Abstract
The Dutch colonial engineers had to encounter a completely different hydrological situation on Java than they knew from their home country. Nearly all Javanese rivers show an flow pattern with large fluctuations in and over days and seasons. The highly irregular rainfall, and the frequently very steep slope of those portions of the catchment basins situated upstream the plains, results in large flash floods. Dutch engineers needed a method to calculate the expected peak flood discharge. Knowledge of the behavior of Dutch rivers was not applicable on Java. One of the first locally adapted formulas used was the Lauterburg formula (from Austria) in the 1890s. However, use of the Lauterburg formula for smaller catchments (smaller than three hundred square kilometers, not an exception on Java) seemed to result in too high peak flows. A Dutch engineer Melchior developed a method, with gave good estimates for peak flows, although for larger catchments the estimates seemed to be too low. This research stimulated further discussions on peek discharge calculations.

Résumé
Les ingénieurs coloniaux néerlandais ont rencontré, à Java, une situation hydrologique complètement différente de celle de leur patrie. Presque tous les fleuves à Java manifestent un mode de courant avec des fluctuations importantes selon les jours et les saisons. La pluie très irrégulière et les versant fréquemment très escarpés des parties élevées de la surface de capture du fleuve, aboutissent à des crues exceptionnelles. Les ingénieurs néerlandais ont eu besoin d’une méthode pour calculer la crue maximale prévue. Leur connaissance du comportement des fleuves hollandais n’était pas applicable à Java. Une des premières formules en usage était la formule Lauterburg (d’Autriche), dans les années 1890. Cependant, l’usage de la formule Lauterburg sur des petites superficies (jusqu’à trois cents kilomètres carrés ne sont pas une exception à Java) impliquerait des crues maximales trop élevées. L’ingénieur néerlandais Melchior a
développé une méthode, qui fait une bonne estimation des crues. Pour de grandes régions, les estimations semblent trop basses. Ces recherches ont stimulé les discussions sur le calcul des crues.

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1. Introduction

In Irrigation Design Standards (1986), an irrigation design handbook of the Indonesian Department of Public Works, written with the assistance the Dutch consultancy firm DHV, the basic irrigation system design process is covered. One of the issues is how to determine the expected peak flow in the river, important for a safe design of river structures. The book mentions the so-called Melchior and Der Weduwen formula's as possible methods to estimate river discharges. Melchior and Der Weduwen are two Dutch irrigation engineers, who developed their methods when Indonesia was still a colony of the Netherlands. Melchior formulated his method to determine peak flows in the last decade of the XIXth century, whereas Der Weduwen published his method just before World War II, in 1937. Both the Melchior and Der Weduwen formula are variations of the Rational method (Institute, 1983). Their appearance in a design handbook gives credit to their creators. Nevertheless, their usefulness has not been uncontested. A flood design manual (Institute, 1983) published just before the Irrigation Design Standards, states that

[…] the Der Weduwen method does not perform particularly well and appears to consistently overestimate floods [...].

According to the same manual, despite some constraints in its use,

the Melchior approach for catchments greater than 100 km² produces reasonable results on the whole [...].

The discussions have not been restricted to recent years, however. In the colonial period, hydrology in general and peak flow hydrology in particular, has been debated upon extensively. This paper presents only a short overview of the debates in peak flow determination history, and concentrates on the first steps by Melchior, whose method after all still appears to be accepted by a larger audience. Most of the sources are in the Dutch language; therefore I translated them (and marked them AT: Authors’ Translation). The paper is part of a larger PhD-research by the author, with knowledge development of Dutch irrigation engineers as central topic. The final thesis (to be published at the end of 2003) will contain more detailed analyses and extended discussions on hydrology and other irrigation related topics as canal design and water management.
2. Irrigation

Irrigation technology has been an important factor in the expansion of sawah area in Indonesia from early times. Especially Javanese and Balinese peasants acquired the technology of wet rice cultivation over centuries, but irrigation was used on other islands of the archipelago too. The Dutch engineers had to encounter a different hydrological situation on Java than they knew from their home country, and they needed to re-establish a useful knowledge base to deal with it. A colonial irrigation technology developed over time. In the beginning of the twentieth century, when colonial irrigation engineers had established the beginnings of a systematical approach to irrigation design, many engineers admired their pioneering colleagues, but also criticized the way they had to work. Lack of maps, money and data, including hydrological information, was standard.

