



Minimum requirements for pumping tests on water bores in New South Wales

Information for landholders, agents and consultants

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1. Introduction

Pumping tests are a common approach used by hydrogeologists to test aquifers. They are done by stimulating the aquifer and measuring the aquifer's response. The objective of a pumping test is to test the production capability and calculate aquifer hydraulic properties such as transmissivity, storativity and hydraulic boundaries.

This document outlines the design, operation and reporting of pumping tests on water bores in accordance with the Australian Standard (*AS 2368—1990 Test Pumping of Water Wells*) and to meet the minimum requirements of the Department of Planning, Industry and Environment—Water.

This document refers to landholders, agents acting on their behalf, and consultants or contractors who may be performing the testing as 'applicants', reflecting the most common times when pumping tests are likely to be required by the department.

1.1 General considerations

Applicants must record accurately the details of the initial (pre-pumping) water level, the pumping rate and all drawdown levels against time, as specified in these requirements, to provide meaningful results from the testing. We have provided minimum pumping rates (according to the equivalent annual volume of groundwater being sought), but these do not preclude the need for a preliminary test (that is the pump rate selection test). It is still necessary to select the longer term discharge setting from the results of the preliminary test to ensure that the pump selected is the correct size for the required test rate and that the potential capacity of the bore (from initial airlift testing) has not been overestimated.

Applicants must record the recovery of water levels in the pumped bore, starting from the instant pumping has stopped, until the water level fully recovers to the initial or pre-pumping water level, or to the duration specified.

Where automatic water level recording instruments are used, applicants must identify and apply appropriate corrections for barometric pressure, groundwater salinity, and tidal influences (where relevant).

1.2 Purpose

An applicant who proposes to extract large volumes of groundwater from a bore or water supply work may be required to carry out a pumping test. The department requires this for assessing the application. Pumping tests must also meet the governing standard identified above.

The department uses the results of pumping tests to assess interference impacts between the subject bore, any existing licensed bores in the area and any environmental features (for example rivers, lakes and groundwater dependent ecosystems). The results are also useful for informing the departmental assessment of proposed dealings, new water supply work applications and for the determination of extraction limits for bores.

1.3 Exceptions and variations

Applicants may obtain exceptions or variations to these pumping test requirements through a written agreement with the department before starting any proposed testing.

For example, the department might consider variations where:

- bores have been sealed at the time of construction and only approximate pressure measurements can be obtained for the test
- it can be demonstrated that the likely effects of long-term pumping will not affect nearby receptors (including other users and environmentally sensitive features).

The department will only consider exceptions and variations where the design and operation of the proposed alternative pumping test program has been thoroughly documented and evidence for the need for a different approach is included. Where the department has not received a fully documented variation and provided written agreement, the pumping test program must comply with these requirements.

1.4 Maintaining a constant discharge rate

A constant discharge pumping test should be carried out on the subject bore for a continuous, uninterrupted period as specified in these requirements.

For large diameter works, such as wells, and situations where the work is to supply water to other properties, the department recommends considerably longer durations of pumping and recovery.

Pumping at a constant discharge rate is essential for the analysis; therefore, every effort should be made to maintain a constant flow throughout the entire test. In most cases, a decrease in discharge rate will occur as the pumping progresses and drawdown increases as the pump works harder against a greater hydraulic head and increasing friction in the system. In such cases, applicants should increase the pumping rate slightly and periodically to maintain the constant rate. Applicants should record the discharge rate each time they measure the water level during the pumping period to achieve industry best practice. Applicants must record all water level and distance measurements in metres (m) and discharge rates in litres per second (L/s).

A variation of $\pm 5\%$ from the initial discharge rate is acceptable, but changes in the pumping rate greater than this require immediate action, therefore the accuracy of the measurements is critical. If the discharge rate varies by more than $\pm 5\%$ from the initial pumping rate at any time, the pumping test should be stopped and recovery water levels monitored. Applicants must allow the water level in the pumped bore to fully recover to the initial or pre-pumping water level before a new pumping test can be started, even though this may delay testing for several days.

A multistage (step drawdown) pumping test is strongly recommended after the preliminary test and prior to the constant discharge test so that the optimum pump depth setting and discharge rate can be determined.

1.5 Pump stoppages

If the pump stops prematurely, or if the water level drops to the intake level and the pump has to be stopped, then the pumping test should be stopped and recovery water levels monitored. Applicants must allow the water level in the pumped bore to fully recover to the initial or pre-pumping water level before starting a new pumping test. A new pumping test using a lower pumping rate (a multistage pumping test may be necessary to determine a suitable, lower pumping rate) should be started after full recovery has been measured in the subject bore.

1.6 Other observations

If there are any other bores or wells that can be accessed near the bore being tested, then applicants must monitor water levels in at least one of those other locations during both the pumping and recovery phases of the test. If those other works being monitored are in use during the test, then applicants must record detailed information on the pumping (duration and rate) from those neighbouring bores during the entire testing period (pumping and recovery). The department highly recommends that the pumping test be undertaken during the non-pumping season or when other neighbouring bores are not in use to simplify the analysis of the measured data.

Applicants must record in detail any variations in weather (rain and atmospheric pressure) during the pumping test to identify any potential outside influences that could affect the accuracy of any measurements.

If required, applicants must give the department the results of independent laboratory analyses of water samples taken at specific times (usually one after one hour of pumping and another before the end of the test). A laboratory accredited by the National Association of Testing Authorities should carry out the analyses, and should at least include:

- major cations (Ca²⁺, Na⁺, Mg²⁺ and K⁺)
- major anions (Cl⁻, SO₄²⁻, HCO₃⁻ and CO₃²⁻)
- sodium absorption ratio
- pH
- electrical conductivity
- total dissolved solids.

1.7 Analysis of the results

An appropriately qualified groundwater professional should analyse the pumping test results. The analysis should include assessment of hydraulic parameters and the long-term impacts of pumping at the proposed rate from the groundwater system.

The department will use the results from the pumping test analysis to assess the effects of extraction at the proposed operating rate and volume on adjacent licensed groundwater users and the environment. Should the test or the analysis results be poorly recorded or reported, the department may require the test to be repeated at a different rate or for a longer period. It is therefore more cost effective for an applicant to carry out a pumping test as correctly as possible at the first attempt, rather than repeating the testing program.

