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Clerk of Supreme Court

# IN THE SUPREME COURT OF THE STATE OF NEVADA

**Case No. 81224**

DIAMOND NATURAL RESOURCES PROTECTION & CONSERVATION ASSOCIATION; J&T FARMS, LLC; GALLAGHER FARMS LLC; JEFF LOMMORI; M&C HAY; CONLEY LAND & LIVESTOCK, LLC; JAMES ETCHEVERRY; NICK ETCHEVERRY; TIM HALPIN; SANDI HALPIN; DIAMOND VALLEY HAY COMPANY, INC.; MARK MOYLE FARMS LLC; D.F. & E.M. PALMORE FAMILY TRUST; WILLIAM H. NORTON; PATRICIA NORTON; SESTANOVICH HAY & CATTLE, LLC; JERRY ANDERSON; BILL BAUMAN; DARLA BAUMAN; TIM WILSON, P.E., NEVADA STATE ENGINEER, DIVISION OF WATER RESOURCES, DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES; AND EUREKA COUNTY;

Appellants,

v.

DIAMOND VALLEY RANCH, LLC; AMERICAN FIRST FEDERAL, INC.; BERG PROPERTIES CALIFORNIA, LLC; BLANCO RANCH, LLC; BETH MILLS, TRUSTEE MARSHALL FAMILY TRUST; TIMOTHY LEE BAILEY; CONSTANCE MARIE BAILEY; FRED BAILEY; CAROLYN BAILEY; SADLER RANCH, LLC; IRA R. RENNER; AND MONTIRA RENNER,

Respondents.

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Appeal From Order Granting Petitions for Judicial Review
Seventh Judicial District Court of Nevada Case No. CV-1902-348

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## JOINT APPENDIX
## VOLUME V

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Docket 81224 Document 2020-35045

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## AFFIRMATION

The undersigned does hereby affirm that the preceding document does not contain the social security number of any person.

Date: September 23, 2020

*/s/ Debbie Leonard*
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## CERTIFICATE OF SERVICE

I HEREBY CERTIFY that I am an employee of Leonard Law, PC, and that on September 23, 2020, the foregoing document was electronically filed with the Clerk of the Court for the Nevada Supreme Court by using the Nevada Supreme Court's E-Filing system (E-Flex). Participants in the case who are registered with E-Flex as users will be served by the EFlex system. All others will be served by first-class mail.

*/s/ Tricia Trevino*
An employee of Leonard Law, PC

**STATE OF NEVADA**

**DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES**

**DIVISION OF WATER RESOURCES**

**BEFORE MALCOLM WILSON, HEARING OFFICER**

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2018 NOV 13 PM 3:06

IN RE:

DIAMOND VALLEY GROUNDWATER MANAGEMENT PLAN
_____________________________________________/

**TRANSCRIPT OF PROCEEDINGS**

**PUBLIC HEARING**

**TUESDAY, OCTOBER 30, 2018**

**EUREKA, NEVADA**

REPORTED BY:

CAPITOL REPORTERS
Certified Shorthand Reporters
BY: CHRISTY Y. JOYCE, CCR
Nevada CCR #625
123 W. Nye Lane Suite 107
Carson City, Nevada 89706
(775)882-5322

TUESDAY, OCTOBER 30, 2018, 10:00 A.M.

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HEARING OFFICER WILSON: As set forth in the notice of hearing dated October --

THE STATE ENGINEER: Ladies and Gentlemen, we're getting started. Mac has got kind of a quiet voice, so he needs to speak up.

HEARING OFFICER WILSON: Hopefully I can get close enough to the microphone here. Is that better? As set forth in the notice of hearing dated October 1st, 2018, this is the time and place set for hearing for the State Engineer of Nevada, Division of Water Resources, in the matter of the proposed Groundwater Management Plan, for the petition to approve that plan within the designated Diamond Valley Hydrographic Basin. That's Basin 153 within Eureka, Elko, and White Pine Counties, Nevada.

Nevada Revised Statutes Section 534.037 provides that in a basin that has been designated as a critical management area pursuant to NRS Section 534.110(7), a petition for approval of the Groundwater Management Plan for the basin may be submitted to the State Engineer accompanied by the proposed plan.

The purpose of this hearing is to provide information to the public and receive written or oral testimony from any interested person about the proposed plan provided in Nevada Revised Statute Section 534.037.

My name is Malcolm Wilson. I'm the hearing officer today for the State Engineer. With me today to my left is Jason King, the State Engineer. And then to his left is Adam Sullivan, the deputy administrator for the Division. And to my right is Kristen Geddes, the chief of the hearing section.

The hearing will proceed as follows: I will begin with introduction of exhibits the State Engineer would like entered in to the record. And then after that I will use the sign-in sheet in order to call people forward to one of the microphones. If you wish to give public comment, please make sure on the sign-in sheet that you've marked that you intend to. I will just basically go through that and call people up in order.

Before I enter the exhibits in to the record, I am going to hand the microphone over to Mr. King, who wants to make some comments.

THE STATE ENGINEER: They're very brief. I just wanted to take this opportunity and thank all of the GMP participants for all the blood, sweat, and tears in getting to this point of this process. Diamond Valley is the first and only critical management area in the state, as you all know. This is the very first hearing of this type in the history of our office on the petition to approve the GMP. So, again, I just really want to acknowledge all the people who have put in all the effort to get us to this point right now. I hope that you get out of this hearing anything you want. We want to hear all of your comments. So, please, if you're on the fence as to whether or not you want to stand up and comment, I would try to encourage you to do that.

We've had a request already to see if there could be written comments to the office at a later date. We've talked internally and talked about by close of business this Friday, November 2nd, by 5:00 o'clock. If there are those of you who still want to get in some written comments, you'll have until that time.

And with that, I'm going to give it back to Mac. And, again, thank you all for all of your efforts.

HEARING OFFICER WILSON: I will now receive introduction of the State Engineer's exhibits, which will be marked 1 through 4. I'll read the exhibit number followed by the name of the exhibit.

Exhibit Number 1 is the petition for approval of the Diamond Valley Groundwater Management Plan.

Exhibit Number 2 is the Diamond Valley Groundwater Management Planning that's been proposed.

Exhibit Number 3 is the notice of hearing to the county commissioners with the certified mail receipts that were received back.

And Exhibit Number 4 is the public notice to the paper and to receive proofs of publication included as well.

The plan marked as Exhibit 2 has been available on the home page of the Nevada Division of Water Resources website for recent use for the past month. The public notice marked as Exhibit 4 was also posted as a recent use item for the same time frame.

Is there any objections to the admission of these exhibits? Hearing none, they will be admitted.

In addition, I will take administrative notice of any other relevant publications, information, and records of the office of the State Engineer.

UNIDENTIFIED SPEAKER: Can you move the mike a little bit closer?

HEARING OFFICER WILSON: Would that be better?

UNIDENTIFIED SPEAKER: Yes, definitely.

HEARING OFFICER WILSON: At this time we will proceed with public comment. Please be courteous to the speakers. If you have to use your cell phone, please step outside. We are limited on time and need to stay focused on the proposed plan. If you have any questions not directly related to the plan, please contact our office during regular office hours and a member of our staff will assist you. This is your opportunity to speak while we listen. So please understand we may not be able to immediately answer questions that you raise today. We're grabbing the sheet right now.

THE STATE ENGINEER: As Mac said, we have a court reporter here and we want to get down your testimony and comments. So please speak clearly and loudly so that the court reporter can hear you. Thanks.

HEARING OFFICER WILSON: The first person I have on the list is Tim Bailey. Mr. Bailey, if you would like to approach either of the microphones. There's one on either side.

MR. BAILEY: Can you hear that?

HEARING OFFICER WILSON: You're good.

MR. BAILEY: For the record, my name is Tim Bailey, T-i-m B-a-i-l-e-y. This document is submitted at the hearing of Groundwater Management Plan held in Eureka, Nevada on October 30th, 2018. I am Timothy Lee Bailey, representing Timothy Lee and Constance Marie Bailey and our irrigation water rights in Diamond Valley.

We are opposed to the Groundwater Management Plan. Prior appropriation does not allow for junior water rights to harm a senior water right. Water table level mainly the drawdown of the water table level in Diamond Valley needs to be taken in to account. No senior water right should be harmed by any junior water right.

I have arrived at this decision because I have read numerous water resource bulletins, state water engineer orders, rulings, testimonies and judicial orders, rulings, opinions, testimonies, and court transcripts that pertain to the water in Diamond Valley Hydrographic Basin 10-153.

If the State Water Engineer is going to sign this document, I strongly urge you to read these documents pertaining to the water in Diamond Valley Hydrographic Basin 10-153 in chronological order before signing this, water resource bulletins, State Water Engineer orders, State Water Engineer rulings, State Water Engineer testimonies, judicial orders, judicial rulings, judicial opinions, testimonies, court transcripts, and hearing transcripts. Thank you for your time.

HEARING OFFICER WILSON: Thank you, Mr. Bailey.

MR. BAILEY: I know I gave you a copy of this to begin with, but here. So thank you.

HEARING OFFICER WILSON: And I will notice that I received copy of the testimony.

David Hillis. Come on up, Mr. Hillis.

MR. RIGDON: I'm David Rigdon with Taggart and

Taggart. Mr. Hillis, Mr. Shoda, and I have a joint presentation. I was going to go first and then the two of them were going to go. We would ask if we could accommodate that. So if we can defer to Mr. Hillis' testimony until after I speak.

HEARING OFFICER WILSON: Yeah. That will be fine. Please go ahead.

MR. RIGDON: Now?

HEARING OFFICER WILSON: Yeah. Please go ahead.

(The court reporter interrupts)

MR. RIGDON: Yes. It's David Rigdon, R-i-g-d-o-n, with Taggart and Taggart, LTD. I'm here representing the Sadler Ranch.

We appreciate the opportunity to provide testimony here today. And we want to make sure everybody is aware that we're not just here to throw bombs and to throw opposition out. But there are serious concerns that we have with the Groundwater Management Plan as written. We do believe that a properly written Groundwater Management Plan could be developed in the valley that would take in to account the concerns of the senior vested right holders in a much better way and provide them relief from the harm that they're experiencing. So we're not opposed to the idea of having a Groundwater Management Plan. It's just the way this groundwater management is written has some major problems with it.

THE STATE ENGINEER: Can you speak closer to the microphone, please, Mr. Rigdon, or raise it, please.

MR. RIGDON: I'll move it up a little bit. Is that better? So there's basically three areas that I wanted to speak to you about with regards to the plan. The first is that to prove any GMP the state law says that it must include the necessary steps for removal of the CMA designation of the basin at the end of the plan. So basically at the end of the plan, withdrawals, all withdrawals, not just withdrawals covered by the plan, but all withdrawals in the basin must be less than the perennial yield. And in order to approve the Groundwater Management Plan, in order for the State Engineer to take action, you have to have substantial evidence in the record supporting this system. So there has to be actual scientific evidence supporting the fact that at the end of this plan the basin will be back in balance.

In addition, the proposed GMP as written does not include those necessary steps. And it does not have the evidence with it. Now, we appreciate the opportunity to provide written comments to you by Friday and the extension of time to be able to do that and we will be providing you with written comments that includes an expert report by an expert that we've hired that shows that the groundwater plan does not meet those requirements of bringing withdrawal below the perennial yield of the valley and will not actually result in groundwater declines halting in the valley by the end of the plan. And so we'll provide you with that information.

We also feel a little bit of a disadvantage. The only evidence that we've been able to review prior to this hearing is what you posted on your website, which is the plan with the appendices. And we assume that that's all the evidence that the proponents of the plan brought forward and put on the record. And if that's the case, that's what we're going off of here. We're assuming that there's no other evidence that's going to be surprised and brought in here today. But if there is, we would like the opportunity to respond to that evidence and have our experts look at it.

The second issue that we have is that the Groundwater Management Plan doesn't provide mitigation for impact for vested water right holders. And we've got people who have their senior vested rights impacted for 35 years. They've had to go through enormous cost to get mitigation rights issued. They've had to go through enormous cost to build replacement wells, those types of things. There's no mitigation in this plan for either of those past costs or the future costs that they're going to incur as a result of this plan.

And, third, the Groundwater Management Plan violates other provisions of Nevada water law. And that's just not acceptable. You can't approve a plan that violates mandatory provisions that the legislature has said you must follow. And this plan does that.

Now, Mr. Hillis is going to follow me and he's going to give you some information about why in his expert opinion he doesn't believe that the plan includes the necessary steps for the removal of the CMA. And he's got various reasons there.

But the one of them is that the amount of groundwater that we have already removed from the top hundred feet of storage in this basin he estimates at about 1.7 million acre-feet over the last 35 years have been already removed from the top 100 feet of storage in the basin. There was only estimated to be by Harold two million acre-feet of storage in the basin back in 1968.

If this plan is allowed to carry out for 35 years, even with the pumping reduction in the plan, we're going to exceed that two million acre-feet in the basin. It's going to be about 2.5 million acre-feet, which will just continue to create groundwater drought in the basin and continue to cause harm to the senior vested rights.

Mr. Shoda is also going to get up here and he's going to tell you about the harm that Sadler Ranch specifically has faced as a result of the groundwater declines and what they'll face as a result of future groundwater decline.

And I think it's very important to remember that under water law, under the prior appropriation system, a senior -- if juniors take a senior's water, they are obligated to provide that senior not just a mitigation right to drill a well and get more water and replace that water, which has been done and we thank the State Engineer's office for the issuance of mitigation rights. We still have some issues with the amount. But we thank you for the issuance of the mitigation rights. But the juniors also have to -- the senior is supposed to get that water at no additional cost to the senior. That means if water free-flowed on the ranch from a spring and now you have to drill a well and you have to pump that water up and pay for the electricity to pump it up and pay for the maintenance and the well pump and pay for the maintenance of the well and all that type of stuff, those costs have to be made up. There's nothing in this plan, even though those continuous groundwater declines, there's nothing in this plan that provides a mitigation fund to mitigate those senior vested rights that are subject to forfeiture. And there should be.

Now, the things that really strike me -- Dave Hillis is an expert in water rights and how water works and Mr. Shoda is an expert in ranching operations, and he'll tell you all about that. But I'm a lawyer and I look at the plan from the standpoint of does the plan comply with the law. And there's several provisions of this plan that we believe violate mandatory provisions of the state law.

And we need to be clear here about something. The Groundwater Management Plan is not the opportunity to write your own water law. That's not what it was intended to be. The Groundwater Management Plan was intended by the legislature to be a system whereby people who have water rights who might get cut in the event of a contaminant because of the completion of a groundwater basin could get together and instead of enforcing senior priority against each other they could agree we'll all take a little bit of a hit so that everybody benefits by that. And that's perfectly fine for the Groundwater Management Plan to do that.

What's not fine is for the Groundwater Management Plan to encroach upon the statutory authority of the State Engineer to take regulatory action. And this plan does that in several important respects. The legislature never intended that a plan would replace mandatory provisions of state law or the plan would encroach upon the State Engineer's regulatory authority.

And let me just point out a couple of examples of that. This is by no means a comprehensive list of these examples. But let's start with the banking program. So in the appendix, in the last appendix, I believe it's appendix G -- I forget what the actual index was. But there's a report by Mr. Bugenig about the banking program. And in that report, Mr. Bugenig states that the banking program is an aquifer storage and recovery program and that's what it is. And he states clearly in that report that that brings it under the regulatory purview for ASR projects. But there's been no permanent file for an ASR plan.

As you know, if you want to do an aquifer storage recovery program, the law requires there's a stiffer permitting process that you have to go through to do that and there's certain things. It's a mandatory process. The State Engineer says -- The legislature has stated that you must apply for an ASR permit and it must include certain things. And those things include financial feasibility, hydrologic feasibility, all of these types of plans. Those are no where included in this GMP.

In addition, we would argue that there is no water available to store it. Any water above the perennial yield that's being appropriated above the perennial yield is by definition water that's not available to store in an ASR program. And the ASR program must show the source of the water that you're storing and you must show that it's a properly appropriated source. And this plan doesn't do it. It allows people to bank water year over year. And without -- without having any kind of a right to that water. Any pumping that's occurring above the perennial yield right now is water that people don't have a right to pump. And so you don't have a right to store that water year over year.

Another big issue with the plan from a legal standpoint is that a GMP cannot waive, just like with the ASR, the GMP cannot waive the mandatory change application permitting requirements of state law. The GMP the way it's written says you get to turn your permits and your shares and these shares can be traded and they can be moved around between any point of diversion in the valley and they can be pumped for any manner of use. It actually says in the plan any manner of use, not just irrigation. Without having to go through a change application process.

And that's just fundamentally a violation of the statute that says that if you're going to change a water right you have to apply for that change. And there's a really good reason that that -- there's that mandatory provisional statute. And that's because when you change a water right, when you change a point of diversion, when you change a manner of use, when you change a place of use, a conflicts check needs to be done. You need to be able to determine whether those changes will conflict with other water rights and other pumping in the basin. That hasn't been done here.

So this plan is essentially -- Essentially what the plan is asking for is basically this super permit, that everybody will have this super permit where they can again pump from any point of diversion, place it on any place of use within Diamond Valley, and put it to any manner of use.

And, again, the manner of use is important, because, remember, the state law mandates you can only have one manner of use per permit. It's right there. You can only have one manner of use per permit.

THE STATE ENGINEER: Mr. Rigdon, I'm sorry for interrupting. But I just feel like I have to. Have you read -- Have you read the plan?

MR. RIGDON: Front to back.

THE STATE ENGINEER: You have? Are you familiar with the section on the water use application that goes before our office to review within 14 days that nothing limits the authority of the State Engineer to look at conflicts and if the use is going to last more than one year there has to be a change application? Are you familiar with those provisions?