Working in rush, without previous study of water levels and flows, let alone of other hydrographically important particularities, practically became the rule. Thus, structures scarcely built, designed with a gross underestimation of the bandjir [flash-flood, ME]-powers of the rivers, were swept away. Others, built without knowledge about the smaller flows, disappointed in their water delivery. (Weijs, 1913) [AT]

Until about 1885 the Dutch usually designed the main structures (weirs in rivers, larger canals), and connected them to existing irrigation systems. From about 1885, this approach gave way to more planned (or technical-scientific) irrigation schemes, based upon the experiences of the earlier period. Extensive research preceded the building of systems, including complete networks of distribution canals as well as major structures. The development of hydrological knowledge applicable in the Javanese situation was one of the first steps taken by the engineers to overcome the natural problems posed on them by the Javanese environment. Especially the determination of the peak flows of the Javanese rivers was highly important, as the peak flow was one of the two most determining factors in weir stability (the other factor being the foundation). In half a century (1890–1940), the Dutch engineers studied and discussed the matter, and came up with a number of approaches. The development of applicable hydrological methods was part of the more general gradual development of a Dutch engineering irrigation approach on Java.

Engineers started building various main works on a small scale at the beginning of the nineteenth century. These works ultimately began to replace the Javanese works that had existed since time immemorial. Ever more often the construction materials used, such as stone and brick, were durable so it was supposed that the modern works would be more permanent than the transient Javanese facilities that had existed before. The
building of a modern weir in the Sampean river demonstrates that the rivers [...] were not so easy to control. (Ravesteijn, 1997)

The first weir in the Sampean river, on the eastern outskirts of Java (Figure 1), designed by Dutch engineers was built in 1832. From 1850, this wooden dam was replaced by several other stone-made weirs, who suffered heavily from the flash floods (bandjirs). In 1887 a more or less satisfactory solution was established, with a combination of weirs, sluices, river improvements and bypasses. Even then, the rapid floods of the Sampean river could damage the structures considerably, as in 1916 (Ravesteijn, 1997).

Figure 1 - Location of the Sampean river on Java

3. Hydrology

The struggle with the Sampean weir in particular provided the stimulus for the Dutch engineer Melchior to study ways to calculate the maximum flow of Javanese rivers (Melchior, 1895/96; Rietveld, 1932). Melchior developed a methodology that has been used throughout the colonial period, despite sometimes severe criticisms on its appropriateness. Melchior did not invent his formula ‘out of the blue’, but modified the approach of a Austrian engineer, Lauterburg (1877). The criticisms on the outcomes of Melchior were brought together by the Dutch engineer Van Kooten (1927), who used data from all over the world. In 1931, engineer Begemann published an article, in which he developed a first statistical approach to peak flow hydrology. Nevertheless, the Melchior formula remained the standard approach, until engineer Der Weduwen (1937) presented his method, which became the standard in the last few years of Dutch colonial power.
Within hydrology as a discipline, one encounters several sub-disciplines. A distinction between the important sub-disciplines of surface hydrology and groundwater hydrology, also marks a different interest between the Netherlands and the Netherlands East Indies. The rivers in the other Dutch colony, the Surinam, show similar characteristics as the Dutch rivers, with gradual flow-in and decreases, and no flash floods as on Java (De Vos, 1938).