2. Procedure

The general design of the pumping test program must meet the governing standard and must include, at a minimum, a:

- preliminary test
- constant discharge test (which is generally comparable to most water supply bore usage)
- recovery test.

Where more comprehensive testing is needed, the department may require a multistage (step drawdown) test. Such a multistage (step drawdown) pumping test can be carried out independently of constant discharge testing, but still after the preliminary test and before the recovery test.

Alternatively, a multistage (step drawdown) test can be incorporated at the beginning or end of the longer, constant discharge period. Where a multistage (step drawdown) test is proposed or required, the number, duration and rates of the stages must be documented by the applicant for the department's consideration. The applicant must get written agreement from the department before starting the testing (refer section 1.3 'Exceptions and variations').

Substitution of the above with other types of tests nominated in the governing standard (that is, for example, a constant head test) may be permitted under written agreement from the department (refer section 1.3 'Exceptions and variations').

The minimum requirements for the three commonly adopted tests are as follows:

- **Preliminary test (pumping rate selection test)**
 - The applicant must measure water levels before, during and after the preliminary test in all bores identified for inclusion in the program and record these with the measurement times.

- The range of discharge over which the production bore is pumped should include at least five separate rates that are appropriate for the bore and the anticipated hydrogeological setting.
- The applicant must measure discharge frequently during the preliminary test to confirm there is no drop-off in the selected rate for the respective pumping period (refer section 6 'Measurement schedules').
- The applicant must measure recovery until the water level has returned to within 80% of the pre-pumping level.
- All measurements, times and rates are to be documented and provided in the final report.
- **Constant discharge test**
 - The test must not start within 24 hours of the preliminary test (or longer if the 80% recovery from the preliminary test has not been achieved).
 - The test is to be continued for the time required (refer section 4 'Selection of test duration') for the schedule under which the applicant proposes to operate the bore.
 - The applicant must measure the pre-pumping standing water level in any bore included in the testing (both pumping and observation bores) within an hour before the test start time.
 - Measurements of pumping and recovery water levels are to be taken in accordance with the schedules specified (refer section 6 'Measurement schedules') before and during the constant discharge test (the recovery period from this test is considered separately) in all bores identified for inclusion in the program and recorded with the times they are taken.
 - Measurements of discharge are to be taken in accordance with the schedules specified (refer section 6 'Measurement schedules') during the test to confirm there is no drop-off or decline in the selected rate for the respective pumping period and recorded with the times they are taken.
 - All measurements, times and rates are to be made at the required accuracy (refer section 3 'Measurement standards'), documented and provided in the final report.
- **Recovery test**
 - Measurements of water levels are to be taken in accordance with the schedules specified (refer section 6 'Measurement schedules') after the constant discharge test in all bores identified for inclusion in the program and recorded with the times they are taken.
 - All measurements, times and rates are to be made at the required accuracy (refer section 3 'Measurement standards'), documented and provided in the final report.

3. Measurement standards

Measurements taken throughout the pumping and recovery periods of the test must be sufficiently accurate and precise to enable a thorough assessment. Table 1 lists the minimum measurement standards.

Table 1. Measurements and required accuracy

| Measurement | Units | Accuracy | Comment |
|-------------|---------|--|---|
| Time | Minutes | Error no greater than the following: <ul style="list-style-type: none"> • Five seconds during first ten minutes • Thirty seconds between ten minutes and one hour • One minute after one hour | Synchronisation of time keeping instruments may be required for tests involving numerous monitoring points. We recommend the use of an electronic water level sensor with continuous recorder. (refer s. 3.3.4.2 of AS 2368—1990) |
| Discharge | Litres | Nearest one litre irrespective of measurement method | Measurements using a flow meter are required where the discharge rate exceeds 10 L/s. |
| Water level | Metres | Resolution no less than the following: <ul style="list-style-type: none"> • Nearest 0.005 m (5 mm) in observation bores • Nearest 0.01 m (10 mm) in discharging bores | Measurements to the nearest metre are not suitable to demonstrate the effects of pumping. We recommend the use of an electronic water level sensor with continuous recorder. (refer s. 3.3.4.4 of AS 2368—1990) |
| Distance | Metres | Separation from pumped bore to each significant feature: <ul style="list-style-type: none"> • Nearest one metre to a property boundary (in every direction) • Nearest one metre to any observation bore • Nearest one metre to any septic tank or sewage system on-site | Measurements of distance using a 30 m or longer tape measure are acceptable if the applicant lays out the tape carefully. |

4. Selection of test duration

Table 2 lists minimum test durations based on the proposed operating regime of the subject bore.

Table 2. Minimum durations of pumping tests and recovery periods

| Operational use | Minimum durations | Example applications |
|---|---------------------------------------|---|
| Periodic and intermittent | 24 hours pumping 18 hours recovery | Domestic and stock supplies |
| Continuous or semi-continuous over 200 days | 48 hours pumping 36 hours recovery | Seasonal irrigation Larger diameter bores (>200 mm), hand dug wells or excavations (irrespective of purpose) Water supply to other properties |
| Continuous or semi-continuous over 365 days | 72 hours pumping 48 hours recovery | Town water supplies Mining and extractive industries |

The durations outlined in the table above are broadly consistent with those specified in AS 2368—1990 for medium- to high-usage facilities.

The durations specified are the *minimum* lengths of time for pumping and recovery to be monitored and, in accordance with AS 2368—1990, the tests should be extended where the consequences of a water supply failing are significant. For example, a bore intended to provide town water supply for a major rural centre may need to be tested for considerably longer periods to confirm its reliability.

5. Selection of discharge rate

The discharge rate selected for the test must be sufficient to provide meaningful data on the behaviour of the groundwater system. Minimum discharge rates have been determined from the equivalent instantaneous pumping (L/s) required to achieve the requested volume over the defined operating period (either 200 days or 365 days). Those values are multiplied by a percentage factor to account for the risk in extrapolating short-term and limited test data to the prediction of effects at operating rates over prolonged durations. Table 3 lists the adopted multiplication factors.