MR. RIGDON: There's a provision about wells. For a new well there's a 14-day time limit. But nothing in that provision that I read the way it's written says that the use of water, the change of water from one well to another has to be approved in 14 days or there has to be any application process at all. What the plan says is that if a well is approved and if there is a diversion rate available in that well, you don't have to go ask your office for anything. That's what it says.

THE STATE ENGINEER: If use lasts more than a year?

MR. RIGDON: Yes, that's the way I read it.

THE STATE ENGINEER: Okay. I mean, it's your public comment. I just was curious because I take some exception to some of the things you're saying. But it's public comment. So thank you.

MR. RIGDON: Well, I guess I would ask, are you saying that people will have to -- if I move -- if I sell somebody else my water I will have to file a change permit application for that every single time whether somebody gets my share?

THE STATE ENGINEER: And I hesitated to even speak up because I don't want to get in to a lot of back and forth. But there was some things that you mentioned, again, that I think aren't true as the GMP is written. But that's fine. It's your public comment.

MR. RIGDON: Okay. Well, I'm reading it as it's written. So, anyway, there is no change permit application process for moving shares around between wells.

You brought up the 14 days. And that's a very, very good point that you brought up because that's another point that I had on here. There's -- The plan basically says that if they file a permit with the State Engineer and the State Engineer does not give them 14 days, it's automatically approved, a permit for a new well that would be used for less than a year.

I would submit to you that you can't waive your responsibility to review permits and approve them. You cannot -- If the system was the State Engineer will try to get it done in 14 days or it's automatically rejected if it's not done within 14 days, that would be appropriate. But you can't have an automatic approval if it's not acted on in 14 days. That's the State Engineer basically deferring his authority to other people. And it's just not appropriate to have in the plan.

And you can't waive compliance with mandatory state well regulations. And the plan has a provision in there where it says that wells will be exempted from NRS 534 and NAC 534. It says that right there. Wells will be exempted from those well requirements or those statutes. There's no authority to do that. The legislature has mandated -- Anything in the NRS is something that the legislature has mandated be done.

So the plan as approved -- as submitted, we don't believe can be approved. It's not legally sufficient. It does not bring the basin back in to balance. There's no mitigation for senior vested right holders who will continue to be harmed in violation of the statute that says there can be no impairment of senior vested right holders. And several of the provisions violate the existing water rights.

And we'll provide a written brief by Friday outlining all of these legal arguments and providing the complete citations for everything that I've told you.

A properly designed GMP -- A properly designed GMP would include pumping reductions that are based on groundwater modeling that shows the reduction would actually bring the basin back in to balance. That's the one thing that's really missing in this plan. I don't see the groundwater model that shows that these pumping reductions are tied to any of the basins at all. They will actually result in groundwater declines in the valley. All we have is a pumping reduction table. That's it. There's no groundwater model that's been run to show 35 years from now, 40 years from now, what groundwater levels will be or whether the basin will be in balance. There's no monitoring plan.

A well-designed GMP would have a monitoring plan. And the monitoring plan would specifically spell out what wells are going to be monitored, how the propagation of cones of depression are going to be monitored, and what the effectiveness of the system, so we can have a positive feedback mechanism on the effectiveness of the reduction to see if they are actually doing with the modeling of the ground would show what they can do.

Finally, the plan doesn't include any objective triggers or thresholds for future management decisions. And this is an area where, again, when you read the plan with the actual, you know -- The actual language in the plan says for the first ten years the State Engineer cannot deviate from the benchmark reductions in the plan. That's what it says, that the benchmark reductions will not be deviated from. After that ten years, it limits your authority to reduce the -- to change the benchmark reduction to two percent a year.

I would argue that that's something that the State Engineer cannot do. The State Engineer reserves the right to regulate the basin under NRS 534.120. The State Engineer reserves his right to regulate the basin depending on events that happen.

If the Groundwater Management Plan isn't working after five years, then the State Engineer reserves the right to come in and, quite frankly, order straight-up curtailment or order changes from the benchmark reduction plan. But that's not what the plan says. The plan says you don't get to do that.

Finally, a well-designed plan would include mitigation for impacts to vested water right holders and it would also include an advisory board that provides equal representation for senior vested right holders. And I mean equal representation of many senior vested right holders on the board as there are junior right holders.

If a plan did that, we would support it. But that would be a plan -- and that would be a plan that would comply with state law and would comply with all the mandates.

So we're going to have Mr. Hillis come up. He's going to talk a little bit about the scientific basis as to why he doesn't think the plan will result in the goal it's supposed to hit, which is bringing the basin back in to balance at the end of the plan. And Mr. Shoda is going to come up and talk about some of the impacts at the Sadler Ranch.

HEARING OFFICER WILSON: Thank you, Mr. Rigdon.

Mr. Hillis, please.

MR. HILLIS: Good morning. Can you hear me? Good morning. My name is David Hillis. I am the principal engineer for Turnipseed Engineering.

THE STATE ENGINEER: You've got to get right on top of it, Dave.

MR. HILLIS: Okay. Sorry about that. I was asked to complete a technical review of the Groundwater Management Plan. And in my professional opinion there are some issues with it. My comments today will be limited to two categories. One, in general, I do not believe the plan as written would be able to remove the CMA designation and the plan unduly favors junior water right holders.

The plan is -- My belief is the plan does not include the necessary steps to remove the CMP designation as the -- There is no substantial technical evidence to show that the pumping levels, although they will be reduced over time, will actually result in the balance coming back -- the basin coming back within balance. There are no -- The plan does not include the triggers and thresholds for management actions. For example, if we start down this plan, we determine that groundwater declines are still occurring on a substantial rate, those pumpings, those pumping reductions, should be looked at to potentially be modified.

The USGS and other reports show that even with the reduction that groundwater mining will still be occurring even at the end of the plan. I believe that the end of the plan the total volume of water being removed is 43,500-ish acre-feet. And that's still in excess of the perennial yield and will still be causing unduly harm to senior water right holders and vested claims.

In 1968, Arrow reported that in the top hundred acre-foot of the soil, the alluvium, that water-bearing strata across the basin, held two million acre-feet. Looking at some of the appendices that were included in the plan, if you look at the historic pumping and then look at the proposed pumping and how that could occur through the plan's duration, there have already been 175 million acre-feet of that two million that have already been depleted from storage. If the plan were to continue at the pumping levels that are proposed, there would be an approximately 2.5 million acre-feet depleted from storage. This is an extreme volume of water.

At the conclusion, the plan will also not reduce the withdrawals below the perennial yield in the basin.

The second point that is a major concern is that I believe the plan unduly favors the junior water right holders. One of the examples of this is the plan, as my understanding, and I've always looked at there is a 20 percent difference between what the senior, the most senior water right holder will receive versus the most junior water right holder. And although that may be true in the priority factor, when you actually look at the duty of water that those irrigators, those permit holders, will actually receive, the difference is actually six percent from the most senior to the most junior. Now, I'm specifically talking about what I would care about as an irrigator is how much water am I going to receive from this permit at the end of the plan.

So when you review the duty that you will actually receive, the most senior will receive roughly 30 percent of his allocation and the most senior water right holder will receive 24 percent of his original allocation. So there's only a difference of six percent, not 20.

The other factor is in the makeup of the advisory board and how voting will continue in the future. The plan states that votes will be counted by a proportionate volume of water. Well, as senior water right holders only represent roughly 23 percent of the total allocation in the basin, if all seniors were to determine that they were not in favor of the plan, there is no possible way that they will ever outvote just by the sheer number, the amount of seniors -- or the amount of juniors.

Those are really the main portions of the comments. And I will have -- I do have more written comments. And those comments will be submitted on Friday to you. Thank you.

HEARING OFFICER WILSON: Thank you, Mr. Hillis.

I believe it was Mr. Shoda that was coming up, please. And if you could please spell your name for the record.

MR. SHODA: My name is Levi Shoda. It's spelled L-e-v-i S-h-o-d-a. I'm the ranch manager for Sadler Ranch. And my comments are pretty brief. Just as a rancher, one thing that really concerns me about this plan is the prior appropriation doctrine and what Mr. Hillis just spoke about is I don't believe that the seniors are really being protected -- I'm talking about the groundwater right seniors -- through this plan with that small of a margin of pumping. And so that's one big concern that I have.

Because, like Mr. King stated at the beginning, this is the first time that this has ever happened. And I don't know that you do it right the first time. It's hard to. But the most important thing is though is if and when or when this gets signed on by you, this will set precedence for the rest of the state. And I do believe that, you know, there's a lot of other basins that are in trouble that are going to be going down this road in the future. So I do want to make sure that we do that correct and that we do want to make sure that we protect the prior appropriation doctrine the best that we can.

Secondly, I have a question. I don't know if you can answer this. But, the way you read the plan, does a senior groundwater right holder if he does not sign off on the plan is he forced to forfeit some of his water to a junior water right holder?

THE STATE ENGINEER: The way I read the statute, and this is a statute that went in to effect in 2011 as Senator Goicoechea, requires a petition by the majority of those water users in a basin. So I interpret that, as a non-attorney, as why would you require a petition by the majority of the users that wasn't binding on all of those users? And in this instance in the GMP it spells out who -- who is in the club. And it's the irrigators and any mining rights that started out. So there's a little bit of a long-winded answer, Levi, but, yeah, it's binding on everyone in the GMP.

MR. SHODA: Okay. I would agree with that, too, the way I see it.

So I guess really my -- ultimately just my concern with the plan is both what Mr. Hillis and Mr. Rigdon both hit on it. I'm just going to reiterate it again. But that there's no continued mitigation for the vested water, that whatever harm still impacts the ranch. And there's nothing to talk about. That's kind of an unknown. We can model it, but we don't know what the future impacts will be. There's nothing in there to go by. So with that, that's really all I have.

HEARING OFFICER WILSON: Thank you, Mr. Shoda.

Next on the list I have Kenny Benson, if you can come up.

MR. BENSON: Yes. For the record, my name is Ken Benson. And I am the owner of valid water rights within this groundwater basin that we're addressing today. I reserve the right to submit extended amended remarks by 5:00 p.m. on Friday.

I have not participated at great length in the formulation of the plan because anybody who was perceived as not being in favor with the ongoing bandwagon was not particularly well-received. And that would be me.

Suffice it to say, for a few minutes, this whole process is an abuse of rule of law and has become a mob rule endeavor by junior water right holders to infringe on the rights of senior water right holders.

In effect, the continued use and access to the water resource by the juniors will only come at the expense of the seniors. And I don't think that was ever envisioned in the state law. Thank you.

HEARING OFFICER WILSON: Thank you, Mr. Benson.

Travis Gallagher, come on up.

MR. GALLAGHER: My name is Travis Gallagher, G-a-l-l-a-g-h-e-r. I do not feel comfortable. I am in support of the GMP, but I will be submitting my written comment.

HEARING OFFICER WILSON: Thank you. Let the record show that we did receive the written comment from Mr. Gallagher.

A little difficult to read this, so please forgive me. Donald Palmore.

MR. PALMORE: Can you hear me? My name is Donald Palmore.

HEARING OFFICER WILSON: Could you please spell your last name to make sure we have it correctly.

MR. PALMORE: P-a-l-m-o-r-e. I'll submit this.

HEARING OFFICER WILSON: Thank you.

MR. PALMORE: When I first came to Diamond Valley 60 years ago there were 80 to a hundred acres of hay. Now there are close to 20,000 acres. During the 1960s, we were clearing brush and drilling wells. We used diesel and propane engines to pump water and mostly based grain to get beneficial use to our lands. Many places changed hands several times.

In 1972 we got electric power and the price of hay improved.

In the early '80s, we had three years of monsoon rains, high power rates, high interest rates and the invasion of rodents. Over the years, much time and energy has been spent just to maintain some control.

Despite all the problems, we are now faced with the biggest challenge of all, water. It seems we have only two possible choices: Curtailment or the Groundwater Management Plan. If the choice is curtailment, what will happen? Our power rates will increase and county revenues will decrease, constantly leaving roads to be poorly maintained. Barns with junior water rights will be overrun with rodents and weeds. A return to these difficult experiences of the past is not a welcome choice.

It has taken so many years of struggle to develop Diamond Valley. But I am very willing to share some water as outlined in the Diamond Valley Water Management Plan. I applaud all the senior water right holders who are willing to share water in order for Diamond Valley to continue to prosper.

I would offer special thanks to the committee members who have worked diligently for several years to develop the Diamond Valley Groundwater Management Plan. My best hope is this plan will allow the viability of all the farms to keep the Diamond Valley a beautiful place to live and work as it is now. Thank you.

HEARING OFFICER WILSON: Thank you, Mr. Palmore.

THE STATE ENGINEER: Can we have your written comment, Mr. Palmore, or no?

UNIDENTIFIED SPEAKER: He handed it in.

THE STATE ENGINEER: I apologize.

HEARING OFFICER WILSON: We did receive the written version of Mr. Palmore's comments.

Ari Erickson, if you could please come up.

MR. ERICKSON: My name is Ari Erickson, A-r-i E-r-i-c-k-s-o-n.

THE STATE ENGINEER: Ari, can you hit the very end of your mike.

MR. ERICKSON: Hello. Can you hear me now? My name is Ari Erickson, A-r-i E-r-i-c-k-s-o-n. I want to comment and first thing I would like to do is my father happens to not be able to come to the conference so he had a letter that he sent out in January that I will be giving you. But I would like to read the first paragraph of that letter just so that it kind of explains the personal --

(The court reporter interrupts)

HEARING OFFICER WILSON: And please don't talk too quickly.

MR. ERICKSON: Okay. That's a problem. If I start talking too quickly, just wave at me and I'll slow down a little bit. I'm nervous also.

Here are the talking points I want to discuss. I have served on numerous boards and committees in my lifetime. And when you are elected to a position, you have a responsibility to represent all the constituents and most importantly the silent. This entails reaching out to them and hearing their voice. Simply because someone doesn't come to the general meetings or senior participate does not negate all the responsibilities to represent them. Still too fast?

HEARING OFFICER WILSON: You're starting to pick up speed.

MR. ERICKSON: Okay. So I took that counsel to heart because I was on and am still on the Groundwater Management Plan Advisory Board as the mining representative.

So as I began to go throughout the community and talk to either the people who weren't there or the people I ran across, I came across a gentleman who had a domestic well and his domestic well had dried up and he had to drink out of bottled water for a couple months while he worked on the domestic well. And I asked him if he would be willing to come today to share his experience about the effects of over-pumping on the domestic well. And I think the scariest thing is that he said I will not because I am too afraid.

So I am concerned that there are others out there, domestic well holders, that might be too afraid of speaking out about their domestic wells and not coming.

So the question I pose is how we can protect the domestic well holders from the effects of an additional 35 years of over-pumping.

The second point that I would like to bring up is as I was reviewing on line and trying to find if there was dissenting opinion of people who were concerned about our water law in Nevada, it minorly changed in ways that might benefit a local community, was there something else out there that we haven't thought of. And I recently came across a University of Denver Water Law Review that was done January

18th, 2018.

HEARING OFFICER WILSON: University of what?

MR. ERICKSON: University of Denver, Water Law Review. January 18th, 2018. And this is a direct quote from that. One significant legal issue in Diamond Valley would be how the water market can address the anti-speculation bill. This doctrine provides under Nevada Revised Statute 533.040 expressly prohibits a water right from being transferred to parties who do not beneficially use the water. The anti-speculation doctrine seeks to prevent hoarding of water by non-users, which could distort supply for farmers and artificially spike prices.

In an additional prior appropriation system, beneficial use stays off speculation, but in a water market, many worry that the water holder might stockpile shares to drive up prices, making it unaffordable.

That made me start thinking, well, are we so close to the GMP that we don't think about what would happen.

So that reference in Nevada Law Journal from August 8th of 2008 which says avoiding speculation through the trinity of beneficial use. So this is reading from the doctrine. Beneficial use is the linchpin of prior appropriation systems, as it is the basis, measure, and limit of the water right. All western water codes encapsulate the doctrine that created beneficial use, waste, and forfeiture. Many western states' constitutions explicitly include the term beneficial use.

The definition of beneficial use is similar along prior appropriation jurisdictions and typically includes just about any domestic, agricultural, or industrial activity, including sewage treatment, crop production, stock watering, hydroelectric power generation, mining and recreational pursuits. It does not, however, extend to speculative water users.

So as I was contemplating this and I was starting to think about the basin system that we put in, I realized that though our permit has a beneficial use, if we put water in to a bank and we have exempted the beneficial use requirement of future use of shared transferred water, we might be creating a system where somebody could bank water for a future use without declaring the future use and we might lose control of that and we might allow in a lateral way the water bearance to appear.

So the question I pose is how can we protect the intent and purpose of the anti-speculation doctrine while allowing an unrestricted bank, any water banked has no beneficial use associated with that at this time.

The third point is I've recently acquired with my wife and my father-in-law and my -- my father, my wife's father-in-law, and my mother, a farm in the valley. And we have a fairly senior water right. Because I knew that if I'm going to invest my livelihood in this valley I would want to make sure that under all conditions I had the ability to continue pumping and continue to farm. And so we bought a water right that was on -- that has a date of March 7th, 1960.

And on March 7th, 1960, there was 4,766 acre-feet allocated in this basin. At the end of March 7th, 1960, there were 10,846 water rights allocated. So in a single day in our history, 6,079 acre-feet were allocated. Under the GMP, all of us get the same priority. That priority is .958. So without getting -- As you can see from the Excel spreadsheet, without getting too technical, the thing that scared me a lot was I would be deficit irrigating on my farm at year three. And what I mean by that is each acre of my farm as its stands alone would need water from somewhere else, be it a dry corner, another farm, a junior farm, or some other asset. At year three I would no longer be able to farm alfalfa under the GMP.