Research on rainfall-runoff relations, which has been emphasized in foreign countries for long, used to be absent in the Netherlands until recently. That is to say, in the former Netherlands East Indies Dutch engineers conducted much research on the relation between tropical rainstorms and runoff flows (the so-called bandjirs). The small interest in our country is related to the natural environment. For the moderate rainfall, the permeable soils and the small terrain slopes together result in the fact that overland flow of rainfall appears hardly in our country. (De Vries, 1982). [AT]

As mentioned above, the relation between rainfall and maximum river flood discharge is the central topic of this contribution. In relation to maximum flows, two other topics have been thoroughly discussed in the Netherlands East Indies. I describe them shortly, and do not discuss them further yet. The first topic deals with the influence of forest and deforestation on river flows. Already in the 1860s the relation between deforestation and (diminishing) flows was discussed in the colony (Van Schaik, 1986). There was a growing concern about the increasing of bandjirs, both in frequency and extent. At the same time, flows in the dry (east monsoon) season became lower, causing problems in several important irrigation areas. By the end of the XIXth century, the deforestation caused by plantations (tea, coffee and tobacco) in the higher parts of the catchment was supposed to cause the changing flow regime, but clearings by the local population were discussed as well. In the first half of the XXth century, the discussion continued, with inputs from (civil and agricultural) engineers and foresters from the Forestry Agency. Attempts were made to clarify the relation between the east monsoon river flows and catchment characteristics, especially vegetation.

The other topic is reservoir hydrology. In the Javanese hydrological setting it is difficult to match water availability to actual water requirements in irrigation systems through a planned water distribution scheme. Water availability within the wet season fluctuates considerably and the difference in river flow between the wet and dry season is enormous. In order to be able to plan and execute a more regulated water distribution system, the possibility for (seasonal and intra-seasonal) storage was discussed. From about 1900 discussions started on storage, first focusing on storage within the irrigation system through night reservoirs. Later, the Dutch discussed possibilities for storage reservoirs outside the irrigation areas. The Dutch have built a few of those reservoirs more reservoirs have been built in Indonesia after independence. The colonial
reservoirs, like Pridjetan and Patjal with respective volumes of 9 and 50 million cubic meters, were relatively small compared to modern reservoirs.

4. Rainfall and rivers

Nearly all Javanese rivers show an flow pattern with large fluctuations in and over days and seasons, with the possibility of zero and maximum flow within 24 hours (particularly in the wet season). The highly irregular flow of the rivers in consequence of the very irregular rainfall, and the frequently very steep slope of higher parts of the catchment basins, upstream the plains, results in weirs generally needing to have a very large capacity in proportion to the area of the catchment basins. In view of the very unequal and frequently enormous quantities of rain that fall in a short period of time, it was often necessary for this constructional work to be of very considerable dimensions. Van Kooten (1927) compares the rainfall on Java with rainfall in countries as Germany and the USA. He distinguishes between two types of rainfall: 'showers' (rains within a period of 12 to 14 hours of high intensity on a small geographical surface) and 'land rains' (rains from some hours to a few days of lower intensity on a small geographical surface). Java does not have land rains, the rains that give the maximum flows are showers.

*Of the 73 large rainfall events per 24 hours, which took place until 1916 in Batavia, Buitenzorg, Pasoeroean and Pontianak, 66 of those were on average for 90 % caused by a single shower with a duration of 2 to 14 hours. (Van Kooten, 1927) [AL]*

A typical Javanese shower pattern is shown in figure 2. Javanese showers not only have a high intensity and a longer period in comparison to those on other countries, but also a somewhat larger geographical area. For catchments up to about one hundred square kilometers, this results in higher peak flows on Java than in central Europe, North America en British India (Van Kooten, 1927). The larger catchment areas on Java, in which the influence of a single shower is much smaller and peak discharges are not caused by single showers, show comparatively lower maximum flows than other countries (Van Kooten, 1927). Peak discharges are generally caused by a number of showers in the catchment area. These showers should fall separately in space and time, the first ones in the higher catchment and the later ones in the lower areas. In such a pattern the late rains reinforce the effects of the early rains, and together they result in a considerable peak flow. Nevertheless, these maximum discharges are generally lower than in catchments with considerable land rains. Thus, Java counts many small catchment areas with relatively high maximum discharges and some larger catchments with relatively lower maximum discharges, and the discharge difference between smaller and larger catchments is not as big as in many other areas.
5. The Lauterburg and Melchior formulas