Table 3. Multiplication factors for determining minimum test discharge rates

| Requested volume range (ML/y) | Risk of error band in extrapolation of short-term test results | Multiplication factor to account for the risk |
|-------------------------------|--|---|
| 20 or less | Very low | 100% |
| 21–50 | Low | 125% |
| 51–100 | Moderate | 150% |
| 101–200 | High | 175% |
| 201–500 | Very high | 200% |
| 500 or greater | Extreme | 250% |

Table 4 provides a guide for the minimum test discharge rates corresponding to the volume of water requested on the application up to 500 ML/y where continuous or semi-continuous pumping is proposed. For volumes over 500 ML/y, the applicant must confirm the required discharge rate with the department before any testing.

The minimum discharge rates can be varied if the results of a preliminary test (refer s. 5.3.2 of AS 2368—1990) demonstrate that the flow cannot practically be achieved. Changes to the minimum discharge rate requirement in the design and operation of a pumping test are only permitted under written agreement from the department (refer section 1.3 'Exceptions and variations').

If the preliminary test shows that the capacity of the bore far exceeds the minimum discharge rate, then the pumping test should be conducted at an appropriately higher flow than that specified in the table.

For consistency and convenience, bores that will be operated only periodically can also be tested at the specified minimum discharge rates.

The minimum discharge rates listed in the table may be rounded up to the nearest litre per second for convenience when designing the test but are not to be rounded down.

Table 4. Minimum test discharge rates for requested volumes up to 500 ML

| Requested volume (ML) | Continuous pumping over 200 days | | Continuous pumping over 365 days | | Multiplication factor |
|-----------------------|---------------------------------------|-----------------------------------|---------------------------------------|-----------------------------------|-----------------------|
| | Equivalent discharge rate range (L/s) | Minimum test discharge rate (L/s) | Equivalent discharge rate range (L/s) | Minimum test discharge rate (L/s) | |
| 3–10 | 0.2–0.6 | 0.6 | 0.1–0.3 | 0.3 | 100% |
| 11–20 | 0.6–1.2 | 1.2 | 0.3–0.6 | 0.6 | |
| 21–30 | 1.2–1.7 | 2.1 | 0.7–1.0 | 1.3 | 125% |
| 31–40 | 1.8–2.3 | 2.9 | 1.0–1.3 | 1.6 | |
| 41–50 | 2.4–2.9 | 3.6 | 1.3–1.6 | 2.0 | |
| 51–60 | 3.0–3.5 | 5.3 | 1.6–1.9 | 2.9 | 150% |
| 61–70 | 3.5–4.1 | 6.2 | 1.9–2.2 | 3.3 | |
| 71–80 | 4.1–4.6 | 6.9 | 2.3–2.5 | 3.8 | |
| 81–90 | 4.7–5.2 | 7.8 | 2.6–2.9 | 4.4 | |
| 91–100 | 5.3–5.8 | 8.7 | 2.9–3.2 | 4.8 | 175% |
| 101–110 | 5.8–6.4 | 11.2 | 3.2–3.5 | 6.1 | |
| 111–120 | 6.4–6.9 | 12.1 | 3.5–3.8 | 6.7 | |
| 121–130 | 7.0–7.5 | 13.1 | 3.8–4.1 | 7.2 | |
| 131–140 | 7.6–8.1 | 14.2 | 4.2–4.4 | 7.7 | |
| 141–150 | 8.2–8.7 | 15.2 | 4.5–4.8 | 8.4 | |
| 151–160 | 8.7–9.3 | 16.3 | 4.8–5.1 | 8.9 | |
| 161–170 | 9.3–9.8 | 17.2 | 5.1–5.4 | 9.5 | |
| 171–180 | 9.9–10.4 | 18.2 | 5.4–5.7 | 10.0 | |
| 181–190 | 10.5–11.0 | 19.3 | 5.7–6.0 | 10.5 | |
| 191–200 | 11.1–11.6 | 20.3 | 6.1–6.3 | 11.0 | 200% |
| 201–210 | 11.6–12.2 | 24.4 | 6.4–6.7 | 13.4 | |
| 211–220 | 12.2–12.7 | 25.4 | 6.7–7.0 | 14.0 | |
| 221–230 | 12.8–13.3 | 26.6 | 7.0–7.3 | 14.6 | |
| 231–240 | 13.4–13.9 | 27.8 | 7.3–7.6 | 15.2 | |
| 241–250 | 13.9–14.5 | 29.0 | 7.6–7.9 | 15.8 | |
| 251–260 | 14.5–15.0 | 30.0 | 8.0–8.2 | 16.4 | |
| 261–270 | 15.1–15.6 | 31.2 | 8.3–8.6 | 17.2 | |
| 271–280 | 15.7–16.2 | 32.4 | 8.6–8.9 | 17.8 | |
| 281–290 | 16.3–16.8 | 33.6 | 8.9–9.2 | 18.4 | |
| 291–300 | 16.8–17.4 | 34.8 | 9.2–9.5 | 19.0 | |
| 301–310 | 17.4–17.9 | 35.8 | 9.5–9.8 | 19.6 | |
| 311–320 | 18.0–18.5 | 37.0 | 9.9–10.1 | 20.2 | |
| 321–330 | 18.6–19.1 | 38.2 | 10.2–10.5 | 21.0 | |
| 331–340 | 19.2–19.7 | 39.4 | 10.5–10.8 | 21.6 | |
| 341–350 | 19.7–20.3 | 40.6 | 10.8–11.1 | 22.2 | |
| 351–360 | 20.3–20.8 | 41.6 | 11.1–11.4 | 22.8 | |
| 361–370 | 20.9–21.4 | 42.8 | 11.4–11.7 | 23.4 | |
| 371–380 | 21.5–22.0 | 44.0 | 11.8–12.0 | 24.0 | |
| 381–390 | 22.0–22.6 | 45.2 | 12.1–12.4 | 24.8 | |
| 391–400 | 22.6–23.1 | 46.2 | 12.4–12.7 | 25.4 | |
| 401–410 | 23.2–23.7 | 47.4 | 12.7–13.0 | 26.0 | |
| 411–420 | 23.8–24.3 | 48.6 | 13.0–13.3 | 26.6 | |
| 421–430 | 24.4–24.9 | 49.8 | 13.3–13.6 | 27.2 | |
| 431–440 | 24.9–25.5 | 51.0 | 13.7–14.0 | 28.0 | |
| 441–450 | 25.5–26.0 | 52.0 | 14.0–14.3 | 28.6 | |
| 451–460 | 26.1–26.6 | 53.2 | 14.3–14.6 | 29.2 | |
| 461–470 | 26.7–27.2 | 54.4 | 14.6–14.9 | 29.8 | |
| 471–480 | 27.3–27.8 | 55.6 | 14.9–15.2 | 30.4 | |
| 481–490 | 27.8–28.4 | 56.8 | 15.3–15.5 | 31.0 | |
| 491–500 | 28.4–28.9 | 57.8 | 15.6–15.9 | 31.8 | |

6. Measurement schedules

6.1 Pumping and recovery phases measurement schedules

Water level and discharge rate measurements must be taken at specific times throughout the pumping period and the recovery period of the test (see Table 5).