So that made me start wondering, well, if I can't farm and I'm fairly senior at year three, what about the most senior acreage? The most senior acre drops -- So when I say farm, I use your number, you being the State Engineer's office, of 2.5 acre-feet as the consumptive use of the crop. So at year four, the most senior acre goes to 2.412 acre-feet per acre, dropping below that 2.5. So with the bank they will be able to farm until year five. Without a bank they won't be able to farm at year four under the current numbers, so that scared me.

So then I went to the most junior and I thought about the two-pivot farmer that has junior water rights, will he be even be able to farm? If we can't farm at year two and three, what about the small land holder, what do they do? And at year one they're below 2.5. So if there is a small land holder with one, maybe two, pivots, they legally won't be able to farm alfalfa at the ET rates and that's concerning.

The other thing that concerned me was at year 35 I will only be able to farm 2.5 acre-feet, 95 acres. I currently possess 200. So as a fully senior water right in the current GMP, I will not be able to farm 200 acres at year three. And at year 35 I will only be able to farm 95 acres of mine, half.

So how do we upload the priority system if my small family farm would be able to raise alfalfa after year two without getting water from some other source? A lot of the other sources that have been speculated on is corners. They put in center pivots so there are parts of their farm that they don't irrigate regularly. I don't have corners. I don't have the luxury of large land holders. I don't have the luxury of extra farms that I can turn off to make money. I have my two pivots and if those two pivots don't -- And my pivots aren't even full pivots. A whole pivot is a circle, for those that don't know, would be 125. Mine is 102 and 98.

The next part is CMA is defined as withdrawals in groundwater consistently exceed the perennial yield of the basin. And this plan must remove the CMA designation. So as I read it, the plan must take all underground pumping below the perennial yield. So the perennial yield recognized by the State Engineer's office and in the plan as well is 30,000 acre-feet. What's weird is within the plan itself there's a sub two recommending that the actual perennial yield is 35,000 acre-feet annually. So it sounds like there's new science that might give us more water, but as it stands now, it's 30,000 acre-feet.

So Diamond Valley reached -- So 13.12 says Diamond Valley reaches perennial yield are expected to be released within 35 years. As I was reviewing the plan in its entirety last night, I don't know if that's true because we have commercial mining rights, domestic including 120, municipal, quasi-municipal, and stock water. The 120 municipal wells that are in the state-issued record are the two acre-feet per acre, so 240. I bring that up to 3,343.8 acre-feet that will be pumped at year 35 in addition to the plan reduction, which brings us to -- the plan reduction brings us to 34,171.82. So if you add 34,000 to the 3,000, you get 37,505.62 underground pumping in Diamond Valley in year 35.

The other thing that was brought to my attention by some of the ranchers is there is currently a preliminary order of 5100 acre-feet of underground vested rights, which, correct me if I'm wrong, and that would be underground pumping so that should be included in a perennial yield calculation. And that would bring the total pumping in Diamond Valley to 42,615.62.

And so my concern, how does the GMP remove the basin from the CMA designation as it's written now if we count for withdrawals from all sources whether or not they are exempt from the plan? And with that I would like to thank you for your time.

HEARING OFFICER WILSON: Thank you very much.

MR. ERICKSON: I would ask for you to have this.

HEARING OFFICER WILSON: Okay. I received the written comments.

Excuse me, John Haeder.

MR. HAEDER: Good morning. Good to be here. I'm from Reno, Nevada, so I enjoy coming out here to the rural areas once in a while with my work. So I appreciate being out here.

My name is John Haeder, J-o-h-n H-a-e-d-e-r. I'm the executive director of Great Basin Resource Watch. We're a 24-year-old non-profit. It was born around 1994 from a coalition of people concerned about environment, ranchers. We actually had a miner on our first board as well.

And what we thought was important was to have a public interest organization that looked at mining in Nevada. Our mission is to protect the health, well-being of the land, the air, water, and wildlife and human communities in the Great Basin from the adverse effects of industrial development and resource extraction and use.

We've been following developments around the Eureka from our involvement with mining and primarily the Mount Hope project, which as you all know about, enormous project. It's still in the state.

So the mining industry significantly acquires water rights and uses a lot of de-watering in the process. And for this reason and the public interest, our organization is interested in this issue as it affects water policy. And that's why we're here and we've gotten involved.

A number -- When the draft -- When the first draft of the resource management -- Excuse me -- first draft of the Groundwater Management Plan first came out, I read through it myself. I'm not a water expert by any means. I know a little bit. But I actually asked these questions organizationally and we wondered given that this is going to be a significant departure or something new from Nevada what are going to be the effects? Are there going to be some groups that might be disproportionately affected by this information or other groups that might be favored by it in some way?

We wanted to answer some of these questions we were wondering about. So we sought an independent analysis. We looked for an organization or a company that could -- that's not in the community per se but understands water law well, understands Nevada water law, to look at the plan of a public interest perspective, who is going to benefit. And so there's a few copies of the hard copies of the report back there. So we commissioned the advocates for community environment to review this plan. And what I'm going to talk about is really primarily what we got from this review.

The plan is the hard copy that I submitted to you is the larger and there's some back there. And it's also available on our website and I'll give the people our URL for that if they want to download it. So that's why we're here and what we want to talk about.

The Groundwater Management Plan, this is the first of its kind in Nevada. It has the potential to set an influence precedent in other groundwater management plans in Nevada and elsewhere in the rest of the United States. There possibly could be very broad implication.

Our organization appreciates the initiative by the State Engineer in designating the Diamond Valley as a critical management area and the work of all the people that developed the draft plan, taking an important step towards correcting historic overdrafts in Diamond Valley's groundwater system and establishing sustainable approach to future groundwater management and use in the Diamond Valley.

Nonetheless, the report, as we explained in the report, we believe that there are some parts of the plan that are not yet adequate to ensure sound, sustainable and equitable future of the groundwater system and the residents of Diamond Valley that should be improved upon for completeness.

So just to stop for a second here, my take from the analysis was done was that a plan like this -- a water marketing system can work but with such a system comes a lot of flexibility with what you can do. And my view -- our view is then with that flexibility also comes a lot of responsibility and it requires a lot of oversight. Because it can go in directions that you may not anticipate or go in directions that you do not want. And that's kind of one of the big things that I took away from the analysis.

It may be a good way to manage water in the future, especially in the arid west, which is predicted to become drier. It can allow for this flexibility as was mentioned earlier. But the flexibility comes as a responsibility. Overall, the plan is needed additional requirements or constraints to ensure that all of the rules set forth in the plan agreed to by the Diamond Valley community occur.

The analysis addresses potential pitfalls and suggests preventive measures. So the only positive aspects can move forward. So that's what the point of view analysis was.

A couple things about management plans in general. They should maximize conservation of water resources and ensure the groundwater is put to its best use as defined by the affected community. So you as the community have to define what is the best use for water in our area. And the plan should move in that direction and adopt management techniques that promote good stewardship of groundwater for future generations and the same access and opportunity to the groundwater resources of the current users.

It's to provide for a transparent system of groundwater governance. This is really critical. People have to really understand what's going on and have to be able to access information, so transparent and transparency is very important.

It should create an institutionalized structure of decision making and government that's fairly representative of the stakeholders connected with those groundwater goals and values.

It also should reflect the range of possible alternative strategies or techniques in achieving the goals in this plan. When the reviewers look at the scope, it appears maybe there was some other approaches that could be pursued that were not discussed in the early phases. And so that may be a weakness also. You may want to go back and think about that.

Some general comments about water markets. Water markets as would be done in this plan are increasingly recognized for the potential useful approach to enhanced proficiency and conservation. However, the general view seems to be that markets are not the whole solution and that what remains -- and that there remains a need for a role of proactive oversight and direction from the appropriate regulator, which would be the State Engineer. So it's critical that there be those importances in place to make sure that the plan goes in the direction and water use in the basin is the way you want it. Water markings approached in isolation pose a risk of unintentionally incentivized and undesirable results.

For example, a shift in the pattern of water use that serves the interest of grants or profit seeking market participants but that undermine associate economic environment and other public interest goals.

A water market with relatively free trading must be bounded by carefully crafted regulatory controls and ensured that the water remains in the hands of the local communities and as always dependent on that availability. So, again, it's flexible, but watch out. You want to make sure that it moves in the direction that you want it to.

So speaking on that particular point, I want to talk a little bit about the character in Diamond Valley. One of the issues I think that arrived was although it may be an unintentional consequence of the water marketing approach employed in this particular plan, the plan appears to anticipate and facilitate conversion of water use away from irrigated agriculture to other purposes, including mining, despite the state's goal of preserving socioeconomic structure of Diamond Valley, which currently is based on an irrigation and irrigated agriculture. The plan does not include proactive measures designed to maintain irrigated agriculture in the Diamond Valley and provides that nearly allocations are freely transferable for any beneficial use recognized under Nevada law. Without prior good measures, it is designed to serve the state's goal of the plan, the purpose -- the purpose of use and trade-in allocation will be left to the market to determine.

If stakeholders and the State Engineer are concerned about the implications of converting water use in Diamond Valley away from irrigated agriculture, which appears to have been a major concern here, and expressed limitation in the plan on changes on the purpose and use of allocation when purchased should be considered.

An example as given is the approach when you look at groundwater sustainability plan currently being implemented in Ventura County, California, which limits trades of existing agricultural ground rights among irrigators. So it's one example that they put on the plan.

We think this is an important criterium. A couple of examples in terms of this movement away, for example, look at the governance. And I think that has been brought up already. The composition of the advisory board, which plays a critical role in this process. To make recommendations to the State Engineer regarding administration of the groundwater management plan presents a little bit of a concern to both agricultural users and the interested public. Specifically, the advisory board does not include position to represent environmental concerns or a position to represent for overall public interest concerns, including local community interest. So you may want to think about the composition there a little bit.

Both of these positions should be considered by stakeholders as a means by which the social and economic character of Diamond Valley have a broader public interest might be protected under the groundwater management program.

Significantly, the plan seems to transition away from agricultural value and composition over the first eight years of its implementation. The result is to create five at large positions which will be open to representation of any type of user, whether it be mining, industrial, municipal, commercial, agricultural, and so forth.

One apparent implication of this provision is that the Groundwater Management Plan assumes a shift away from agricultural use in the Diamond Valley without an intention to provide any guarantee that the agricultural uses or interest will continue to prevail or have any control over the character of water in the Diamond Valley.

There is a substantial possibility, if not likely, that financially powerful interest could influence and quickly require the majority of shares to the relatively free trading of water shares permitted on the plan and could also use their voting power to skew the membership of the advisory board in the direction that would be no longer protective of the local irrigated agricultural or local community priorities or public interest.

So, again, this can be avoided. These are just some possibilities to think about in terms of how it could go in the direction, what does the community really want to have.

Stakeholders should consider how the representation might be allocated differently. We talked about that. Additionally, according to the plan, votes from the election of the advisory board will be weighted according to the number of shares held by the voting rights holder. Such a weighing will facilitate concentration of power to control the advisory board membership and decisions in the hands of one of the few dominant water shareholders. Again, another potential risk.

A final concern around the governance is that there is a provision for a three-day period of notice on the advisory board meetings. And while that's the minimum required by law, it's probably not sufficient. The reviewer recommends at least a week for notification so that people have time to prepare.

Another point on the scope of the plan itself, the decision to limit the scope of the groundwater -- limit the scope to groundwater irrigation rights and mining rights, the irrigation base means that mining rights, for example, without irrigation base rights along with commercial rights and municipal rights would otherwise be completely curtailed under the strict priority administration, would not be subject to significant reduction over time that are incorporated in the plan. The effect of excluding these junior water rights appears to be protecting them from curtailment while subjecting water rights covered up by the plan to progressively reduce water allocations over time. This as a reviewer does seem to -- while excluding non-irrigation water rights for specific circumstances in Diamond Valley may serve a purpose, this limited approach should not be taken as a general precedent of other groundwater basin management plans as a default starting point -- default starting point should be -- seek a comprehensive scope as possible.

And then another point that's connected to this is the diminished State Engineer and public scrutiny and review of changes and purpose of place. We did some discussion of this already. But the Diamond Valley Groundwater Management Plan approach to annual trading allocation facilitates and thereby encourages temporary transfers that may be repeated over many years, which in effect may amount to permanent transfers. So under this procedure of established by the plan, those temporary transfers would be subject to a significantly reduced level of scrutiny by the State Engineer and the concerned public as compared with what would be required for openly permanent or long-term transfer, including an exemption from a protest and hearing process.

Stakeholders, you all should consider strongly incorporating environmental consideration along with a meaningful opportunity for public comment in to the review process for all transfer applications likely to be repeated or actually being repeated after the first year, in order to ensure that adequate protections for the environment and other aspects of the public interest are satisfied.

We do support -- We do think that the

out-of-basin transfers should be limited. They're currently not in the plan. We think that's good. There is a provision to possibly change that in the future. But there might want to consider some constraints on how those transfers can occur and what can happen with them.

If a stakeholder is to prevent unwanted out-of-basin transfers, it would be advisable to include standards of the plan applicable to all transfers. So, again, another component.

You know, in summary, it's important for stakeholders and the State Engineer to consider revisions to address potential unintended consequences of the plan. Limiting the scope of the Groundwater Management Plan and its pumping reductions to groundwater irrigation rights and mining rights of the irrigation base and not including a position on the advisory board to represent public interest, including local community interest, environmental concerns, built-in transition, built-in transition away from guaranteed agricultural representation at large positions on the advisory board that may be held by whatever division or entity might purchase water for other uses in the plan, the diminished State Engineer public review changes in purpose and place of use that will result from encourage and trading allocation on a temporary annual basin.

Allocating -- Allowing the water -- Allowing the market to determine what dominant purchase of water exists in Diamond Valley. Failure to provide environmental protection in the census for environmentally-friendly uses and the potential for unbundling water from the land and create increased pressures for out-of-basin transfers.

Again, we appreciate all the energy that went in to creating this. And, again, from stepping back from the review that we had done, yes, this process can work but with additional constraints, requirements, to ensure that the character of your valley is preserved.

Again, there's a few copies of our report back there. If you're interested in downloading it off the website, you can go to gbrw.org/publications and you'll see it on that page. And thank you very much for your time and hospitality of Eureka and Diamond Valley.

HEARING OFFICER WILSON: We received a copy of the testimony of the report that you had.

D'Mark Mick.

MR. MICK: I'm D'Mark Mick, Diamond Valley Ranch. D-apostrophe-M-a-r-k M-i-c-k. I'm an irrigator here in Diamond Valley. We own and operate 19 pivots here in the valley. We also represent about five percent of the senior water rights here in the valley, if you were to take the

30,000 acre-feet as the cut-off. So we're both a senior and a junior water rights holder. And I guess we've been involved in the process from early on. I have attended many of the meetings. I won't say a majority, but a vast number of the meetings throughout the process to go through the development of the Groundwater Management Plan. And I applaud the efforts of the group that have been put in at every meeting by the advisory board that put in all the extra time.

And I do want to come out and state that we are in favor of the Groundwater Management Plan. We recognize that as a senior water rights holder with enough water to irrigate eight pivots after the full curtailment that we're going to be impacted by this plan. But we also recognize that the easy way out is to just accept curtailment as quoting one statute that's in place and saying that we are going to manage by seniority and curtail everybody below line for which there apparently has been a science, although it's been argued that whether or not the science is either valid or in place. But there has been a line drawn in the sand. And so the easy number is to pick that number and say everybody above it gets to continue to irrigate.

The downside and the thing that seems to concern us is that what's the impact on the community, the greater community, of not only the irrigators of which would be impacted but by the people who voted for the bond for the fire house, for the people who, you know, invest in Raine's Market or for some of the other businesses here in place that if you see an impact of two-thirds of your water rights users disappear what is the ultimate impact on the greater community of Eureka. And we're willing to take the hit as a senior water rights holder in order to support the greater good of the community.

So, like Mr. Benson, I would like to reserve the right to submit additional comments in writing. But we want to come out publically in support of the plan as presented. Thank you.

HEARING OFFICER WILSON: Thank you, Mr. Mick.

Marty Blaskett.

MR. BLASKETT: Marty Blaskett, B-l-a-s-k-e-t-t. I am Marty Blaskett, a life-long farmer in the Diamond Valley. I support the implementation of the Groundwater Management Plan a hundred percent because of the following reasons: The plan was created and accepted by the majority of those it will affect through many years of deliberation and design input from the regulatory site plan management. A local solution by locals with the State Engineer's oversight to bring the basin in to balance and remove the critical management area designation.

The pumping reduction schedule is based on water right seniority, favors ultimate water use efficiency, better management practices, and rewards water conservation with credits.

I have proven to myself on my own farm in the last two years that it will not affect my yields and ability to produce a quality product. Better efficiency and better management, along with advances in farming in the coming years, will offset the pumping reductions in my operation.

The plan was purposely designed to keep the community whole, allowing all users access to water and balancing the basin for ultimate health of the aquifer. The tax base is maintained and all the social economic units involved in the community are not disrupted by dwindling population that will occur with our alternative options, curtailment of pumping.

The plan is flexible in that it has set benchmark reductions with yearly allocations adjusted through well monitoring data, annual precipitation values, and conservation relief.

Until a better solution rises, it is the most logical path toward basin water balance.

In closing, it is important to recognize and appreciate all the hours in meetings, time traveling, arguing, and refining a solution to a problem that has been festering for 50 years at least.

Thank you, State Engineer staff, for your involvement in plan structure and management. Thank you, Eureka County, for allowing our resource manager to keep the ball rolling, uphill, which is a gross understatement. Thank you, Eureka County hydrology experts, for arming us with the data to qualify, quantify our efforts. I would like to thank all of my DNR PCA members, the GMP committee. The conservation district has supported this greatly. Mining partners that see the value in the plan support us. And there is no I in this team dedicated to making Diamond Valley sustainable. Thanks.