Because of the typical nature of Javanese river flow behavior, knowledge of the behavior of Dutch rivers was not applicable on Java. As the Dutch engineers did not have a readily available formula for the Javanese circumstances, they looked across their borders to find a suitable method. In the early 1890’s, the Dutch engineer De Meyier found it in the formula developed by Lauterburg from Austria (Van Maanen, 1931). Lauterburg published his formula in 1877 (Lauterburg, 1877). It reads

\[ Q = \alpha \gamma q_n F \]

in which

- \( Q \) represents the peak flow to be calculated (in m\(^3\)/s);
- \( F \) represents the surface of the catchment (in km\(^2\));
- \( q_n \) represents the expected highest local rainfall (expressed in m\(^3\)/km\(^2\)/s), for which Lauterburg provides three possible values, dependent on the length of the rainfall;
- \( \gamma \) represents a reduction factor (without dimension), to provide for the fact that the maximum rainfall does not cover the whole catchment area \( F \). The reduction value depends on \( q_n \) and can have three values as well; and
- \( \alpha \) represents a factor taking into account the part of the rainfall flowing directly to the river (without dimension).

In the Lauterburg formula it is assumed that the peak flow is a function of the surface of the catchment. The dimension of time is taken only into account in
a very crude way, and the length of the river is not taken into account at all. The
great advantage of the approach is that one only needs a number of measured
flows of rivers in a certain area, to determine the factors representative of that
area. Using these values, flows for other rivers in the area can be calculated. The
results for rivers in Europe were moderately accurate (with a difference between
15 and 20 % between measured and calculated peak flows), but for Javanese
rivers mean differences were about 65 % (Van Kooten, 1927). Especially in
smaller catchments (smaller than 300 square kilometers, not an exception on
Java), the Lauterburg formula calculated much higher peak flows than measured
up to then (Van Maanen, 1931).

Based on experiences with the Sampean works, the Dutch engineer Melchior
developed a method, with gave calculated estimates for peak flows more in
accordance with flow measurements, although for larger catchments the
estimates seemed to be too low. The Melchior formula is of the Pascher type
(developed for the determination of peak flows in the Wien river, Austria) (Van
Kooten, 1927). The formula of Pascher reads

\[ Q = \alpha \beta q F \]

in which

- \( Q \) represents the peak flow to be calculated (in m\(^3\)/s);
- \( F \) represents the surface of the catchment (in km\(^2\));
- \( q \) represents the expected highest local rainfall (expressed in m\(^3\)/km\(^2\)/s), which
  should be determined for each catchment separately;
- \( \beta \) represents a reduction factor (without dimension), to provide for the fact
  that the maximum rainfall does not cover the whole catchment area \( F \), which
  relates to the runoff time \( T \) of the catchment; and
- \( \alpha \) represents a factor taking into account the part of the rainfall flowing
directly to the river (without dimension).

The Pascher formula looks very similar to the Lauterburg formula, with only
one factor different (\( \beta \) versus \( \gamma \)). It takes too far to discuss the difference in this
paper, but although both these are reduction coefficients, the Lauterburg \( \gamma \)
actually encompasses two reductions in one factor. The most important
difference between the two formulas is the time factor. In the Pascher formula,
the time factor is included in the factor \( \beta \). In the method developed by Melchior,
the time factor is included somewhat different. Melchior calculates the length
of the rainfall period responsible for the peak flow (\( t \)) relates using the time span in
which the peak flow develops (\( T \)) using graphs, and uses the result to determine
\( q \). Therefore, the factor \( \beta \) is not included in the Melchior formula, but is
represented in a somewhat hidden way throughout the calculation (see box), and
as a result the Melchior formula reads
in which the different components represent similar factors as in the Pascher
formula. Melchior uses an iterative combination of graphical and numerical tasks.
The surface of the catchment is determined (using maps), and an ellips is drawn
around the catchment (of which the small axe should be at least 2/3 of the large
axe). Furthermore, the length and mean slope of the river are needed (without
taking into account the highest 10 % of the catchment). The slope does not
influence the outcomes much. Rainfall data were needed. The factor $\alpha$ was set at
0.52. In the box the calculation route is given (see also appendix).