Table 5. Measurement schedules for water levels and discharge rate

| Test phase | Water level measurement schedule (since start of pumping or start of recovery periods) | Discharge rate measurement schedule (since start of pumping period) |
|-----------------|--|---|
| 0 to 10 min | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 min | 10 min |
| 10 to 20 min | 12, 14, 16, 18, 20 min | 20 min |
| 20 to 60 min | 25, 30, 35, 40, 45, 50, 55, 60 min | 30, 40, 50, 60 min |
| 1 to 8 hr | 90, 100 , 120, 150, 180, 210, 240, 270, 300, 330, 360, 390, 420, 450, 480 min | 90, 100 , 120, 180, 240, 300, 360, 420, 480 min |
| 8 to 24 hr | 9, 10, 11, 12, 13, 14, 15, 16, 16.7 (1,000 min) , 17, 18, 19, 20, 21, 22, 23, 24 hr | Every time a water level measurement is taken |
| 24 to 48 hr | 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48 hr | Every time a water level measurement is taken |
| More than 48 hr | Every 4 hr | Every time a water level measurement is taken |

Measurements of discharge rate should be taken frequently throughout the test to establish that a constant rate is being maintained. This is necessary to identify:

- a decline in discharge rate with an increase in pumping head as the water level is lowered in the bore, or
- development of an equilibrium between the discharge rate and groundwater inflow from the aquifer.

Changes to the above measurement schedules in the design and operation of a pumping test are only permitted under written agreement from the department (refer section 1.3 'Exceptions and variations').

6.2 Critical measurements

There are five measurements of water level and four measurements of discharge that are considered critical during the preliminary and pumping phases of the testing, these being the:

- initial standing water level (SWL) prior to starting the test
- water level and discharge rate at 10 minutes after the start of the test
- water level and discharge rate at 100 minutes after the start of the test
- water level and discharge rate at 1,000 minutes after the start of the test
- final drawdown level and discharge rate immediately prior to the end of the test

Applicants must complete these critical measurements as near as possible to the actual time scheduled. Applicants should prioritise these measurements when planning the testing so that they can record information at these critical points.

7. Reporting

Applicants must give the department a pumping test report identifying the key aspects of the bore and proposed water supply operation. The report must meet the requirements outlined below (Table 6).

Applicants must give the department the test measurement data on the prescribed forms (sample forms are included in Appendices 1 to 7 for reference) in an electronic file format appropriate for specialist analysis. Electronic versions of these forms are available from the department on request. The reporting requirements cover the basic information needed to demonstrate due diligence with water management legislation and regulation.

Table 6. Contents of pumping test report

| Section | Required information |
|------------------------------|--|
| Introduction | <ul style="list-style-type: none"> • Landholder’s name • Property address and Lot and DP numbers • Details of current authorisations and relevant application |
| Geology and physiography | <ul style="list-style-type: none"> • Terrain, weather during test • Tidal influence in coastal areas • Stratigraphy intersected by the subject bore • Identification of geological unit boundaries or structural features around the property |
| Hydrogeology | <ul style="list-style-type: none"> • Identification of applicable groundwater source and water sharing plan • Tabulated list of neighbouring bores including work number, date of completion, depth, water bearing zones, stratigraphy, lithology, standing water level, yield and salinity, elevation, distance from pumping bore. |
| Subject bore details | <ul style="list-style-type: none"> • Site details including elevation • Drilling record • Bore construction • Lithological description of subsurface materials • Depth of water bearing zones and standing water level (SWL) • Depth of slotted or screened intervals |
| Pumping and recovery results | <ul style="list-style-type: none"> • Date and time at start of test • Date and time at end of pumping period/start of recovery period • Date and time at end of recovery period • Specifications of pump used • Calculated specific capacities of bore at 10, 100 and 1,000 minutes elapsed time. • Calculated transmissivity, hydraulic conductivity and storage coefficient (or specific yield) • List of analytical assumptions (well hydraulic theory) • Conceptualisation of the aquifer type (confined, unconfined, semi-confined) • Identification of any boundary responses in results and possible attribution to barrier or recharge conditions |
| Groundwater quality | <ul style="list-style-type: none"> • Description of initial groundwater quality within subject bore • Tabulated summary of any required water quality analytical results and all routine field measurements (to identify any changes occurring throughout the test) |
| Figures | <ul style="list-style-type: none"> • Diagram illustrating location of property • Scaled map with coordinates showing location of production and observation bores • Illustration of bore construction • Plot of drawdown versus time used for analysis |
| Attachments | <ul style="list-style-type: none"> • All raw measurement data in electronic format • Copies of written agreements for variations • Signed statement of completion of the test to these requirements with qualifications of the supervising person |

Changes to the above reporting requirements for a pumping test are only permitted under written agreement from the department (refer section 1.3 ‘Exceptions and variations’).

8. Examples of completed tests

8.1 Tests suitable for assessment

Appropriately designed and implemented pumping test programs provide meaningful results for the assessment of proposed groundwater use. Examples of well-conducted testing, measurement and data reporting are illustrated below for reference (Figure 1) for both a constant rate test and a multistage (step drawdown) test.