HEARING OFFICER WILSON: Thank you. And we did receive the written comments of that statement.

Russell Conley.

MR. CONLEY: Hello. My name is Russell Conley, C-o-n-l-e-y. I'm an irrigator in Diamond Valley and I'm also --

(The court reporter interrupts)

MR. CONLEY: I'm an irrigator in Diamond Valley and I'm also a member of the advisory board that helped develop this Groundwater Management Plan. As you know, Diamond Valley is mostly comprised of family farming operations. We enjoy a rural way of life, good schools, strong community, and the ability to make a modest living on the ground we own. Our local climate enables us to produce very high quality hay and forage and good farmers have a chance to make a decent living for their families.

My family's operation, similar to others in the valley, we currently raise hay, cattle, and three children. The farming portion of our operation is completely reliant upon groundwater. And our water rights have been in effect since early 1961.

Even though these rights have been active over the last 57 years, they are still considered to be junior and would be amongst those curtailed if the State Engineer was forced to curtail based on priority.

As we avert, not all people agree with the development of the local Groundwater Management Plan. Some believe that the prior appropriation doctrine should be strictly adhered to. I believe that it is the failure to follow the documents from the beginning to allow allocation of this precious resource by over three times the perennial yield.

Now we are in a situation where people work hard to develop their land, raise their families, and establish roots here. The people in this basin have created great agricultural area that has grown to be a large part of the community. Many of the irrigators in the basin have come together to develop this Groundwater Management Plan. But while the plan may not be perfect in everyone's eyes, most of the irrigators agree that it is a workable solution that would bring our basin back in to balance. In addition, it would enable most of the agricultural community to stay intact. I believe that approving this Groundwater Management Plan would be the best solution for the resource as well as the community that relies so much upon it. Thank you very much.

HEARING OFFICER WILSON: Thank you, Mr. Conley. And I did receive a hard copy of the testimony.

James Moyle, come on up.

MR. MOYLE: My name is James Moyle. I'm a farmer in Diamond Valley. My last name is spelled M-o-y-l-e. I first of all would like you to know that I am in total support of the plan. I have participated in the meetings over the last two years. I think in excess of two years we've been meeting.

My first exposure to a Groundwater Management Plan was not two and a half years ago. It was when Mr. Pete Goicoechea was first elected to the United States legislature. And when he come home for the recess in the summertime, he approached me and asked me if I would be willing to start a Groundwater Management Plan. I'm not quite sure how many years ago that was, but it was quite a few.

Given the nature of the valley and my past experience having lived here through the water wars of '77 and '78, I chose not to put that target on my back. But I decided once again to come and get involved in the water management plan.

As a participant in the process, I can tell all of you who I consider newcomers to the issue, you are always welcome. If you chose not to come, that's your idea how you participate. But one of the things that was important for me to say today is the plan was put together by the people who had skin in the game. You have people who were going to lose more than they wanted to, more than they thought they were entitled to. And you also had people that they thought might get something more than they were entitled to. But, after all, we are only talking about whether all legal water rights, junior or senior. And this plan was an intent to, from my point of view, was to do nothing more than to maintain the economy in this valley. That's been first and foremost on every decision that ever came out of my vote over the last two years. For those of you that may or may not know, the State Engineer was vetted in the last two years at every meeting we had. I can tell you that to my knowledge I think I only missed two of those meetings out of the year, out of the two years.

So I can tell you I did not get everything I wanted as a participant through the process, but I was willing to sign off on it for the betterment of the valley.

So, once again, I thank the State Engineer for initiating this. I thank him for having his representative in the room for the past two years, so that we were not stumbling around blindly. There was heated discussions on a lot of the things. A lot of people left in tears. But they came back. That was the important thing. Some didn't.

But I support the plan 100 percent and I want to thank the State Engineer and all the people that participated on a regular basis. Thank you.

HEARING OFFICER WILSON: Thank you, Mr. Moyle.

Mark Moyle.

MR. MOYLE: Hello, everybody. My name is Mark Moyle, M-o-y-l-e. I'm here representing Mark Moyle Farms. I've been a farmer here in Diamond Valley for 35 years. I'm also representing DNRPCA, which is Diamond Natural Resources Protective Conservation Association.

I'd like to take a moment and thank the many people that have worked so hard for so long to develop and create the Diamond Valley plan. We've been fortunate enough to have so many talented individuals working on this, the first of its kind, Groundwater Management Plan in the State of Nevada.

It is very important to keep in mind that the Diamond Valley Groundwater Management Plan was developed specifically for Diamond Valley. As we've seen today, there's been a lot of outside interest and concerns outside of Diamond Valley. What will be the future? And that's why I say that. How it will affect other people in the state.

Diamond Valley has its own unique circumstances and conditions that this Groundwater Management Plan has been designed for. It is not intended to deal with other areas of the State and their challenges. Because this plan is the first of its kind in Nevada, there will no doubt be concerns about how this plan might impact the rest of the state. I am sure that there will be more plans developed in the future that may adopt some of the futures of this plan, but the future plans will have to deal with different conditions and situations.

It is my concern that the interest outside of Diamond Valley, fearful of the unknown, may try to interfere with what has been developed for this unique area by the people who live here.

We do welcome outside constructive criticism and input as long as its intention is for making the plan better for its intended purpose here.

There have been hundreds of hours of meetings and discussions as well as intense debates that have gone in to the development of this plan. There have been a lot of compromises and consideration given to the many issues that this plan needs to address. The goal has always been to get consensus on the issues at hand. We did not always get consensus, but we did get the majority to agree before we moved on.

The goal and development of the groundwater -- The goal in the development of the Groundwater Management Plan is to reduce groundwater pumping in a manner that will do the least damage to the water users directly, the local economy, the environment in regards to weed and rodent problems and return the groundwater resource back to a sustainable level.

The Diamond Valley Groundwater Management Plan is not perfect in every way. It comes at cost to all irrigators who will cut their pumping by 30 percent in the first ten years that this plan is implemented. The irrigators that support this plan understand that and we all need to sacrifice for the long-term benefit of the community and the long-term continued success of the farming industry in Diamond Valley.

Diamond Valley is the heart of the southern Eureka County's economy. Few irrigators who are not in favor of this plan are not so concerned about the whole economy. They're only concerned about themselves.

The implementation will come at a cost to so many, that it is understandable that there will be people who will not support it. Strong, willing, giving people who understand that it takes community effort to sustain and survive built Diamond Valley. It took a huge group effort to get the electric power that everybody enjoys in Diamond Valley right now, even those that aren't in favor. It took a huge group effort to work on the power cost to increase challenges that occurred in the eighties. It took a group effort to develop weed and gopher control to deal with those problems. It took a group effort to get the roads paved in Diamond Valley. It took the same group effort to develop the Diamond Valley Groundwater Management Plan.

The purpose of the Groundwater Management Plan is to continue the ongoing success of the entire southern Eureka County area and all of the enterprises that exist there.

The long-term residents of Diamond Valley have endured a lot of challenges in the past and have worked together to solve it. I am confident in the resilience of the people who have made a living here. I would encourage them to be aware of some residents who have demonstrated by their actions or intent to only take from this community.

There are only two options: Strict curtailment by priority or adopting the Groundwater Management Plan. The Groundwater Management Plan is the best solution to an extremely difficult situation that was created by actions and conditions in the past. It is an extremely proactive solution created by the people who are the most impacted. The Diamond Valley Groundwater Management Plan has been developed with input and participation from the agency responsible for its implementation, the Nevada Division of Water Resources.

I'm extremely grateful for all of those who have worked and participated in developing this plan. It is now time to put the plan in to effect so we can ensure that the water resource that we all depend on will be preserved in the future.

That's what I have written. I want to add a few other things based on a few other statements if that's all right.

HEARING OFFICER WILSON: It's your comment. Go ahead.

MR. MOYLE: Some of the other people that got up and spoke, I really have to take -- I wonder where they got their information. Obviously they didn't read it or they haven't got -- they got bits and pieces of the plan. But you can come in to a meeting like this and you can skew little bits and pieces of things that you read or you want to make a stand on to make it sound like that what it really is is something different and I take offense to that.

You're entitled to your opinion, but when you get up in front of people and make accusations that basically are not true or you weren't involved in the process, you don't maybe know, maybe don't understand.

This plan was designed to meet the perennial yield based on not a model but based on what the perennial yield estimates are. It is not a mitigation rights plan. It is not the groundwater mitigation rights plan. It is the Groundwater Management Plan. Mitigation rights are up to the State Engineer to deal with, not the plan.

I've heard that it violates other provisions of water law. This plan was developed under the provisions of Nevada water law. Water law says that if you have a critical management area there's a time period to develop a water management plan to deal with that. That's exactly what we've done.

It doesn't need -- I've heard that this plan will not have the end goal of getting the CMA designation in the end. It absolutely does.

It's my hope that these outside influences will not be a major factor in the plan that has been developed in this area. It's been developed by the people who live here and will be most affected and everybody sacrifices.

I would like to reserve the option to turn in some more written comment by Friday. You've got my written response so far. And thank you.

HEARING OFFICER WILSON: Thank you, Mr. Moyle. Yes, we have received the written portion.

We're going to take a five-minute break and resume the public comments. So only about five minutes and give everybody a chance to stretch.

(Recess was taken)

HEARING OFFICER WILSON: Let's go back on the record. We will continue with public comment. Bob Burnham.

MR. BURNHAM: Mr. King and staff, thank you for your contribution to this process. My name Bob Burnham, and that's B-u-r-n-h-a-m.

I'd like to take this opportunity to support the implementation of the Diamond Valley Groundwater Management Plan. I and many others have worked very hard to develop this proposal, which implemented can ensure a successful and prosperous future for the local agricultural community as well as be an example for the State of Nevada and indeed the western US of what is possible for maximizing the agricultural potential of finite water supplies.

In the last year I have sold my family farm after living here for 42 years. My father first invested in Diamond Valley nearly 60 years ago. Although I no longer have a financial stake in the valley, I care deeply about the future of this community and its agricultural base. This process was the right thing to do when we started it seven years and it is still the right thing to do.

Through genetics, improved genetics, changing property patterns, and new technology, we can become increasingly and continuously more efficient. In other words, the status quo is not the future as far as what is possible with water use.

And I'd like to thank the Division of Water Resources for participating in this process and making your staff available and vetting what we did. Thank you very much.

The GMP is an opportunity for this state, the driest in the nation, to be at the forefront of resource conservation and to show what is possible for modern agriculture in terms of efficiency and water management. The days of needing an acre-foot of water to grow a ton of hay --

(The court reporter interrupts)

MR. BURNHAM: The days of needing an acre-foot of water to grow a ton of hay are a thing of the past and we all need to move forward to a more productive future.

I, like many others here, have dedicated our lives to making this valley an economic success and a cornerstone of this community for more than half a century. This GMP program is the best way to ensure that the success story continues for many generations to come. If decades from now the children and grandchildren of the families that bought my farm are still farming, that will be a wonderful legacy, not just for me but for the community, the Division of Water Resources, and the State of Nevada. The GMP is the single best tool to preserve that legacy and indeed the legacy of all of those that have worked so hard to build this community.

It is also an opportunity to make Nevada a leader in preserving irrigated agriculture in the west.

And I too would like to reserve the opportunity to provide some more written comment. Thank you very much.

HEARING OFFICER WILSON: Thank you, Mr. Burnham. We did receive a copy of your written letter.

Jim Gallagher, if you would like to come up.

MR. GALLAGHER: Good morning. Jim Gallagher, G-a-l-l-a-g-h-e-r. It depends on where you draw the line, but I think my farm is senior and I'm very much in favor of the plan and I worked on the plan for the three years it took us to develop it.

We worked hard in the last three, four years, my kids and myself, to learn how to irrigate. We have got by by using two foot or less to grow a full crop in each of the last three years. And I think by learning how to irrigate instead of run water, the valley can survive and will survive. I think if we do not have the plan and we have to go to curtailment and there's only 50 or 60 circles left in production, they won't last very long because the weeds and the rodents will take them over. I think under the plan there will probably be still 170 or 180 circles in production out of the 200 at the end of the time of the plan. But I think everybody is going to have to learn to irrigate, work together. But the plan will work and I think we can all do that.

I've heard people talk about exporting the water under the plan. There's no inter-basin transfers and they said it's easy enough just to amend it. Well, that's bull. Because you'll have to recreate the plan, get all the petitions signed again, go through this hearing again. It's not an easy deal. So the water will stay in the valley. The advisory board balance, if you can't export the water, why would somebody buy it to keep it here?

So the people in charge of the water will be the farmers. And so we will be in charge of it. And so -- But thank you guys for coming and I think the plan needs to be passed.

HEARING OFFICER WILSON: Thank you.

Dan Venturacci.

MR. VENTURACCI: My name is Daniel Venturacci. The last name is V-e-n-t-u-r-a-c-c-i. I'll give you these. My wife and I own the Thompson Ranch located on the north end of Diamond Valley. Our ranch consists of the deeded acres at the home ranch, the Cox Ranch, the willow field, the rock field, the box springs, and mountain base at Davis Canyon. In addition, we also have a Diamond Springs grazing permit which surrounds the city.

Due to the over-allocation of the pumping that has been allowed to continue to occur in Diamond Valley, all of the vested surface water, irrigated and sub-irrigated meadows located on the valley floor of the Thompson Ranch have been destroyed. The Thompson Ranch has been begging the State Engineer for help to restore its impaired vested water rights since 1982. The State Engineer has continued to let the over-pumping and para vested rights surface water rights on the ranch as well as others in Diamond Valley. The current proposed Diamond Valley Groundwater Management Plan allows junior water rights holders to continue to pump in excess of the perennial yield, which in turn drops the water table and continues to impair vested surface water rights.

Not only has the over allocation of Diamond Valley caused us to lose our vested surface water on the valley floor, our vested mountain runoff water is also being impaired. The over-pumping -- The over-pumping has resulted in the subsidence of the valley floor, which has created large fissures. These fissures prevent the vested mountain runoff water from reaching the existing meadow, therefore impairing our vested rights even more.

If you flip through the papers, you can see the pictures that I've provided with GPS coordinates. And the GPS coordinates in the pictures are just a couple that I got for evidence. There is fissures throughout the north end of the valley on all the ranches in the valley floor.

As long as the over-pumping is allowed to continue, these fissures will continue to increase both in number and size, causing us financial harm, as we will -- as well as impairing our vested rights. We feel that the GMP is in violation of statute NRS 533.085, which states nothing contained in this chapter shall impair vested rights.

Due to the fact that vested -- Due to the fact that vested surface water rights are continuing to be impaired and no mitigation plan is addressed in this GMP, we will not support the GMP. We feel that before the GMP is signed by you, Mr. King, our concerns need to be addressed and result immediately so that we -- I'm nervous -- so that our vested surface water rights do not continue to be impaired. Thanks.

HEARING OFFICER WILSON: Thank you, Mr. Venturacci. For the record, Mr. Venturacci handed the copy of the letter which he was reading in to the record and the pictures which he referenced in his statements.

Carolyn Bailey.

MS. BAILEY: Hello. I'm Carolyn Bailey. And I wanted to reiterate the fact that the meetings were very intense and mention that I did not feel welcome at them so I didn't attend very many of them.

I'm representing the Bailey Ranch today. And the Bailey Ranch has been in operation in Diamond Valley since 1863. Current laws protect the viability of our heritage.

When laws were not enforced, our ranch was harmed by the drawdown of the water table. The water table that naturally flows from springs was devastated. The springs, ponds, meadows, and forests that our family, livestock, wildlife and plant communities relied on was severely affected. We were left to mitigate this damage at an extensive expense that goes beyond our pocketbook.

We support efforts to create a Groundwater Management Plan that is environmentally sound and would not further injure our ranch vested water rights and help the agricultural sector. The only water rights included in the GMP are agricultural water rights. The GMP needs more than a modest revision.

The way the plan has been proposed has had a chilling effect on the Bailey family and those with whom it would be applied. The option given was to sign on to this plan or be curtailed.

One agreement between Eureka Moly and Eureka Producers Co-op, dated August 18th, 2010, required Eureka Producers Co-op not to participate in any manner directly or indirectly to interfere with Eureka Moly's plans to secure water and place Mount Hope in to operation and further to persuade any other protestants to settle any appeals to water requirements. A settlement between Eureka County, Diamond

Valley, Resource -- Natural Resources Protection and Conservation Association and Moly Mine dated September 12th, 2018, states that Moly shall not assist any party financially or otherwise that opposes or is adversarial to approval or implementation of the GMP. These and other settlements with individual ranchers and farmers have interfered with the ability of stakeholders to speak out. This plan could profoundly change the demographics of Diamond Valley and in effect do the opposite of what the stated goals of the plan represent.

Walker and Associates, including Michael Young, were hired to facilitate this process and are experts at changing demographics of natural resources for the benefits of their clients.

Issues regarding non-consumptive use phreatophytes, transparency, board structure, and weighted voting are some of our concerns. Giving shares to abandon water and banking shares adds to the future demand on the aquifer. Water bank balances could quickly exceed available resources. There is no contingency plan for large withdrawals in the future. Out-of-basin transfers would not help our basin's sustainability. Vested and mitigation water should be managed under NRS 533 laws.

Baileys have seven generations on the Bailey

Ranch in a century and a half of continuous operation. This represents a century prior to the farms considered for management under the GMP plan. The Bailey family also owns farms in Diamond Valley and we recognize the need for and do not oppose implementation of a GMP plan that would protect agriculture for future generations. The Bailey Ranch asks for the State Engineer to revise the GMP or consider alternatives.

