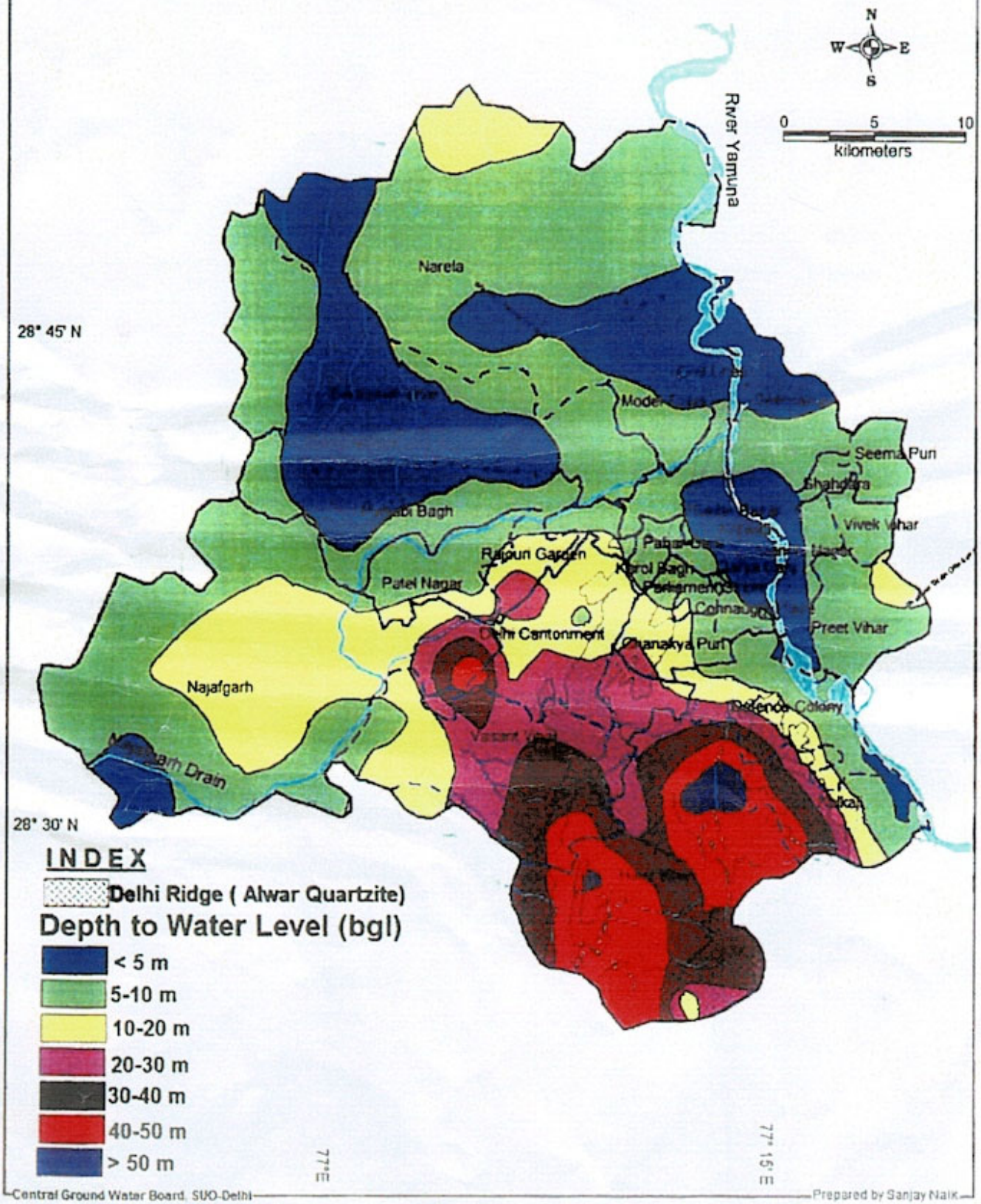

TEHSIL MAP
NATIONAL CAPITAL TERRITORY, DELHI
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
28° 30' N
Civil Lines
Sadar Bazar
Kotwali
INDEX
Delhi Ridge (Alwar Quartzite)
Major Drainage and Canals
77°E
77° 15' E
Central Ground Water Board, SUO-Delhi

GEOLOGY AND GEOMORPHOLOGICAL MAP OF NCT DELHI



DEPTH TO WATER LEVEL MAP FOR RAIN WATER HARVESTING STRUCTURES

NATIONAL CAPITAL TERRITORY, DELHI



Central Ground Water Board, SUO-Delhi

Prepared by Sanjay Naik