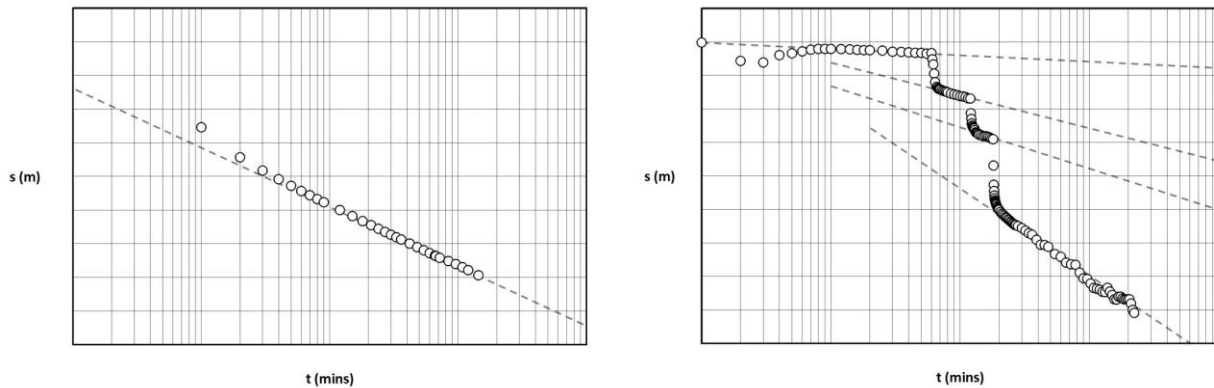


Figure 1. Examples of actual pumping tests—well conducted testing, measurement and data reporting

The examples shown above would be considered acceptable and would allow an assessment to be completed by the department.

8.2 Tests not suitable for assessment

Tests are not suitable for the purpose of graphical analysis where:

- no measurable drawdown has been recorded (that is, there is no slope on the line of visual fit)
- drawdown measurements have been recorded to the nearest metre (that is, the data is not accurate enough for assessment)
- only one discharge rate measurement has been recorded (that is, the data is not accurate enough for assessment).
- pump capacity only is mentioned at the start of the test and no discharge readings are provided (i.e. the data is not accurate enough for assessment)
- raw data is incorrectly reported (for example, discharge rate measurement units are in error)
- discharge rate has not been kept constant (that is, the flow is not maintained within $\pm 5\%$ of initial rate).

Where the results of a pumping test are not suitable for assessment, the department will not accept the report and may reject the application for a lack of appropriate supporting information. In such cases, the applicant may need to repeat the test to address the identified shortcomings.

Figure 2 and Figure 3 illustrate poorly conducted tests for reference. The first two examples show the results of testing with a discharge rate that is not suitable to obtain meaningful results. The second two examples show the results of testing where there was not enough control over the discharge rate to maintain a constant flow throughout the pumping test.

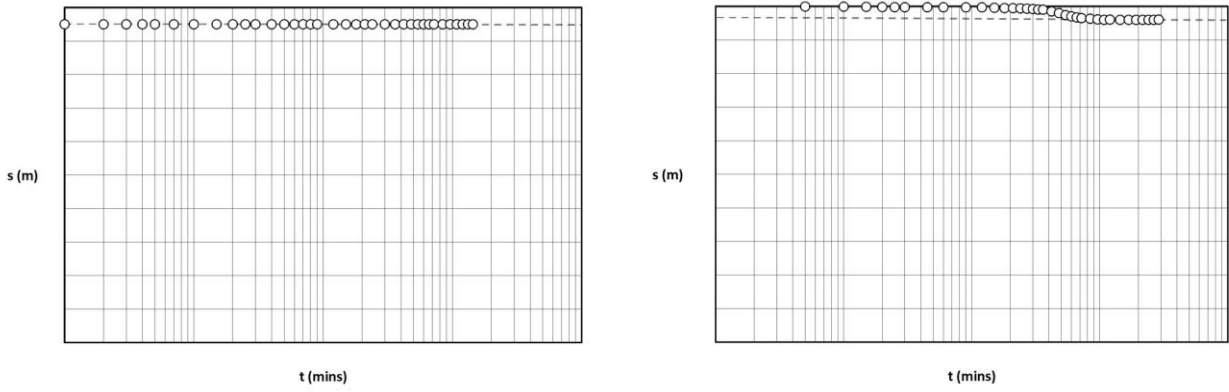


Figure 2. Examples of actual pumping tests—selected discharge rate too low

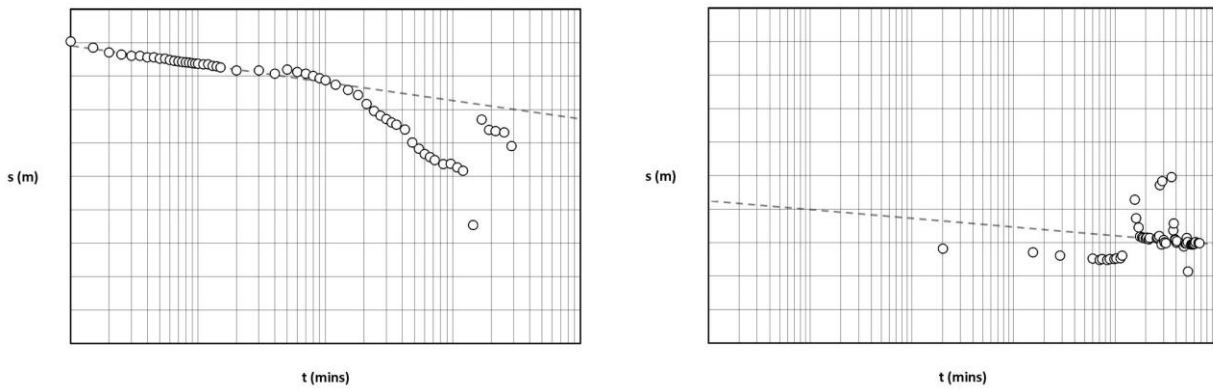


Figure 3. Examples of actual pumping tests—discharge rate not maintained at constant flow

The examples shown above would not be considered acceptable and would require the pumping test to be repeated.