HEARING OFFICER WILSON: Thank you. And we did receive the written copies you were speaking to just now.

Patrick Rogers.

MR. ROGERS: My name is Patrick Rogers. I'm the vice president of permitted and environmental compliance for General Moly. I've been working in this community to develop the world class Mount Hope Mine for going on 12 years. Hope to continue that and continue to support the community in addressing important issues such as the sustainability of the Diamond Valley aquifer.

I represent General Moly and Hobie Valley Ranches. We support the Diamond Valley Groundwater Management Plan and we support its acceptance by the State Engineer.

HEARING OFFICER WILSON: Thank you, Mr. Rogers.

Vicki Buchanan.

MS. BUCHANAN: My name is Vicki Buchanan for the record, B-u-c-h-a-n-a-n. First of all, I would like to thank our current State Engineer and his staff for all the headaches and input that they had putting in -- coming in to this.

The whole problem, there's not a person in this room that has a water right that's doing anything illegal. Every single water right that's issued, whether you're junior or senior or anything else, they're not pumping any more water than they're allowed to by law currently. And my family -- I guess I should go back. My family is one of only two or three original desert land proprietors left in the valley. And water law -- water law is not set in stone. It is for right now. But when we originally filed on the water rights in Diamond Valley, we had to prove beneficial use on those water rights. And it was our understanding at that time that if we proved beneficial use on that water right that that was our water right. And I'm not positive of the year that it happened.

But Roland Westergard, one of the prior State Engineers, came out here to a Conservation District meeting. And it's when the, we'll just call it the use or lose it clause came in to effect. And he sat there and Chuck was here, Birdie was probably here. My mom was here. And he said this law isn't supposed to affect Diamond Valley. It's not going to affect the people that are sitting here in this room. It's just for people that are speculating. It's to protect the water rights around Las Vegas. It's not ever going to affect Diamond Valley. Well, it sure did. But that was a change in water law.

A change isn't something that any of us come by easily. It's just like Chuck said, you know, when it came time to get power in this valley, Don Nelson, Chuck, my dad went around and they had to knock on doors to get power. They passed a petition and only by one signature, one signature, they got enough people to sign on to this petition to get power in our valley. And it's true that if we didn't have power we probably wouldn't be sitting here today because we would all be broke and gone.

But, anyway, what I'm getting at is that change is scary and the Groundwater Management Plan is a deviation from what we've always been doing. But what we've always been doing, we've been fighting for 40 years that I know of, and it's been ugly. And if this Groundwater Management Plan, if we can come to an agreement on it and it's something that we can all live with. No, it's not perfect. And I, with having all senior water rights people ask me why -- why are you in favor of it. Well, when it comes down to it, when I put my pump in the hole and there's no water coming out, it doesn't matter what my water right says. If I'm tied to that piece of property, I can't -- I have no flexibility. And so what good is me to have a senior water right if all the junior water rights around me go away and I still don't have any water.

And I understand that there's a lot of litigation going on. There's adjudication process. There's the mitigation rights. And that stuff has been going on, not the adjudication, but the rest of it, pretty much my whole life. And I have a feeling that it might go on through my son's life.

But this Groundwater Management Plan to me is a positive step to reducing the pumping in Diamond Valley and trying to keep as many people viable as possible. And it's not -- You know, a lot of those juniors, there's some on the very bottom that, I'm sorry, they are going to go away. They're not going to be able to survive. But at least if they can sell their rights to somebody else, if they can find a different way to farm, if they can look at alternative crops, if they can farm one pivot instead of three, give themselves time to figure out a game plan to figure out what they can do to stay efficient, you know, then that gives them -- that gives them a chance. It gives them an option.

It leaves the option in their hands, rather than the State Engineer coming in and saying, you know what, I'm sorry, but next summer you're not going to -- your farm is done. And, you know, like I said, there's nobody in here that has a water right that hasn't been issued a water right.

And, you know, like I said, I'm in favor of the, you know, the first in right, first in time. But when it should have been enforced was 40 years ago, you know. And it's, you know, the prior state water engineers -- There's not enough time to talk about all of the inequities that have been put on this valley through all the years through State Water Engineers. And present company excluded, Jason.

But the other thing that this Groundwater Management Plan will do is it will stop a lot of the nit-picking, the pettiness, the -- You know, it will start us with a clean slate and it's up to us where we go from there. So thank you for your time.

HEARING OFFICER WILSON: Thank you, Ms. Buchanan. Matthew Morrison.

MR. MORRISON: Hi. Is this working? I would like to --

(The court reporter interrupts)

HEARING OFFICER WILSON: Just so we have a record -- Excuse me. So that we have it on the record could you state your name and spell your name, please.

MR. MORRISON: Okay. My name is Matt Morrison, M-a-t-t M-o-r-r-i-s-o-n. And first I would like to thank people so I get that out of the way. I would like to thank the water engineer's office and those people that came out and helped us. Especially I want to thank all the people that were on boards both on the water organizations. And I especially wanted to thank Dale, who has been out measuring wells. And most of all I want to thank Jake, who has really sacrificed for us.

I'm kind of like one of the first people here in this valley. My mom and my dad, Birdie Morrison and Don Morrison, filed desert planting trees, and we first came out here in '59 and went back to Seattle. My dad used to work for Boyd Airplane Company in Seattle, Washington, without a college education or a high school diploma. He was quite a person and quite admired.

I remember coming out in this valley and it was sagebrush. I sat in that tractor with my mom going around in a square beating the brush out here to be a farmer, to raise our crop is what my dad always wanted to do.

And we never thought we would not be senior. But come to find out, we were one of the first ones here and we cleared the land, and she's, like, two weeks from being a senior.

I kind of left and went to college and joined the Navy and came back in 1970 because I loved this area and I wanted to be a part of it. And so I brought my wife out here in 1980 and bought a piece of ground and helped my dad farm and become a part of this community, which I love, and worked hard.

And now I find out that she's two weeks from being a senior. That on the place that I bought I'm a month away. And another place that I have that I bought first initially is pretty junior, but there is a little bit of rights on there that is a little older, but nothing senior.

So we have worked hard. We didn't have any money. We were poor. And we worked our way up. And my dad enabled me to buy property and enabled my brother also to buy property here in this valley. And the human side of it is that we have been here since the very beginning just about, and we're not senior. And we have our families and we have everything invested in this valley.

Now, if you'll go back that far, the junior rights, then you're going to see a tremendous amount of people leave this place. You're going to see a lot of pivots out there shut off. You're going to see -- You might see a lot of crescent weed planted. You might see -- You'll see rodents come in. It won't be good for this area.

And I understand, you know, people who have senior rights and I understand some people have junior and senior rights. But I also understand this community, this has been allowed to go on. And I think we were the backbone in this community. We were here before the mines were even here. And we filled the schools and the school bus and picked the kids up. And I would just like to see that continue.

So, what I'm doing, we put meters on all of our wells to try and get -- to make sure we know what we're pumping, put drops on three of my pivots, and we're going to put drops on two more. We're going to try to -- We're looking to put panels on so our pivots can shut off at 1:00 o'clock and maybe turn back on at four so they'll be off and try to save water. And a lot of times I've been told the conservation might save 20, 25 percent.

And another thing I admire in this plan is the ability to take water from one well and apply it to another well as long as you don't exceed what that well is supposed to pump. Because when your cut crops, you need to rotate, you need to clean up your fields. And if you have a field that you need take out and clean up, you don't need to use the water, you can use it somewhere else. Because as we decrease these amounts on each pivot, there will be pivots that will not have maybe quite enough water in the foreseeable future to irrigate a crop. So you may be able to take one out and keep that. But at least keep the ground viable, keep the rodents out, keep things going, and still be able to make a living and still be able to pass your farm down to your children that I have worked for all my life. I'm 69 years old. I don't think I'm going to be doing anything else.

And another bad thing is going to be if we're forced to turn our water off, you know, a lot of us are indebted to banks to a certain extent on the properties. A lot of us have to get loans. And so all of a sudden if you are a farmer and you are productive and you are working with the banks and all of a sudden you see a human with bankruptcy coming possibly for a lot of people.

And so this plan is a plan to make everything work even from the lowest -- to the most non-senior to the senior. It's trying to design a plan that will work for everybody. If we could have made it work we would have been in favor of giving more to the seniors. But it took the plan that we created in order to keep everybody -- give everybody a chance.

So, again, I would just like to thank everybody and I'm for the management plan. I hope it goes through. And thank you very much.

HEARING OFFICER WILSON: Thank you, Mr. Morrison.

At this time we went through everyone that indicated they wanted to speak on the sign-in sheet. We've got a little bit more time. If there is anyone else who wants to come up to the microphones, they can do so now.

UNIDENTIFIED SPEAKER: There's some more people on the sheet. Sorry. There's a new sheet.

HEARING OFFICER WILSON: Thanks. We have one more page on the sign-in sheet. So Dusty like would like to speak as well. Dusty Moyle, go ahead and come up.

MS. MOYLE: Good afternoon. My name is Dusty Moyle, M-o-y-l-e. I am a second generation farmer here in Eureka, Nevada, and in the last ten years I've been purchasing land and it's not been senior. It's been junior. And I would just like to thank everybody who put this plan together because I am in favor of it. And when you go and you're a business owner and you look at things that can help people in the community move your business forward and the community, you don't purchase land next to you that is a senior water right holder and has never had any production on it. And I had the opportunity to do that and didn't.

So this plan helps everybody move forward and I am in support of it and I appreciate everybody's time who did put this plan together. I know it was a lot of time. So thank you.

HEARING OFFICER WILSON: Thank you, Ms. Moyle.

Is there anyone else who would like to speak?

MR. RIGDON: I would like to ask a couple of process questions.

HEARING OFFICER WILSON: I'm sorry. There's someone in the back. If you wanted to come up. When you get to the mike, please identify yourself for the record and spell your last name.

MR. MORRISON: Yes. My name is Lloyd Morrison. I'm a farmer in Diamond Valley. And I believe that we finally are trying to do something about the water. We've talked about water for 40 years in this valley. We actually have a plan that we can experiment with, see what we can do, finally make a positive step towards conservation, even though, you know, adding pivot irrigation and drops and stuff, the farmers have reduced the amount of water that could have been used on 160 versus 125 acres. We have done a lot of conservation.

But this plan can help us start doing something about a problem that we've all been aware of for a long time. And I am concerned that, you know, in the last 40 years there have been a lot of special interest groups that have moved in to the area that actively work to try to stop this plan. I think this plan should have a chance to be put on the ground and put in to motion to see how it works so we can at least do something, not start from the beginning and redo somebody else's idea. We have a plan. Let's put it to work.

HEARING OFFICER WILSON: Thank you, Mr. Morrison.

Is there anyone else? Please come up to the microphone.

MS. MORRISON: I know my voice does not carry very well. I sound loud to me. Can you hear me?

THE STATE ENGINEER: If you'll hit the end of the microphone.

MS. MORRISON: Can you hear me now? I don't suppose I can --

(The court reporter interrupts)

HEARING OFFICER WILSON: Could you please state your name and spell your last name.

MS. MORRISON: My name is Alberta Morrison, Mrs. Donald Morrison, M-o-r-r-i-s-o-n. My husband and I and five little children came here in 1958. We found that we were in the clutches of an unscrupulous promotor, so we had to leave for two years in order to get money to come back and continue working for our claim in Diamond Valley. We struggled for years. We came in 1960 and have lived here continually ever since.

My husband, while he was alive, had his farm. Actually we developed some of the farms around us that do have senior rights, but because we didn't have many behind us, we had to do that work to earn money to prove up on our land, which we did. But that caused us to be in two weeks behind others that where the cut-off line is. But actually on some of these lands around us that have senior rights I drove the tractor to clean the land.

We struggled for years having no one to back us. We came as pioneers, to have it being the land. In fact, my husband worked for others in order for us to survive. We scraped and saved every way that we could. We were going by what the water engineer told us. And our water rights were secured and we farmed as carefully as we could all of these years.

Now, I don't know how this is going to come out. We were always trying to save the water to conserve water, where many others who continue to have senior rights were watering the highway, which was against the rules, and things like that.

Also, at that time, we were told that we had two years to develop our water and we could only have two -- I'm not sure about some facts. But I know that they told us that we had only -- we could only get two extensions so that we had to develop our water within that time or lose it.

Well, I find now that there are places in the valley that have held their land by having extensions and not only until last year did they develop their land and have the senior water rights. I don't understand why they could get extensions longer than we did.

Well, very complicated things have happened since then. It was, as someone else had stated, no one did wrong. We all thought we did everything we could and we developed our land and thought we had water. But here we are now and I don't know how this is going to come out.

But there's another point that I am really concerned about. If we have to stop farming, we're going to have to leave our houses empty and stuff there, people won't be able to carefully transition from what we're doing to something else. But many have other jobs too and have maybe reached retirement age, not counting what Matt mentioned about people that have bank loans. Not everyone is debt-free. It would be very bad on this community. So bankruptcies, that will happen.

And the other thing is, you know, we could live here. Some people, as you know, work in town. Many people have retirements that they could retire on, except for one fact. To live on our farms you have to have some domestic water. The domestic wells were to be curtailed too. And I don't know when this became a law, back in pioneer times, which I was based on my grandfather, in the Cherokee script. In fact $200 I inherited from him went down on a lease on this land.

But it seems that our domestic rights are connected with the other rights. You would have no water. You couldn't retire on your farm because you've got to have water for everything. You have to take a bath and shower or water your cats.

I would suggest that everyone talk to your legislators when you get a chance, talk to your commissioners, talk to everyone you can and try to get it passed that our domestic rights are exempt from curtailment. But please do that, try to speak --

(The court reporter interrupts)

MS. MORRISON: Can you hear me? Try to speak to the legislators. That's one way to get things done.

I really also want to thank those that worked so hard on this plan and I'm really hopeful. Thank you very much.

HEARING OFFICER WILSON: Thank you, Ms. Morrison.

Anyone else want to provide comment? I believe we had a question. Mr. Rigdon, if you would like to come up to the microphone and address it.

MR. RIGDON: Just two real quick process questions. A lot of written material was submitted today. When will that be available for inspection and copy?

MS. GEDDES: As soon as tomorrow when we get back to the office we can make that available.

MR. RIGDON: And then the second question is similar with the transcript, when would that be available for inspection?

MS. GEDDES: Two weeks.

HEARING OFFICER WILSON: Okay. If there's no other comments here, I wanted to thank everyone for attending and providing their input. And I will remind everyone here as well that we will accept written comment by close of business this Friday, the 2nd of November.

With nothing further, this hearing is declared closed and submitted to the State Engineer. Thank you.

(Hearing concluded at 12:45 p.m.)

STATE OF NEVADA )
)ss.
COUNTY OF WASHOE )

I, CHRISTY Y. JOYCE, Official Certified Court Reporter for the State of Nevada, Department of Conservation and Natural Resources, Division of Water Resources, do hereby certify:

That on Tuesday, the 30th day of October, 2018, I was present at the Eureka Opera House, Eureka, Nevada, for the purpose of reporting in verbatim stenotype notes the within-entitled public hearing;

That the foregoing transcript, consisting of pages 1 through 89, inclusive, includes a full, true and correct transcription of my stenotype notes of said public hearing.

Dated at Reno, Nevada, this 8th day of November, 2018.

CHRISTY Y. JOYCE, CCR #625

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Prepared in cooperation with Eureka County, Nevada

# Budgets and Chemical Characterization of Groundwater for the Diamond Valley Flow System, Central Nevada, 2011–12

Scientific Investigations Report 2016–5055

U.S. Department of the Interior
U.S. Geological Survey

**Cover photographs**

Upper left

Southern Monitor Valley looking northwest toward the Toquima Range. Valley floor vegetation is composed primarily of phreatophytic greasewood (*Sarcobatus vermiculatus*) and rabbitbrush (*Chrysothamnus spp.*).

Upper right

Monitor Valley looking southwest over the Monitor Valley playa toward the Toquima Range. Low-growing vegetation on the playa margins is saltgrass (*Distichlis spicata*).

Bottom

Diamond Valley looking northwest toward a dust plume from the Diamond Valley playa. Foreground vegetation is composed primarily of sagebrush (Artemisia tridentata) and rabbitbrush (*Chrysothamnus spp.*)

Background

Antelope valley looking north toward Lone Mountain (central, foreground), Roberts Mountains (left).

All photographs by Susan G. Buto

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By David L. Berger, C. Justin Mayers, C. Amanda Garcia, Susan G. Buto, and Jena M. Huntington

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**U.S. Department of the Interior**
**U.S. Geological Survey**

**U.S. Department of the Interior**
SALLY JEWELL, Secretary

**U.S. Geological Survey**
Suzette M. Kimball, Director

U.S. Geological Survey, Reston, Virginia: 2016

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# Contents

## Plate



## Figures

## Tables

# Conversion Factors

Inch/Pound to International System of Units

| Multiply | By | To obtain |
|---|---|---|
| | Length | |
| inch (in.) | 2.54 | centimeter (cm) |
| inch (in.) | 25.4 | millimeter (mm) |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| | Area | |
| acre | 4,047 | square meter ($m^2$) |
| square foot ($ft^2$) | 929.0 | square centimeter ($cm^2$) |
| square foot ($ft^2$) | 0.09290 | square meter ($m^2$) |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |
| | Volume | |
| cubic inch ($in^3$) | 16.39 | cubic centimeter ($cm^3$) |
| cubic inch ($in^3$) | 0.01639 | liter (L) |
| acre-foot (acre-ft) | 1,233 | cubic meter ($m^3$) |
| | Flow rate | |
| acre-foot per year (acre-ft/yr) | 1,233 | cubic meter per year ($m^3$/yr) |
| foot per year (ft/yr) | 0.3048 | meter per year (m/yr) |
| cubic foot per second ($ft^3$/s) | 0.02832 | cubic meter per second ($m^3$/s) |
| | Hydraulic gradient | |
| foot per mile (ft/mi) | 0.1894 | meter per kilometer (m/km) |
| | Transmissivity* | |
| foot squared per day ($ft^2$/d) | 0.09290 | meter squared per day ($m^2$/d) |

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as °F = (1.8 × °C) + 32.