\[ Q = \alpha q F \]

(1) The catchment surface $F = 169 \text{ km}^2$.
(2) The long ax of the ellips is 28.4 km, and the
short ax is taken as $2/3 \times 28.4 = 18.9 \text{ km}$. The
ellips' surface becomes $nF = \frac{1}{4} \pi \times 28.4 \times 18.9 =
422 \text{ km}^2$.
(3) River length $L = 39.2 \text{ km}$. Without the highest
1/10 of the catchment, the remaining 35.3 km
passes a height of about 1700 m, thus slope $i =
1700/35300 = 0.0480$.
(4) Maximum rainfall of the four stations inside or
just outside the catchment is respectively 146,
165, 244 en 236 mm, resulting in a mean
maximum rainfall $h = \frac{1}{4} (146 + 165 + 244 + 236)
= 198$, say 200 mm.
(5) First approach, with table I (appendix) and $nF =
422 \text{ km}^2$: $q$ set at value 3. Thus $Fq = 169 \times 3 =
507$. With $i = 0.0480$, and graph II (appendix), $v =
1.35 \text{ m/s}$. Than $T = 1000L/60v = 39200/(60 \times 1.35) = 484 \text{ minutes}$. From graph
III (appendix) $q = 3.8 \text{ m}^3/\text{km}^2\text{s}$.
(6) With this value for $q$ as input, the calculation is repeated. Results are $F \times q =
169 \times 3.8 = 642$, $v = 1.42$, $T = 460 \text{ min}$, $q = 3.95$. Another repetition with this
last value of $q$ does not result in a more secure value, giving $q = 3.95$ as the value
to be taken. As $T = 460 \text{ minutes}$, 8% must be added to the value of $q$ (table IV in
the appendix). The final $q = 4.27$.
(7) The total peak flow is calculated as $Q = \alpha Fq = 0.52 \times 169 \times 4.27 = 372 \text{ m}^3$.

Sources: Nijman, 1914/1933; Van Maanen, 1931

Box - Example of the Melchior method for the Pekalen river (East Java)
6. Empirical data

Melchior published his approach in 1896, in a period with many irrigation development activities, and his method had been used already for the Sampean works in the late 1880’s. Some twenty years after publication, it became clear that the real peak flows were often much higher than the determined ones with Melchior. Engineers wrote about it in their own periodical, De Waterstaatsingenieur (for example, Redactie, 1915, and Feber, 1916). In this last contribution, the author Feber mentions, that ‘locally heavy rainfall’ caused a flash flood of about nine hundred cubic meters by second (which could not be measured exactly, as it flooded the weir itself too) in the Pekalen river, the same river for which Melchior (see box!) calculates a peak flow of 372 cubic meters by second. Feber blames the coefficient $\alpha$ of 0.52, and indicates that it was raised to 0.60 because of the event he describes. He goes on saying:

As main point of current experience, the unemployability of the calculation method of Melchior for catchments as the Pekalen river has to be put forward. [...] Leaving that for a correct application of the method a very exact knowledge is needed, amongst others of the vegetation and formation of the catchment, imperfections are adhere to the method, that should induce carefulness with the elaboration of the found results. (Feber, 1916) [AT]

Even in the catchment in which the Melchior method had been born, the Sampean river, the results of the formula did not correspond with the measured peak flows. Although part of this phenomenon could have been caused by a changing flow regime (at least according to the majority view in the Netherlands East Indies), the difference between measured and calculated discharge was considerable:

In the 1887 design one assumed that the peak flow of the Sampean river was 1000 m$^3$/s, somewhat more than the maximum calculated by Melchior. The largest discharge experienced then was the 1788 m$^3$/s from 1878. Besides this, since 1876 one had not measured more than 700 m$^3$/s. In 1887, however, about 2075 m$^3$/s passed, in 1916 about 2 700 m$^3$/s! (Ravesteijn, 1997) [AT]

Although the results appeared to be open for critique, Melchior remained a highly esteemed engineer by later generations. They might not have taken the results of his approach for granted, but Dutch irrigation engineers honored the way he approached the subject of peak flow determination. Melchior can be considered as one of the first Dutch irrigation engineers who introduced a scientific approach to solve problems encountered in practice. He was well aware of limitations of his method, and he regarded it as
a by no means completely satisfying attempt to arrive at a solution for the problem. (Melchior, 1895/1896; Van Staalen, 1932) [AT]

Discussions as presented above show an important aspect of the development of hydrological science and methods on Java and probably in general: the importance of empirical data. With more measurements available, the measured peak flow becomes more reliable (and probably higher), and the determination of coefficients representative for catchment characteristics becomes more reliable. The Melchior formula requires much more data than the Lauterburg formula. In theory, Melchior should give to more reliable results, were it not that Melchior and his immediate successors possessed these data only sporadically. Melchior had to replace the missing data with several assumptions.

Even the data that were available were probably not good enough. Rainfall measurements were scarce enough already, and most of them were daily measurements. For peak flow calculations, the total amount of rain per 24 hours is not enough, as one needs to know the real duration of the rainfall event and the (change in) intensity of the rainfall during the event. As the intensity is highly variable, the best measurements are done by a self registering rain measurement device.

On Java, since 1902 shower observations are done using self-recording rainfall meters by the Magnetic and Meteorologic Observatory in Batavia [...] originally on only three stations (Batavia, Buitenzorg, Pasoeroean), later on a much larger number. Only in Batavia a lesser performing self-recording meter was present between 1879-1902 too. (Van Kooten, 1927) [AT]

It is thus not a coincidence that Melchior used rainfall data from Batavia. He determined the intensity curve for F = 0 from those data. Furthermore, he used measurements from a region called Bagelen (middle Java) to determine the point for t = 24 hours for each of the other intensity curves. Melchior had to make a number of assumptions to draw the shape of the graphs, like the assumption that the maximum mean rainfalls which for different time spans could fall on an unlimited surface were proportional to the normal rainfalls of Batavia for similar time spans. Another assumption was based on a rainfall event from Europa, in which the intensity at three kilometers from the center of the shower appeared to be half the centers’ intensity. Showers on Java have different characteristics, making the assumption questionable (Van Kooten, 1927).

Other assumptions that Melchior had to make include the one, that the ratio between the river length and the time span of the maximum rainfall is proportional to the velocity at maximum water level in the last river profile section of the catchment (the velocity is calculated with the Bazin formula). Van Kooten (1927) shows that this assumption is incorrect. A last assumption mentioned here refers to the coefficient $\alpha$. Melchior sets its’ value at 0.52, but in
reality it is highly variable and can become much higher. A footnote in Nijman (1933) states that a value of 0.52 is ‘somewhat low’, and that a value of 0.62 might be better. In some cases, the value for $\alpha$ would have been determined at 0.80! Changes in the value of $\alpha$ through time as a consequence of changing catchment characteristics have been discussed thoroughly in the Netherlands East Indies. As mentioned at the start of this paper, this discussion is out of scope now.