Appendix 1—Multistage test drawdown forms

Multi Stage Pumping Test (Pumping bore)



Planning,
Industry &
Environment

Owner:

Bore Licence No: Bore number/name :

GPS Location:

Date of test : Tested by :

Weather condition:

Description of Reference Point :

Height of reference point above ground surface (m) :

Depth to top of screens/slots (m) : Depth to bottom of screens/slots (m) : Depth of pump intake (m) :

Pump Type : Method of measuring discharge :

| Actual time | Time Since Pumping Started | | Depth to Water from reference point Metres | Pumping Rate L/s | Remarks (changed pump rate) |
|-------------|----------------------------|---------|---|---------------------|--------------------------------------|
| | Hour | Minutes | | | |
| | 0 | 0 | | | Initial water level stage 1 |
| | | 1 | | | |
| | | 2 | | | |
| | | 3 | | | |
| | | 4 | | | |
| | | 6 | | | |
| | | 8 | | | |
| | | 10 | | | |
| | | 15 | | | |
| | | 20 | | | |
| | | 30 | | | |
| | | 45 | | | |
| | 1 | 60 | | | |
| | | 75 | | | |
| | | 90 | | | |
| | 2 | 120 | | | |
| | | 1 | | | Discharge rate increased for stage 2 |
| | | 2 | | | |
| | | 3 | | | |
| | | 4 | | | |
| | | 6 | | | |
| | | 8 | | | |
| | | 10 | | | |
| | | 15 | | | |
| | | 20 | | | |
| | | 30 | | | |
| | | 45 | | | |
| | 1 | 60 | | | |
| | | 75 | | | |
| | | 90 | | | |
| | 2 | 120 | | | |

Note: The above times are the recommended ones at which readings of water level and pumping rate should be made. Should the measurements be made at other times, it is essential that the actual times at which the measurements are made be recorded.

Multi Stage Pumping Test

[Continued]



Planning,
Industry &
Environment

Owner:

Bore Licence No: Bore number/name :

Date of test : Tested by :

Weather condition:

| Actual time | Time Since Pumping Started | | Depth to Water from reference point | Pumping Rate | Remarks (changed pump rate, neighbouring bore pumping...) |
|-------------|----------------------------|---------|-------------------------------------|--------------|--|
| | Hour | Minutes | | | |
| | | 1 | | | Discharge rate increased for stage 3 |
| | | 2 | | | |
| | | 3 | | | |
| | | 4 | | | |
| | | 6 | | | |
| | | 8 | | | |
| | | 10 | | | |
| | | 15 | | | |
| | | 20 | | | |
| | | 30 | | | |
| | | 45 | | | |
| 1 | | 60 | | | |
| | | 75 | | | |
| | | 90 | | | |
| 2 | | 120 | | | |
| | | 1 | | | Discharge rate increased for stage 4 |
| | | 2 | | | |
| | | 3 | | | |
| | | 4 | | | |
| | | 6 | | | |
| | | 8 | | | |
| | | 10 | | | |
| | | 15 | | | |
| | | 20 | | | |
| | | 30 | | | |
| | | 45 | | | |
| 1 | | 60 | | | |
| | | 75 | | | |
| | | 90 | | | |
| 2 | | 120 | | | |

Note: The above times are the recommended ones at which readings of water level and pumping rate should be made. Should the measurements be made at other times, it is essential that the actual times at which the measurements are made be recorded.

Appendix 2—Single rate test pumping bore drawdown forms

Single Rate Pumping Test (Pump Drawdown)

(Pumping bore)



Planning, Industry & Environment

Owner:

Bore Licence No: Bore number/name :

GPS Location:

Date of test : Tested by :

Weather condition:

Description of Reference Point

Height of reference point above ground surface (m) :

Depth to top of screens/slots (m) : Depth to bottom of screens/slots (m) : Depth of pump intake (m) :

Pump Type : Method of measuring discharge :

| Actual Time and Date | Time Since Pumping Started | | Depth to Water from reference point | Flow meter Readings | Pumping Rate | Remarks (changed pump rate, neighbouring bore pumping...) |
|----------------------|----------------------------|------------|-------------------------------------|---------------------|--------------|--|
| | Hour | Minutes | | | | |
| | 0 | 0 | | | | ** Mandatory pumping rate measurement |
| | | 1 | | | | Initial Standing Water Level |
| | | 2 | | | | |
| | | 3 | | | | |
| | | 5 | | | | |
| | | 6 | | | | |
| | | 7 | | | | |
| | | 8 | | | | |
| | | 9 | | | | |
| | | 10 | | | | ** |
| | | 12 | | | | |
| | | 14 | | | | |
| | | 16 | | | | |
| | | 18 | | | | |
| | | 20 | | | | ** |
| | | 25 | | | | |
| | 0.5 | 30 | | | | ** |
| | | 35 | | | | ** |
| | | 40 | | | | ** |
| | | 45 | | | | |
| | | 50 | | | | ** |
| | | 55 | | | | |
| | 1 | 60 | | | | ** |
| | | 90 | | | | ** |
| | | 100 | | | | ** |
| | 2 | 120 | | | | ** |
| | | 150 | | | | |
| | 3 | 180 | | | | ** |
| | | 210 | | | | |
| | 4 | 240 | | | | ** |
| | | 270 | | | | |
| | 5 | 300 | | | | ** |
| | | 330 | | | | |
| | 6 | 360 | | | | ** |

Note: Minimum duration of this pumping test must be for 24 hours.
The above times are the recommended ones at which readings of water level and pumping rate should be made. Should the measurements be made at other times, it is essential that the actual times at which the measurements are made be recorded.

Single Rate Pumping Test (Pump Drawdown Continued) (Pumping bore)

Owner:



Planning,
Industry &
Environment

Bore Licence No: Bore number/name:

Date of test: Tested by:

| Actual Time and Date | Time Since Pumping Started | | Depth to Water from reference point Metres | Flow meter Readings | Pumping Rate L/s | Remarks (changed pump rate, neighbouring bore pumping...) |
|----------------------|----------------------------|-------------|---|---------------------|---------------------|--|
| | Hour | Minutes | | | | |
| | | 390 | | | | ** Mandatory pumping rate measurement |
| | 7 | 420 | | | | ** |
| | | 450 | | | | |
| | 8 | 480 | | | | ** |
| | 9 | 540 | | | | ** |
| | 10 | 600 | | | | ** |
| | 11 | 660 | | | | ** |
| | 12 | 720 | | | | ** |
| | 13 | 780 | | | | ** |
| | 14 | 840 | | | | ** |
| | 15 | 900 | | | | ** |
| | 16 | 960 | | | | ** |
| | 16.7 | 1000 | | | | ** |
| | 17 | 1020 | | | | ** |
| | 18 | 1080 | | | | ** |
| | 19 | 1140 | | | | ** |
| | 20 | 1200 | | | | ** |
| | 21 | 1260 | | | | ** |
| | 22 | 1320 | | | | ** |
| | 23 | 1380 | | | | ** |
| | 24 | 1440 | | | | ** |
| | 26 | 1560 | | | | ** |
| | 28 | 1680 | | | | ** |
| | 30 | 1800 | | | | ** |
| | 32 | 1920 | | | | ** |
| | 34 | 2040 | | | | ** |
| | 36 | 2160 | | | | ** |
| | 38 | 2280 | | | | ** |
| | 40 | 2400 | | | | ** |
| | 42 | 2520 | | | | ** |
| | 44 | 2640 | | | | ** |
| | 46 | 2760 | | | | ** |
| | 48 | 2880 | | | | ** |
| | 52 | 3120 | | | | ** |
| | 56 | 3360 | | | | ** |
| | 60 | 3600 | | | | ** |
| | 64 | 3840 | | | | ** |
| | 68 | 4080 | | | | ** |
| | 72 | 4320 | | | | ** |
| | 76 | 4560 | | | | ** |
| | 80 | 4800 | | | | ** |
| | 84 | 5040 | | | | ** |
| | 88 | 5280 | | | | ** |
| | 92 | 5520 | | | | ** |
| | 96 | 5760 | | | | ** |