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as °C = (°F – 32) / 1.8.

## Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

## Supplemental Information

Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness ([$ft^3$/d]/$ft^2$)ft. In this report, the mathematically reduced form, foot squared per day ($ft^2$/d), is used for convenience.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L) or micrograms per liter (µg/L).

# Abbreviations

| | |
|---|---|
| BCM | Basin Characterization Model |
| cfs | cubic feet per second |
| DEM | Digital elevation model |
| DVFS | Diamond Valley flow system |
| EBR | energy-balance ratio |
| EPA | U.S. Environmental Protection Agency |
| ET | evapotranspiration |
| $ET_c$ | energy-balance corrected evapotranspiration |
| $ET_{gw}$ | groundwater discharge by evapotranspiration |
| EVI | Enhanced Vegetation Index |
| G | Soil-heat flux at land surface |
| GBCAAS | Great Basin Carbonate and Alluvial Aquifer System |
| GDA | groundwater discharge area |
| GIS | Geographic Information System |
| GMWL | global meteoric water line |
| GPS | Global positioning system |
| DEM | Digital elevation model |
| H | Sensible-heat fluxe |
| HA | Hydrographic area |
| LEDAPS | Landsat ecosystem disturbance adaptive processing system |
| LMWL | local meteoric water line |
| MCL | maximum contaminant level |
| MSAVI | Modified Soil-Adjusted Vegetation Index |
| NAIP | National Agriculture Imagery Program |
| NDVI | Normalized Difference Vegetation Index |
| NDWR | Nevada Division of Water Resources |
| PRISM | Parameter-elevation Relationships on Independent Slopes Model |
| $r^2$ | coefficient of determination |
| RASA | Regional Aquifer Systems Analysis |
| RAWS | Remote Automatic Weather Station |
| Rn | Net Radiation |
| SNOTEL | Snow Telemetry |
| TDS | total dissolved solids |
| TM | Thematic Mapper |
| USGS | U.S. Geological Survey |
| WRS2 | World Reference System 2 |
| $\lambda E$ | Latent-heat flux |

x

# Budgets and Chemical Characterization of Groundwater for the Diamond Valley Flow System, Central Nevada, 2011–12

By David L. Berger, C. Justin Mayers, C. Amanda Garcia, Susan G. Buto, and Jena M. Huntington

## Abstract

The Diamond Valley flow system consists of six hydraulically connected hydrographic areas in central Nevada. The general down-gradient order of the areas are southern and northern Monitor Valleys, Antelope Valley, Kobeh Valley, Stevens Basin, and Diamond Valley. Groundwater flow in the Diamond Valley flow system terminates at a large playa in the northern part of Diamond Valley. Concerns relating to continued water-resources development of the flow system resulted in a phased hydrologic investigation that began in 2005 by the U.S. Geological Survey in cooperation with Eureka County. This report presents the culmination of the phased investigation to increase understanding of the groundwater resources of the basin-fill aquifers in the Diamond Valley flow system through evaluations of groundwater chemistry and budgets. Groundwater chemistry was characterized using major ions and stable isotopes from groundwater and precipitation samples. Groundwater budgets accounted for all inflows, outflows, and changes in storage, and were developed for pre-development (pre-1950) and recent (average annual 2011–12) conditions. Major budget components include groundwater discharge by evapotranspiration and groundwater withdrawals; groundwater recharge by precipitation, and interbasin flow; and storage change.

Groundwater in the basin-fill aquifer of the Diamond Valley flow system was mostly a calcium or sodium bicarbonate water type and generally within acceptable drinking-water standards. The general water type was similar among the individual hydrographic areas. Stable isotopes of oxygen-18 and deuterium from precipitation varied seasonally, such that enrichment from evaporation was greater during warmer months than cooler months. The isotopic signature of shallow groundwater was similar to cool season precipitation, indicating recharge was relatively recent (similar to recent climatic conditions) and was derived from cool season precipitation.

Site-scale groundwater evapotranspiration was estimated from eddy-covariance and micrometeorological measurements collected at four sites and ranged from 0.15 feet per year in sparse, undisturbed shrubland to 1.13 feet per year in a grassland meadow. Vegetation indices calculated from satellite imagery and field mapping were used to define three evapotranspiration units (shrubland, grassland, and playa) and to extrapolate site-scale groundwater evapotranspiration rates to basin-scale estimates. Annual pre-development groundwater evapotranspiration for individual hydrographic areas ranged from 2,900 acre-feet per year (acre-ft/yr) in northern Monitor Valley to 35,000 acre-ft/yr in Diamond Valley. Total groundwater evapotranspiration from the Diamond Valley flow system under pre-development conditions was about 70,000 acre-ft/yr.

Areas of irrigated land in the Diamond Valley flow system increased from less than 5,000 acres in the early 1960s to more than 25,000 acres in 2012 and are mostly for growing alfalfa in southern Diamond Valley. Annual (2011–12) net groundwater withdrawals for irrigation, assumed to be the volume of groundwater consumed by crops and pastureland, ranged from about 420 acre-ft/yr in Antelope Valley to 67,000 acre-ft/yr in Diamond Valley. Total net groundwater withdrawals for irrigation in the Diamond Valley flow system were about 69,000 acre-ft/yr (2011–12).

Groundwater recharge, the largest inflow component to the Diamond Valley flow system, was determined as the sum of groundwater evapotranspiration and net subsurface outflow (subsurface outflow minus subsurface inflow). Annual groundwater recharge estimates ranged from 200 acre-ft/yr in Stevens Basin to 35,000 acre-ft/yr in Diamond Valley.

Subsurface flow between hydrographic basins was evaluated using estimated transmissivity, groundwater-flow sections derived from remotely sensed imagery, and hydraulic gradients determined from 2012 water-level data. Subsurface outflow ranged from 0 acre-ft/yr for Diamond Valley to 3,400 acre-ft/yr for northern Monitor Valley into western Kobeh Valley. Subsurface inflow ranged from 0 acre-ft/yr for southern Monitor Valley to 4,200 acre-ft/yr for Kobeh Valley from northern Monitor and Antelope Valleys.

The pre-development, steady state, groundwater budget for the Diamond Valley flow system was estimated at about 70,000 acre-ft/yr of inflow and outflow. During years 2011–12, inflow components of groundwater recharge from precipitation and subsurface inflow from adjacent basins totaled 70,000 acre-ft/yr for the DVFS, whereas outflow components included 64,000 acre-ft/yr of groundwater evapotranspiration and 69,000 acre-ft/yr of net groundwater withdrawals, or net pumpage. Spring discharge in northern Diamond Valley declined about 6,000 acre-ft/yr between pre-development time and years 2011–12. Assuming net groundwater withdrawals minus spring flow decline is equivalent to the storage change, the 2011–12 summation of inflow and storage change was balanced with outflow at about 133,000 acre-ft/yr.

# Introduction

The Diamond Valley flow system (DVFS) consists of six basins or hydrographic areas (HAs) in central Nevada (Harrill and others 1983; fig. 1). The six basins are, in part, hydrologically connected by ephemeral streams, by groundwater flow in shallow basin-fill aquifers, and, possibly, by subsurface flow in deeper carbonate-rock aquifers. Groundwater in basin-fill aquifers moves from southern Monitor Valley to northern Monitor and then into western Kobeh Valley. Eastern Kobeh Valley also receives groundwater from Antelope Valley. A small amount of groundwater moves from eastern Kobeh Valley into southern Diamond Valley in the basin fill beneath Devils Gate. The large playa in the northern part of Diamond Valley is the terminus of the flow system. Subsurface flow from Stevens Basin into adjacent basins is unknown but assumed to be minimal.

As early as 1964, the Nevada State Engineer recognized that areas in the DVFS required additional regulation of groundwater withdrawals, particularly in the southern part of Diamond Valley and, later, the entire hydrographic areas of Diamond and Kobeh Valleys. In 1983, Diamond and Kobeh Valleys both were declared "designated" groundwater basins. In designated basins, the State Engineer is granted the authority to, among other directives, "designate preferred uses of water within the respective areas" in the interest of public welfare of the area involved (Nevada Revised Statutes, chapter 534).

Local government officials and citizens are concerned about the continuing development of water resources for irrigation and mining and about the potential for groundwater exportation to basins outside the DVFS. In 2005, the U.S. Geological Survey (USGS), in cooperation with Eureka, Lander, and Nye Counties and the Nevada Division of Water Resources (NDWR) began a three-phased study of the flow system to gain a better understanding of the groundwater resources. Phase 3 (2009–12), documented in this report, was the final phase of work designed to build on and further characterize the groundwater resources of the flow system by evaluating groundwater quality and groundwater budgets, with emphasis on groundwater evapotranspiration by phreatophytes (plants that rely on groundwater to fulfill a part of their water needs) under predevelopment conditions.

## Purpose and Scope

This report presents the culmination of results from the multi-phased investigation of the groundwater resources in the DVFS. The report characterizes groundwater chemistry of the basin-fill aquifers in terms of major-ion water types, drinking-water standards, and groundwater recharge and mixing. Annual groundwater budgets for each hydrographic area, representing recent conditions (2011–12), are presented and compared with revised pre-development (pre-1950) groundwater budgets. Components of the groundwater budgets include groundwater recharge from precipitation; subsurface flow between basins; and groundwater discharge by (1) evapotranspiration from areas composed of phreatophytic vegetation, (2) evaporation from playas, and (3) estimated net groundwater withdrawals for irrigation. Groundwater evapotranspiration from phreatophyte areas was measured in Kobeh Valley, and adjusted values were applied to other DVFS basins. A groundwater budget for the complete DVFS also is presented and includes a summation of all inflow and outflow components and an estimate of storage loss resulting from groundwater withdrawals.

## Description of Study Area

The DVFS (fig. 1) covers about 3,100 square miles ($mi^2$, or 1,984,000 acres) in central Nevada and includes six basins or HAs. The flow system was defined initially by Harrill and others (1983) as part of a regional aquifer-systems analysis in the Great Basin of Nevada, Utah, and adjacent states. A large playa (nearly 43,000 acres) in the northern part of Diamond Valley is the terminus of the DVFS. Another playa, covering about 1,400 acres, is in the northern part of southern Monitor Valley. Most groundwater development in the DVFS has been in the southern part of Diamond Valley and has resulted in nearly 100 feet (ft) of water-level decline since 1962. A more detailed description of the study area can be found in Tumbusch and Plume (2006).

The DVFS is mostly in Eureka County; however, small portions lie in northern Nye, eastern Lander, and southern Elko Counties (fig. 1). The city of Eureka (population of about 610) is an unincorporated community and the county seat of Eureka County (population of about 2,000; U.S. Census Bureau, 2015a, 2015b). U.S. Highway 50 traverses Kobeh Valley and southern Diamond Valley, connecting the towns of Austin and Eureka. Nevada State Route 278 runs from 3 miles west of Eureka north along the western side of southern Diamond Valley (fig. 1).

## Previous Hydrologic Studies

The earliest water-resource appraisals in the study area were commissioned by the Nevada State Legislature in 1960 and published in two reconnaissance-series reports. Eakin (1962) focused on Diamond Valley and Rush and Everett (1964) focused on southern and northern Monitor Valleys, Antelope Valley, Kobeh Valley, and Stevens Basin. The reconnaissance studies provided available climatic data and general conditions of the hydrologic systems, including geology and groundwater quality in terms of suitability for agricultural use. Additionally, both studies provided estimates of annual groundwater recharge and discharge under nearly natural conditions. Natural groundwater recharge and discharge assumes pre-development, steady-state conditions, with little or no anthropogenic effects. Although water-chemistry data for groundwater collected from wells and springs were limited at the time of the reconnaissance studies, groundwater was considered suitable for irrigation in most areas. The reconnaissance studies relied on the precipitation map developed by

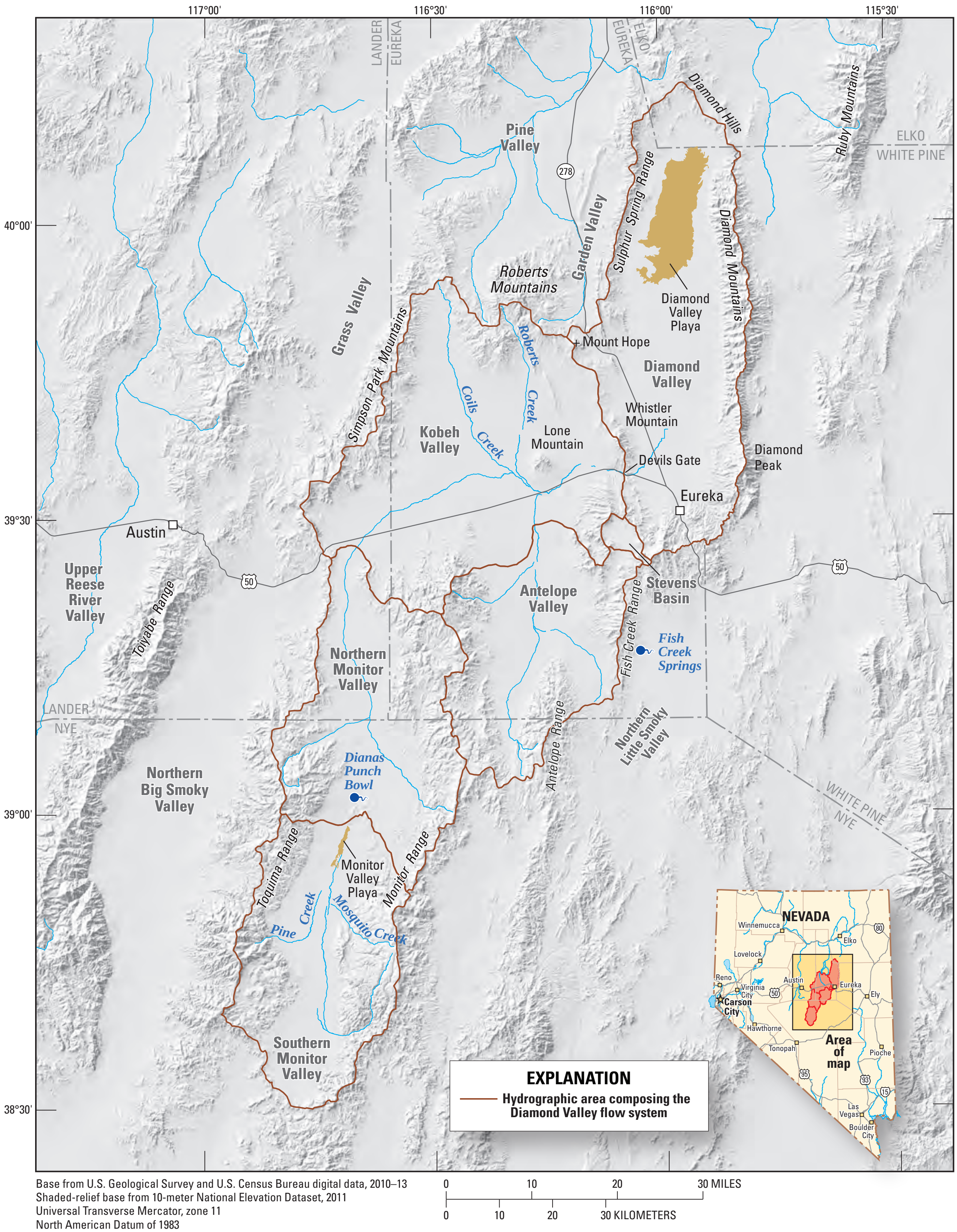


**Figure 1.** Hydrographic areas and selected geographic features in the Diamond Valley flow system, central Nevada.

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Hardman (1936) and Hardman and Mason (1949) to estimate groundwater recharge using an empirical method known as the Maxey-Eakin Method (Maxey and Eakin, 1949; Eakin and others, 1951). At the time of these studies, groundwater discharge in the area was dominated by evapotranspiration (ET) from areas with phreatophytic vegetation, and, to a much lesser degree, by evaporation from playas. Groundwater ET is composed of evaporation from bare-soil surfaces with transpiration by phreatophytes. Natural groundwater discharge through ET was estimated by applying assigned groundwater ET and groundwater evaporation rates to areas of phreatophytes and playas, respectively. These assigned rates were adopted from studies outside the study area (Lee, 1912; White, 1932; Young and Blaney, 1942). Groundwater discharge was not estimated from the large playa in the northern part of Diamond Valley (Eakin, 1962). The resultant balance between groundwater recharge and discharge developed by the two studies indicated that recharge was about 70 percent of discharge in Diamond Valley and about 120 percent of discharge in the other four basins.