7. Beyond Melchior

Despite the criticism, the Melchior method has remained the standard approach for some forty-five years. In the last issue of De Waterstaatsingenieur of 1933, a reprint of the Nijman article of 1914 appears, as many requests had reached the editors, and many young engineers did not know the original Melchior article of 1895/1896. As Nijman only presents the calculation method, and provides virtually no discussion on the considerations of Melchior, it can be doubted whether a complete picture was presented to those young engineers. One could also argue that Lauterburg deserves some kind of rehabilitation. The formula was disapproved of because its results were considered too high, and replaced with a method which gave estimates that appeared to be (sometimes far) too low. Lauterburg, however, has kept the image of the first attempt, that was replaced by the more adequate, but still not perfect Melchior formula, in all hydrological discussions in the Netherlands East Indies.

Melchior might have been the standard, but the engineering community remained engaged in discussions on flow calculations. The drive for the discussion was application in practice, and the majority of the contributions, especially in the 1910’s and 1920’s dealt with potential ways to solve problems with hydrology in engineering practice. Next to this practical orientation, however, some contributions are more scientifically oriented, in the sense that attempts are made to explain the phenomena, instead of designing a method to calculate them. Contributions from this view take the basic formula $Q = \alpha \beta q F$ as a starting point and discuss one or more factors in detail. In the 1930’s the first statistical approaches enter the scene. Naturally, this paper can only touch upon all these developments. In the upcoming thesis they will receive the full attention they deserve.

The names of three Dutch engineers come to the front when developments in hydrology in the Netherlands East Indies after Melchior are discussed: Van Kooten, Der Weduwen en Begemann. The discussions of Van Kooten and Der Weduwen center around best use of available topographical data (as Melchior did), like surface, shape, river length, slope, and meteorological data, like rainfall, relevant for the catchment for which the calculations have to be made (Roessel,
Begemann (1931) has a different approach, as he tries to apply statistical theory to the discharge data of the catchment (Roessel, 1940).

The studies of Van Kooten are already announced by Feber (1916), but his book apparently only was published in 1927 (in 1932 the book was published in German). Van Kooten discussed all factors used in formulas like Lauterburg, Pascher and Melchior, using a large quantity of data from countries like the USA, Germany and the Netherlands East Indies. The enormous amount of data he had to work through probably explains why it took some years to publish the results, but the amount did provide a much better base for analysis than others had been able to achieve before him. He describes different ways to calculate the maximum river discharge, without selecting the best. Therefore, in a way, his work is more scientific than practice oriented.

Der Weduwen (1937) wanted to present an improved method for peak flow determination in catchments up to 100 square kilometers. Originally developed for the area of Batavia (nowadays Jakarta) and surroundings, the Der Weduwen method (basically a nomogram) began to replace the Melchior approach as the new Public Works standard in design procedures for river works in small catchments shortly after its’ publication (Kras, 1940). Engineer Kras had some objections to a general application of the Der Weduwen method, amongst others because the method assumed a certain standard division of rainfall over the day, something which ‘does not exist’ (Kras, 1940). Der Weduwen himself already had made a similar remark (Der Weduwen, 1937; Kras, 1940), but

Lacking more data, these objections have to be set aside. (Kras, 1940)

Even in the late 1930’s and early 1940’s, the lack of data appears as an argument to choose a certain simplification. In a reaction to Der Weduwen, Verweij (1939) points out, that striving for a method that always works (like the nomogram of Der Weduwen), in all situations for all possible applications is not always worthwhile. In situations where larger amounts of data (including discharges) over a longer time span are available, Verweij would prefer the method developed by Begemann, especially as it would be for ‘important subjects’ (Verwij, 1939). Begemann used measurements from the Tuntang river, in Demak, one of the first areas of Dutch colonial water works. The Begemann approach remains somewhat of a sideline, however, and besides some reference to him as a splendid piece of work, applications of it are hidden. Whether this is the case because of the applicability of the method, the preparedness of Dutch engineers to use it, or the research capabilities of the author of this paper has to remain an unanswered question yet.
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**Appendix**

**Tables for the calculation of peak flows using Melchior**

Source: Nijman, 1914/1933

**Table I**

<table>
<thead>
<tr>
<th>NF (km²)</th>
<th>q (m³/km²s)</th>
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<td>144</td>
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**Table IV**

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