Appendix 3—Single rate test pumping bore recovery forms

Recovery Records after Single Rate Pumping

(Pumping bore)



Planning, Industry & Environment

Owner:

Bore Licence No: Bore number/name :

Date of test : Tested by :

Weather condition:

Description of Reference Point

Height of reference point above ground surface (m) :

Depth to top of screens/slots (m) : Depth to bottom of screens/slots (m) :

Time pumping stopped : Time pumping started :

| Actual Time and Date | Time Since Pumping Stopped | | Depth to Water from reference point Metres | Remarks |
|----------------------|----------------------------|------------|---|--|
| | Hour | Minutes | | |
| | 0 | 0 | | Pumped Water Level just before pumping stopped |
| | | 1 | | |
| | | 2 | | |
| | | 3 | | |
| | | 5 | | |
| | | 6 | | |
| | | 7 | | |
| | | 8 | | |
| | | 9 | | |
| | | 10 | | |
| | | 12 | | |
| | | 14 | | |
| | | 16 | | |
| | | 18 | | |
| | | 20 | | |
| | | 25 | | |
| | 0.5 | 30 | | |
| | | 35 | | |
| | | 40 | | |
| | | 45 | | |
| | | 50 | | |
| | | 55 | | |
| | 1 | 60 | | |
| | | 90 | | |
| | | 100 | | |
| | 2 | 120 | | |
| | | 150 | | |
| | 3 | 180 | | |
| | | 210 | | |
| | 4 | 240 | | |
| | | 270 | | |
| | 5 | 300 | | |
| | | 330 | | |
| | 6 | 360 | | |
| | | 390 | | |
| | 7 | 420 | | |
| | | 450 | | |

Note: Duration of this recovery monitoring should be at least 18 hours.
 The above times are the recommended ones at which readings of water level should be made.
 Should the measurements be made at other times, it is essential that the actual times at which the measurements are made be recorded.

Recovery Records after Single Rate Pumping (Continued) (Pumping bore)



Planning,
Industry &
Environment

Owner:

Bore Licence No: Bore number/name :

Date of test : Tested by :

| Actual Time and Date | Time Since Pumping Started | | Depth to Water from reference point Metres | Flow meter Readings | Pumping Rate L/s | Remarks |
|----------------------|----------------------------|------|---|---------------------|---------------------|---------|
| | Hour | Days | | | | |
| | 8 | 480 | | | | |
| | 9 | 540 | | | | |
| | 10 | 600 | | | | |
| | 11 | 660 | | | | |
| | 12 | 720 | | | | |
| | 13 | 780 | | | | |
| | 14 | 840 | | | | |
| | 15 | 900 | | | | |
| | 16 | 960 | | | | |
| | 16.7 | 1000 | | | | |
| | 17 | 1020 | | | | |
| | 18 | 1080 | | | | |
| | 19 | 1140 | | | | |
| | 20 | 1200 | | | | |
| | 21 | 1260 | | | | |
| | 22 | 1320 | | | | |
| | 23 | 1380 | | | | |
| | 24 | 1440 | | | | |
| | 26 | 1560 | | | | |
| | 28 | 1680 | | | | |
| | 30 | 1800 | | | | |
| | 32 | 1920 | | | | |
| | 34 | 2040 | | | | |
| | 36 | 2160 | | | | |
| | 38 | 2280 | | | | |
| | 40 | 2400 | | | | |
| | 42 | 2520 | | | | |
| | 44 | 2640 | | | | |
| | 46 | 2760 | | | | |
| | 48 | 2880 | | | | |
| | 52 | 3120 | | | | |
| | 56 | 3360 | | | | |
| | 60 | 3600 | | | | |
| | 64 | 3840 | | | | |
| | 68 | 4080 | | | | |
| | 72 | 4320 | | | | |
| | 76 | 4560 | | | | |
| | 80 | 4800 | | | | |
| | 84 | 5040 | | | | |
| | 88 | 5280 | | | | |
| | 92 | 5520 | | | | |
| | 96 | 5760 | | | | |

Appendix 4—Single rate test observation bore drawdown forms

Drawdown Records (Single Rate Test)

(Observation Bore / Nearby Bore)



Planning, Industry & Environment

Owner:

Bore Licence No: Bore number/name :

GPS Location: Distance from Pumping Test Bore:

Date of test : Tested by :

Weather condition:

Description of Reference Point :

Height of reference point above ground surface (m) :

Distance from pumping bore (metres): S.W.L.(metres):

Depth to top of screens or slots (metres): Depth to bottom of screens or slots (m) :

Time Pumping Started : Time pumping stopped :

| Actual Time and Date | Time Since Pumping Started | | Depth to Water from reference point (metres) | Remarks |
|----------------------|----------------------------|---------|--|------------------------------|
| | Hour | Minutes | | |
| | 0 | 0 | | Initial Standing Water Level |
| | | 1 | | |
| | | 2 | | |
| | | 3 | | |
| | | 5 | | |
| | | 6 | | |
| | | 7 | | |
| | | 8 | | |
| | | 9 | | |
| | | 10 | | |
| | | 12 | | |
| | | 14 | | |
| | | 16 | | |
| | | 18 | | |
| | | 20 | | |
| | | 25 | | |
| | 0.5 | 30 | | |
| | | 35 | | |
| | | 40 | | |
| | | 45 | | |
| | | 50 | | |
| | | 55 | | |
| | 1 | 60 | | |
| | | 90 | | |
| | | 100 | | |
| | 2 | 120 | | |
| | | 150 | | |
| | 3 | 180 | | |
| | | 210 | | |
| | 4 | 240 | | |
| | | 270 | | |
| | 5 | 300 | | |
| | | 330 | | |

- Note:**
- The above times are the recommended ones at which readings of water level should be made. Should the measurements be made at other times, it is essential that the actual time at which the measurements are made be recorded.
 - If you have more than one observation bore, then please make copies of this sheet.