In the early 1960s, the State Engineer became concerned about the increasing groundwater withdrawals in southern Diamond Valley. In response, the USGS performed a more detailed evaluation of the hydrology of Diamond Valley with an emphasis on the effects of groundwater withdrawals as of 1965 (Harrill, 1968). To facilitate the analysis, Harrill (1968) divided Diamond Valley into north and south subareas. Nearly all the natural discharge was in the north subarea, whereas nearly all major groundwater development was in the south subarea. As part of the reappraisal, two groundwater-level surfaces were created—pre-development (1950) and post-development (1965). Additionally, a revised precipitation-altitude relation was developed on the basis of the available precipitation data. Harrill (1968) concluded that average annual precipitation was generally greater in the northern subarea than in the southern subarea and that the precipitation-altitude relation in the southern subarea probably was similar to that in Kobeh Valley. This north-south division in precipitation resulted in a 30 percent increase in precipitation-derived groundwater recharge when compared to estimates by Eakin (1962). Harrill (1968) developed a groundwater budget for Diamond Valley that included inflow components of recharge from precipitation, subsurface flow from Kobeh Valley through Devil's Gate, and subsurface flow from Garden Valley (outside the flow system) to the northwest of Diamond Valley (fig. 1). Outflow components of the budget included groundwater discharge by (1) ET from phreatophyte-dominated areas, (2) springs, and (3) playa evaporation. Groundwater chemical analyses allowed Harrill (1968) to develop a general relation between water chemistry and groundwater flow. Groundwater in Diamond Valley, except that in the shallow aquifer in the north subarea, was generally suitable for irrigation, stock, and domestic use. Harrill (1968) cautioned that continued groundwater withdrawals could cause the reversal of natural gradients toward the playa and induce flow of poor-quality water toward the developed areas in the south subarea.

The DVFS, as it is currently defined, consists of the six basins in the study area and was first recognized and delineated by Harrill and others (1983) and Harrill and others (1988) in an effort to improve the understanding of groundwater flow on a regional scale (Regional Aquifer Systems Analysis, or RASA). Using the limited existing data at the time, flow-system boundaries were generally defined and guided by regional-flow potential lines based on groundwater altitudes. A basic premise for flow-system delineation was that each flow system terminated in a discharge area.

Two reports have been published as part of the phased approach of the (2005–12) study. The phase 1 study (2005–06; Tumbusch and Plume, 2006) defined the hydrogeologic framework of the flow system, evaluated the presence and movement of groundwater, and quantified historical water-level changes. The phase 2 study (2006–09; Knochenmus and others, 2011) provided data collected from 2006 to 2009 and described the general approach for estimating natural groundwater discharge as part of phase 3.

## Hydrologic Setting

Nearly all water in the study area originates as precipitation, either in the form of rain or snow. Some of the precipitation runs off, most is evaporated or consumed by vegetation, and some eventually recharges the groundwater system. Streams in the study area generally are ephemeral and flow only during spring runoff or as a result of intense storms; however, some streams in the upper reaches of the watershed are perennial, but typically infiltrate before reaching the valley floor. Groundwater in the basin-fill aquifer is under confined and unconfined conditions and is derived from infiltration of mountain-block precipitation and streamflow. The movement of groundwater is controlled, in part, by the hydrogeology. The hydrogeology in the DVFS consists of carbonate rocks, siliciclastic sedimentary rocks, igneous intrusive rocks, volcanic rocks, and basin-fill deposits (plate 1). Details on the hydrogeologic units identified in the study area and their water-bearing characteristics can be found in Tumbusch and Plume (2006).

A separate, cooperative monitoring program by the USGS and Eureka County designed to collect streamflow and groundwater data in and around the southern extent of the Roberts Mountains (figs. 1, 2) began in 2010. The monitoring program includes continuous data collection at 5 surface-water and 1 groundwater site, 13 miscellaneous streamflow and 3 groundwater-level measurements, and water-chemistry sampling at 13 sites. The program was designed to characterize baseline hydrologic conditions in response to a proposed molybdenum mine in the Mount Hope area (fig. 1). As part of this program, seepage was estimated along two streams that originate in the Roberts Mountains.

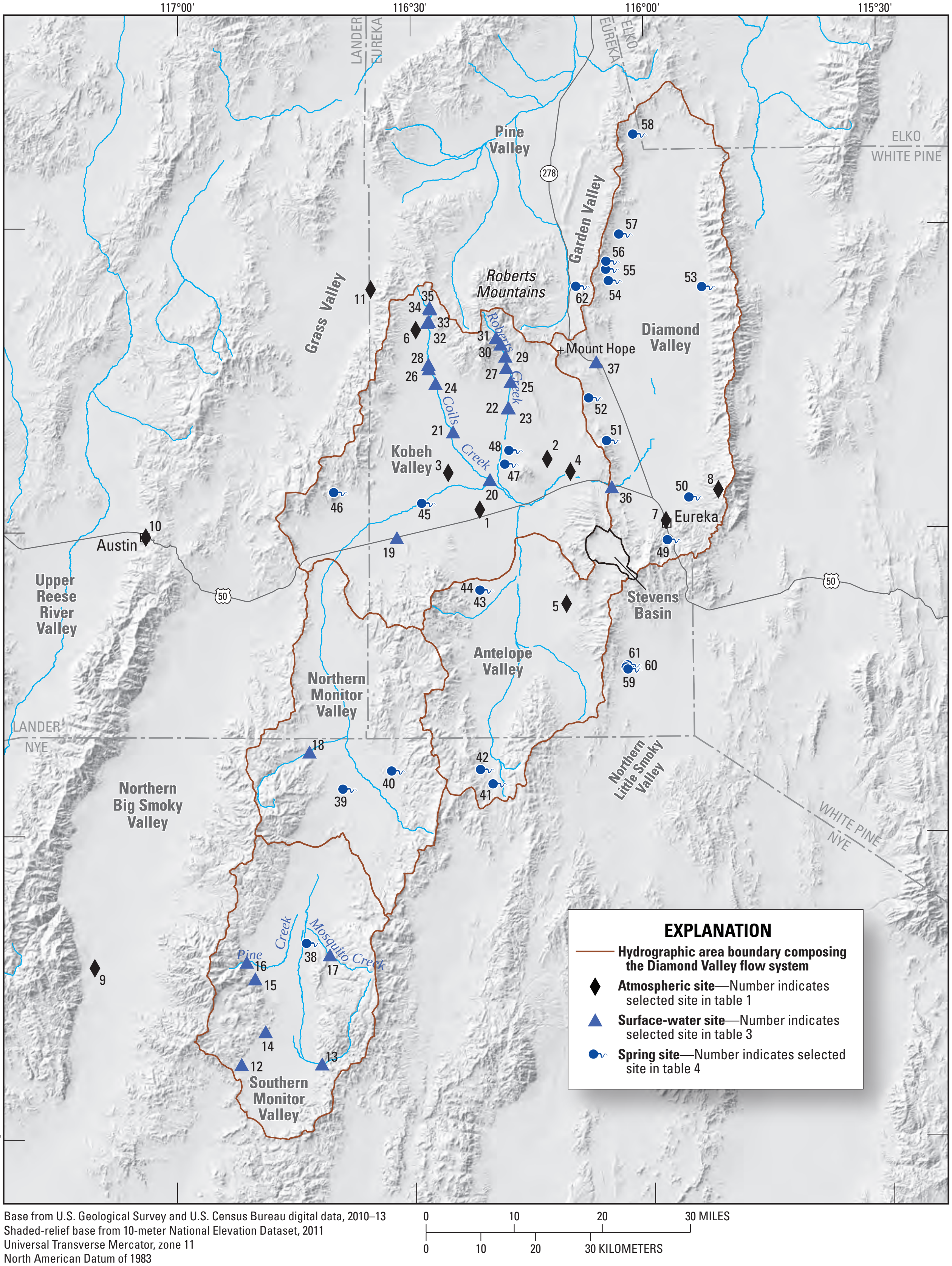


**Figure 2.** Atmospheric sites, surface-water sites, and spring sites in the Diamond Valley flow system, central Nevada.

## Climate

The climate of central Nevada generally can be divided into two zones. The valley floors are part of the mid-latitude steppe zone, which is semiarid with warm to hot summers and cold winters. The surrounding mountain ranges are a part of the subhumid continental zone, with cool to mild summers and cold winters, where annual precipitation is mostly snow (Houghton and others, 1975). The majority of the precipitation comes from the Pacific Ocean as winter storms. Localized summer thunder storms can produce large amounts of rain, but do not contribute much to the total annual precipitation in the area.

Climate conditions vary considerably in the study area by location, altitude, and seasonality. Climate data based on long-term averages can be advantageous for comparison of discontinuous or recent short-term datasets with historical conditions. Continuous long-term climate data were very limited in the study area; however, 30-year averages could be computed from selected sites near the study area (Western Region Climate Center, 2015; National Centers for Environmental Information, 2016). The closest climate stations that had annual precipitation and temperature data for a 30-year period (1981–2010) included Austin number 2, Beowawe 49 S (U of N Ranch), Eureka, and Smoky Valley Carvers (sites 10, 11, 7, and 9; respectively, fig. 2; tables 1, 2). Weather stations in the study area (fig. 2; tables 1, 2) that had between 20 and 30 years of annual climate data included Diamond Peak Snow Telemetry (SNOTEL, 1984–2012, site 8), Coils Creek Remote Automatic Weather Station (RAWS, 1990–2012, site 6), and Combs Canyon RAWS (1986–2012, site 5). As part of this study, precipitation and temperature data (2011–12) were collected at four ET sites established in Kobeh Valley (sites 1–4; fig. 2; tables 1, 2).

Average monthly temperatures over the 30-year period (1981–2010) in Austin, Beowawe, Eureka, and Smoky Valley ranged from a low of 26–31 degrees Fahrenheit (°F) in December and January to a high of 69–73 °F in July. Although these weather stations mostly lie outside the DVFS, the temperature range is likely comparable to that of similar altitudes in the study area. During the 1991–2010 period, average monthly temperatures at higher altitudes, represented by Diamond Peak, ranged from 26 to nearly 66 °F.

A simple linear relation (fig. 3) between the station altitude and the 30-year average annual precipitation (1981–2010) was developed for Austin (6,780 ft), Beowawe (5,740 ft), Eureka (6,430 ft), and Smoky Valley (5,647 ft). The relation was used to compare the long-term average annual precipitation to that measured in the study area for water years[1] 2011 and 2012. About 87 percent of the variability in average annual precipitation at the four long-term weather stations can be explained by altitude. Precipitation collected from stations, including those within the study area (Coils Creek, Combs Canyon, Eureka, and the four Kobeh Valley ET sites), was generally greater in 2011 and less in 2012 than the long-term average (1981–2010). At the Kobeh Valley ET sites, 2011 precipitation averaged 1.3 times more than the long-term average, whereas 2012 values averaged 1.2 times less than the long-term average. For stations with complete precipitation records for water years 2011 and 2012, precipitation in water year 2011 was 17–55 percent greater than in 2012.

[1] A water year is the period from October 1 to September 30 and is designated by the year in which it ends. Water year is used almost exclusively throughout this report. In order to reduce confusion between calendar years and water years in this report, all reference to years and periods is to water years, unless specifically referred to as a calendar year.

**Table 1.** Location and general description of atmospheric measurement sites, Diamond Valley flow system, central Nevada.

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. USGS, U.S. Geological Survey; NOAA, National Oceanic and Atmospheric Administration; ET, Evapotranspiration; WX, general weather; GHCND, Global Historical Climatology Network-Daily]

| Site number | Hydrographic area | USGS or NOAA station identifier | Local or site name | Latitude (degrees) | Longitude (degrees) | Altitude (feet) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|
| 1 | Kobeh Valley | [1]393214116212402 | Sparse shrubland | 39.5371 | 116.3576 | 6,098.7 | ET, WX | 2, 17, 18B |
| 2 | Kobeh Valley | [1]393711116124501 | Moderate-to-dense shrubland | 39.6197 | 116.2134 | 6,051.8 | ET, WX | 2, 17, 18B |
| 3 | Kobeh Valley | [1]393553116252401 | Moderate-to-dense shrubland | 39.5981 | 116.4242 | 6,131.3 | ET, WX | 2, 17, 18B |
| 4 | Kobeh Valley | [1]393555116094802 | Grassland | 39.5987 | 116.1642 | 6,012.5 | ET, WX | 2, 17, 18B |
| 5 | Antelope Valley | [2]GHCND:USR0000NCOM | Combs Canyon, NV US | 39.3814 | 116.175 | 6,590 | WX | 2 |
| 6 | Kobeh Valley | [2]GHCND:USR0000NCOI | Coils Creek, NV US | 39.8333 | 116.4917 | 6,800 | WX | 2 |
| 7 | Diamond Valley | [2]GHCND:USC00262708 | Eureka, NV US | 39.517 | 115.9621 | 6,430 | WX | 2 |
| 8 | Diamond Valley | [2]GHCND:USS0015K03S | Diamond Peak, NV US | 39.5667 | 115.85 | 8,000 | WX | 2 |
| 9 | Northern Big Smoky Valley | [2]GHCND:USC00267620 | Smoky Valley Carvers, NV US | 38.784 | 117.1739 | 5,647 | WX | 2 |
| 10 | Upper Reese River Valley | [2]GHCND:USC00260507 | Austin Number 2, NV US | 39.493 | 117.0675 | 6,780 | WX | 2 |
| 11 | Grass Valley | [2]GHCND:USC00260800 | Beowawe 49 S U of N Ranch, NV US | 39.9004 | 116.5876 | 5,740 | WX | 2 |

[1]USGS station identification; latitude, longitude, and altitude values are from the USGS National Water Information System (*http://waterdata.usgs.gov/nwis*).

[2]NOAA station identification; latitude, longitude, and altitude values are from the NOAA National Climatic Data Center (*http://www.ncdc.noaa.gov*).

**Table 2.** Measured precipitation data at four evapotranspiration sites in Kobeh Valley, seven climate stations near the Diamond Valley flow system, and Parameter-elevation Regressions on Independent Slopes Model (PRISM) estimates, central Nevada.

[All values are in inches. Water year precipitation values at sites 1–4 are corrected for wind undercatch. PRISM values are from the grid cell closest to the station location. USGS, U.S. Geological Survey; NOAA, National Oceanic and Atmospheric Administration; —, no data; IR, incomplete record]

| Site number | Hydrographic area | USGS or NOAA station identifier | Local or site name | Measured precipitation | | | | | | | PRISM precipitation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Average annual (1981–2010)[1] | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Average annual (1981–2010)[1] | 2011 | 2012 |
| 1 | Kobeh Valley | [2]393214116212402 | Sparse shrubland | — | — | — | — | — | — | 6.8 | 8.9 | 11.4 | 7.0 |
| 2 | Kobeh Valley | [2]393711116124501 | Moderate-to-dense shrubland | — | — | — | — | — | 12.3 | 8 | 9.2 | 11.8 | 7.1 |
| 3 | Kobeh Valley | [2]393553116252401 | Moderate-to-dense shrubland | — | — | — | — | — | 10.7 | 6.6 | 9.1 | 11.4 | 6.8 |
| 4 | Kobeh Valley | [2]393555116094802 | Grassland | — | — | — | — | — | — | 8 | 9.2 | 12.2 | 7.4 |
| 5 | Antelope Valley | [3]GHCND:USR0000NCOM | Combs Canyon, NV US[4] | IR | 5.0 | 1.7 | 5.8 | 3.0 | 7.9 | 6.6 | 9.6 | 14.1 | 9.8 |
| 6 | Kobeh Valley | [3]GHCND:USR0000NCOI | Coils Creek, NV US[4] | IR | 3.4 | 1.1 | 8.4 | 2.9 | 9.3 | 4.1 | 12.0 | 14.6 | 8.1 |
| 7 | Diamond Valley | [3]GHCND:USC00262708 | Eureka, NV US[5] | 11.30 | 11.9 | 6.3 | 11.1 | 10.6 | 14.7 | 9.8 | 11.0 | 15.4 | 10.1 |
| 8 | Diamond Valley | [3]GHCND:USS0015K03S | Diamond Peak, NV US[6] | IR | IR | IR | IR | IR | IR | IR | 18.1 | 19.0 | 11.5 |
| 9 | Northern Big Smoky Valley | [3]GHCND:USC00267620 | Smoky Valley Carvers, NV US[5] | 6.81 | 4.8 | 3.2 | 6.3 | 6.0 | 9.7 | 5.6 | 6.5 | 8.5 | 6.1 |
| 10 | Upper Reese River Valley | [3]GHCND:USC00260507 | Austin Number 2, NV US[5,7] | 13.19 | IR | IR | IR | IR | IR | IR | 12.1 | 15.9 | 8.3 |
| 11 | Grass Valley | [3]GHCND:USC00260800 | Beowawe 49 S U of N Ranch, NV US[5] | 9.58 | 7.9 | 5.4 | 10.5 | 6.9 | IR | IR | 9.7 | 13.7 | 7.4 |

[1]Values based on calendar year.
[2]USGS station identification.
[3]NOAA station identification.
[4]Remote Automatic Weather Station (RAWS).
[5]Gap filled missing monthly data using nearby stations.
[6]Snow Telemetry (SNOTEL).
[7]Normalized missing annual data to Eureka station.