Drawdown Records (Single Rate Test Continued)

(Observation Bore / Nearby Bore)



Planning,
Industry &
Environment

Bore Licence No:

Date :

Bore No./name :

S.W.L.(metres):

| Actual Time and Date | Time Since Pumping Started | | Depth to Water from reference point (metres) | Remarks |
|----------------------|----------------------------|------|--|---------|
| | Hour | Days | | |
| | 6 | 360 | | |
| | | 390 | | |
| | 7 | 420 | | |
| | | 450 | | |
| | 8 | 480 | | |
| | 9 | 540 | | |
| | 10 | 600 | | |
| | 11 | 660 | | |
| | 12 | 720 | | |
| | 13 | 780 | | |
| | 14 | 840 | | |
| | 15 | 900 | | |
| | 16 | 960 | | |
| | 16.7 | 1000 | | |
| | 17 | 1020 | | |
| | 18 | 1080 | | |
| | 19 | 1140 | | |
| | 20 | 1200 | | |
| | 21 | 1260 | | |
| | 22 | 1320 | | |
| | 23 | 1380 | | |
| | 24 | 1440 | | |
| | 26 | 1560 | | |
| | 28 | 1680 | | |
| | 30 | 1800 | | |
| | 32 | 1920 | | |
| | 34 | 2040 | | |
| | 36 | 2160 | | |
| | 38 | 2280 | | |
| | 40 | 2400 | | |
| | 42 | 2520 | | |
| | 44 | 2640 | | |
| | 46 | 2760 | | |
| | 48 | 2880 | | |
| | 48 | 2880 | | |
| | 52 | 3120 | | |
| | 56 | 3360 | | |
| | 60 | 3600 | | |
| | 64 | 3840 | | |
| | 68 | 4080 | | |
| | 72 | 4320 | | |
| | 76 | 4560 | | |
| | 80 | 4800 | | |
| | 84 | 5040 | | |

Appendix 5—Single rate test observation bore recovery forms

Recovery Records (Single Rate Test) (Observation Bore / Nearby Bore)



Owner:

Bore Licence No: Bore number/name :

GPS Location: Distance from Pumping Test Bore:

Date of test : Tested by :

Weather condition:

Description of Reference Point :

Height of reference point above ground surface (m) :

Distance from pumping bore (metres): S.W.L.(metres):

Depth to top of screens or slots (metres): Depth to bottom of screens or slots (m) :

Time Pumping Started : Time pumping stopped :

| Actual Time and Date | Time Since Pumping Started | | Depth to Water from reference point (metres) | Remarks |
|----------------------|----------------------------|---------|--|------------------------------|
| | Hour | Minutes | | |
| | 0 | 0 | | Initial Standing Water Level |
| | | 1 | | |
| | | 2 | | |
| | | 3 | | |
| | | 5 | | |
| | | 6 | | |
| | | 7 | | |
| | | 8 | | |
| | | 9 | | |
| | | 10 | | |
| | | 12 | | |
| | | 14 | | |
| | | 16 | | |
| | | 18 | | |
| | | 20 | | |
| | | 25 | | |
| | 0.5 | 30 | | |
| | | 35 | | |
| | | 40 | | |
| | | 45 | | |
| | | 50 | | |
| | | 55 | | |
| | 1 | 60 | | |
| | | 90 | | |
| | | 100 | | |
| | 2 | 120 | | |
| | | 150 | | |
| | 3 | 180 | | |
| | | 210 | | |
| | 4 | 240 | | |
| | | 270 | | |
| | 5 | 300 | | |
| | | 330 | | |

- Note:**
- The above times are the recommended ones at which readings of water level should be made. Should the measurements be made at other times, it is essential that the actual time at which the measurements are made be recorded.
 - If you have more than one observation bore, then please make copies of this sheet.

Recovery Records (Single Rate Test Continued) (Observation Bore / Nearby Bore)



Planning,
Industry &
Environment

Bore Licence No:

Date:

Bore No./name:

S.W.L.(metres):

| Actual Time and Date | Time Since Pumping Started | | Depth to Water from reference point (metres) | Remarks |
|----------------------|----------------------------|------|--|---------|
| | Hour | Days | | |
| | 6 | 360 | | |
| | | 390 | | |
| | 7 | 420 | | |
| | | 450 | | |
| | 8 | 480 | | |
| | 9 | 540 | | |
| | 10 | 600 | | |
| | 11 | 660 | | |
| | 12 | 720 | | |
| | 13 | 780 | | |
| | 14 | 840 | | |
| | 15 | 900 | | |
| | 16 | 960 | | |
| | 16.7 | 1000 | | |
| | 17 | 1020 | | |
| | 18 | 1080 | | |
| | 19 | 1140 | | |
| | 20 | 1200 | | |
| | 21 | 1260 | | |
| | 22 | 1320 | | |
| | 23 | 1380 | | |
| | 24 | 1440 | | |
| | 26 | 1560 | | |
| | 28 | 1680 | | |
| | 30 | 1800 | | |
| | 32 | 1920 | | |
| | 34 | 2040 | | |
| | 36 | 2160 | | |
| | 38 | 2280 | | |
| | 40 | 2400 | | |
| | 42 | 2520 | | |
| | 44 | 2640 | | |
| | 46 | 2760 | | |
| | 48 | 2880 | | |
| | 48 | 2880 | | |
| | 52 | 3120 | | |
| | 56 | 3360 | | |
| | 60 | 3600 | | |
| | 64 | 3840 | | |
| | 68 | 4080 | | |
| | 72 | 4320 | | |
| | 76 | 4560 | | |
| | 80 | 4800 | | |
| | 84 | 5040 | | |