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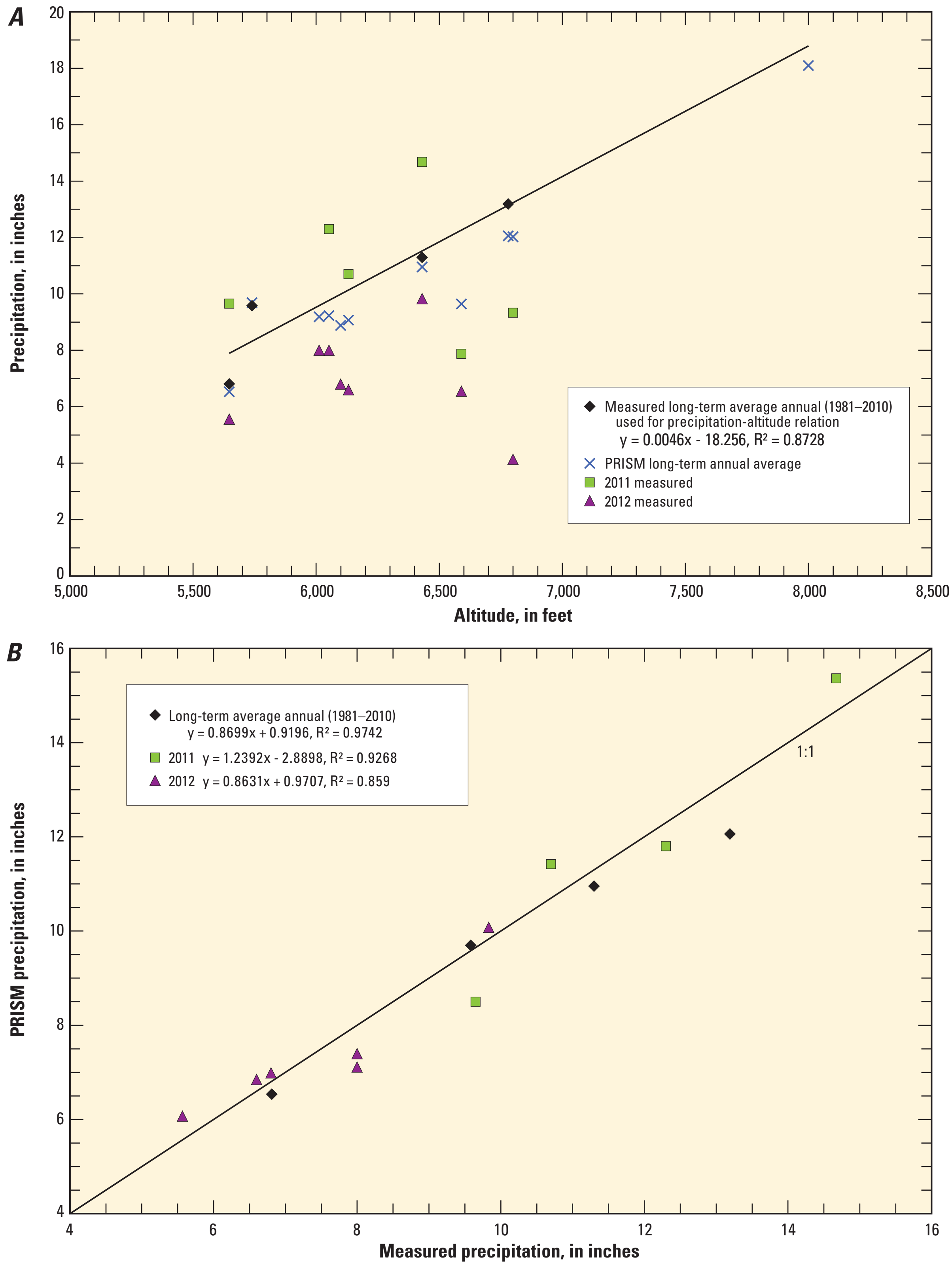


**Figure 3.** Comparison between average annual precipitation for four long-term precipitation stations (1981–2010), Diamond Valley flow system, central Nevada, and ***A***, station altitude, and ***B***, PRISM (Parameter-elevation Relationships on Independent Slopes Model) derived precipitation.

Owing to the limited long-term precipitation and temperature datasets in the study area, long-term, average annual precipitation for Austin, Beowawe, Eureka, and Smoky Valley (1981–2010) was compared with 1981–2010 Parameter-elevation Relationships on Independent Slopes Model (PRISM; PRISM climate group, 2014; table 2) precipitation. Evaluation of long-term precipitation was relevant for evaluating pre-development groundwater ET rates across the DVFS (see the "Groundwater Discharge" section). The 30-year average annual PRISM estimates at the Austin, Eureka, and Smoky Valley sites were an average of 5-percent less than measured 30-year average annual values, whereas the 30-year PRISM estimate at the Beowawe site was one percent greater than the measured 30-year value. Differences could, in part, reflect different accumulation periods and the generalized area of PRISM estimates (800-meter or 0.5-mile cell size). Measured data were for water years 1981–2010, whereas PRISM data were for calendar years 1981–2010. Despite these differences, a least squares regression explained about 97 percent of the variability between measured and estimated values (fig. 3).

Comparisons between measured precipitation and PRISM data (table 2) also were made for water year 2011 at four sites and water year 2012 at six sites using least-squares regressions. The PRISM rates at Coils Creek (Kobeh Valley) and Combs Canyon (Antelope Valley) were consistently above measured values (by an average of 70 percent), and including these sites in multi-site comparisons between measured and PRISM values produced poor relations (coefficient of determination, or $r^2$, 0.51–0.52). These precipitation stations were in steep, narrow canyons and steep terrain. Considering that water-year PRISM estimates are generalized to a 4-kilometer (2.5-mile) cell size, discrepancies between measured and estimated values in this terrain type were expected. Water year 2011 and 2012 relations that excluded these two sites were improved markedly ($r^2$ 0.96 and 0.93, respectively; fig. 3) and indicated that PRISM-estimated values largely captured the variability in precipitation measured across the study area. At ET sites on the floor of Kobeh Valley (see the "Evapotranspiration" section), annual measured and PRISM-estimated precipitation rates during 2011–12 were within 2 percent, on average (table 2). Site data were scaled to the basin and flow-system level using remote sensing and long-term (1981–2010) PRISM data.

Annual precipitation data from Eureka (1966–2012) were used to evaluate trends in long-term climate conditions in the study area (fig. 4). The Eureka precipitation dataset was nearly complete, with 6 of the 48 years having missing data for no more than 3 months per year. The missing data were gap filled by using precipitation data from nearby stations. The estimated average annual precipitation at Eureka for the

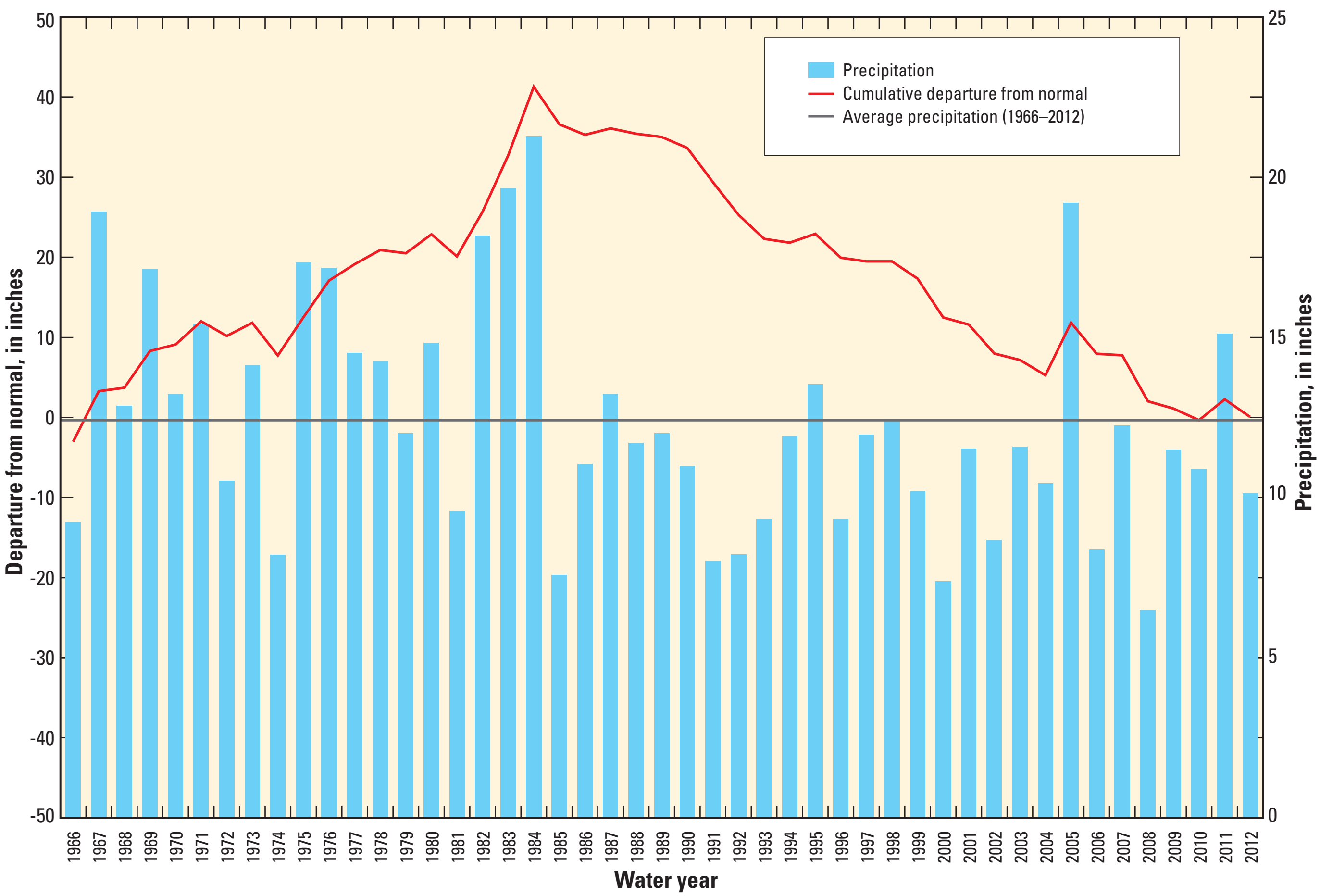


**Figure 4.** Annual water year precipitation and cumulative departure from normal (1966–2012), Eureka, central Nevada.

48 years was 12.04 inches (in.). Cumulative departure from normal can be used to characterize trends in precipitation, where upward slopes indicate increased precipitation and downward slopes indicate declining precipitation. The graph of cumulative departure from normal for Eureka (fig. 4) shows an upward slope from 1966 to 1984, indicating most years had above average precipitation. From 1985 to 2012, the cumulative departure from normal indicated declining precipitation. In general, annual precipitation over the 28 years from 1985 through 2012 exhibited a trend of declining precipitation.

## Surface Water

Daily streamflow data in the DVFS were available at 5 sites, and intermittent or peak discharge measurements collected over various periods were available at 21 sites (table 3). In April and May 1964, Rush and Everett (1964) collected 38 miscellaneous streamflow measurements in southern and northern Monitor, Antelope, and Kobeh Valleys. Harrill (1968) published a series of discharge measurements for 13 streams in Diamond Valley collected in 1965 and 1966. Additional streamflow data in southern and northern Monitor Valleys were available from three sites with continuous daily streamflow from 1977 generally through 2005 (sites 16–18; fig. 2; table 3) and from four sites with monthly discharge measurements from April 1997 to September 2000 (sites 12–15; fig. 2; table 3). In 2010, the USGS began collecting streamflow data at 2 sites (sites 26 and 29; fig. 2; table 3) and miscellaneous discharge data at 14 sites along Coils Creek and Roberts Creek in northern Kobeh Valley (sites 20–25, 27, 28, 30–35; fig. 2; table 3). As part of the 2010 monitoring program, the USGS also has been collecting miscellaneous discharge data at a site in Devil's Gate (site 36; fig. 2; table 3), which represents the only surface-water outflow from Kobeh Valley.

Infiltration of streamflow is a source of groundwater recharge. Most streamflow originates in the mountain block and infiltrates through coarse channel deposits on alluvial fans. Occasionally, under above-average conditions (for example, water year 2011) or following intense storm events, precipitation can generate streamflow that reaches the valley floor.

**Table 3.** Location and general information of surface-water measurement sites, Diamond Valley flow system, central Nevada.

[The locations of sites are shown on figure 2. Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. Latitude, longitude, and altitude values are from the USGS National Water Information System (*http://waterdata.usgs.gov/nwis*). USGS, U.S. Geological Survey; Qm, miscellaneous discharge measurement; Qd, daily discharge; Qp, peak discharge; Qw, water quality]

| Site number | Hydrographic area | USGS station identifier | Latitude (degrees) | Longitude (degrees) | Altitude (feet) | Available data |
|---|---|---|---|---|---|---|
| 12 | Southern Monitor Valley | [1]10245912 | 38.626 | 116.8656 | 7,825 | Qm |
| 13 | Southern Monitor Valley | [1]10245905 | 38.6266 | 116.6967 | 7,255 | Qm |
| 14 | Southern Monitor Valley | [1]10245902 | 38.6799 | 116.8151 | 7,305 | Qm |
| 15 | Southern Monitor Valley | [1]10245901 | 38.7669 | 116.8367 | 7,425 | Qm |
| 16 | Southern Monitor Valley | [1]10245900 | 38.7944 | 116.8545 | 7,564.73 | Qd, Qm, Qp, Qw |
| 17 | Southern Monitor Valley | [1]10245910 | 38.806 | 116.6795 | 7,204.65 | Qd, Qm, Qp, Qw |
| 18 | Southern Monitor Valley | [1]10245925 | 39.14 | 116.7212 | 6,884.36 | Qd, Qm, Qp, Qw |
| 19 | Kobeh Valley | [1]10245950 | 39.4921 | 116.5342 | 6,204.23 | Qp |
| 20 | Kobeh Valley | 393513116200901 | 39.5869 | 116.3357 | 6,086 | Qm |
| 21 | Kobeh Valley | 393956116244901 | 39.6657 | 116.4135 | 6,193 | Qm |
| 22 | Kobeh Valley | 394217116174101 | 39.7046 | 116.2948 | 6,296 | Qm |
| 23 | Kobeh Valley | 394217116174601 | 39.7048 | 116.2961 | 6,296 | Qm |
| 24 | Kobeh Valley | 394444116270101 | 39.7457 | 116.4502 | 6,348 | Qm |
| 25 | Kobeh Valley | 394452116172401 | 39.7478 | 116.29 | 6,464 | Qm |
| 26 | Kobeh Valley | 10245960 | 39.7698 | 116.4644 | 6,405 | Qd, Qm, Qp, Qw |
| 27 | Kobeh Valley | 394616116175701 | 39.7712 | 116.2992 | 6,612 | Qm |
| 28 | Kobeh Valley | 394638116275501 | 39.7774 | 116.4652 | 6,437 | Qm |
| 29 | Kobeh Valley | 10245970 | 39.7898 | 116.3009 | 6,743 | Qd, Qm, Qp, Qw |
| 30 | Kobeh Valley | 394835116183901 | 39.8098 | 116.3109 | 6,923 | Qm |
| 31 | Kobeh Valley | 394914116191401 | 39.8206 | 116.3205 | 7,075 | Qm |
| 32 | Kobeh Valley | 395045116280201 | 39.8458 | 116.4671 | 6,643 | Qm |
| 33 | Kobeh Valley | 395052116275001 | 39.8479 | 116.4638 | 6,641 | Qm |
| 34 | Kobeh Valley | 395206116274001 | 39.8684 | 116.4611 | 6,722 | Qm |
| 35 | Kobeh Valley | 365216116274401 | 39.8711 | 116.4621 | 6,741 | Qm |
| 36 | Diamond Valley | 10245980 | 39.5733 | 116.0767 | 6,004 | Qm, Qp |
| 37 | Diamond Valley | [1]10246010 | 39.7791 | 116.1073 | 6,024 | Qp |

[1]Inactive site.

Seepage estimates can be used to establish a relation between streamflow and groundwater by delineating reaches that are gaining or losing streamflow at a particular time. Seepage was estimated using a series of eight discharge measurements along Coils Creek (sites 20, 21, 24, 28, 32–35; fig. 2; table 3) and seven measurements along Roberts Creek (sites 22, 23, 25, 27, 29–31; fig. 2; table 3) in spring 2011. On the basis of these discharge measurements, Coils Creek gained about 16 cubic feet per second (cfs) of streamflow in the upper reach between sites 35 and 26 (fig. 2; table 3). Downstream from site 26, Coils Creek began to lose flow where the channel crossed alluvial deposits. The discharge measurement taken farthest downstream (site 20; fig. 2; table 3) was 1 cfs, indicating that 16 cfs of streamflow infiltrated beneath Coils Creek and recharged the shallow basin-fill aquifer. Similar gain and loss results were observed along Roberts Creek, where nearly 10 cfs of streamflow was lost, likely infiltrating and recharging the shallow basin-fill aquifer beneath the stream. Although ET occurred along the measurement reaches, this loss was considered to be negligible compared with the streamflow loss.

Playas are flat, undrained, and unvegetated areas that typically are on a valley floor and periodically flood, accumulating fine-grained sediments and salts. Sediment grain size increases from the playa center toward the edge, which typically is bounded by phreatophytes and springs. Water can accumulate on playas from run-on of surface water, spring discharge, or direct precipitation. Surface morphology of Nevada playas typically ranges from hard, compact, generally smooth surfaces to soft, friable, or puffy surfaces. Hard surfaces typically reflect recent inundation by precipitation or run-on, whereas soft, puffy surfaces often reflect recent soil-water evaporation and subsequent salt deposition. A recent study by Garcia and others (2014) indicated that soft, puffy surfaces only were present following cool season precipitation. Low potential ET during cooler months facilitated downward percolation of precipitation or run-on and mixing with resident saline soil water. Subsequent evaporation of this water provided a mechanism for salt migration to and deposition on the playa surface. Friable surfaces were apparent following percolation and subsequent evaporation of cool-season precipitation and during the warmest and driest time of year. The source of playa soil water can vary seasonally from percolation of precipitation or “run-on” to groundwater. Similarly, groundwater discharging from playas can be derived from a mix of local recharge from precipitation and run-on to the playa and regional groundwater recharge (Garcia and others, 2014). Additional research is required to fully understand the role playas play in hydrologic processes.

The DVFS contains two playas—a relatively small playa (about 1,400 acres) in the northern part of southern Monitor Valley and a large playa (about 43,000 acres) in northern Diamond Valley (fig. 1). Rush and Everett (1964) noted that the southern Monitor Valley playa was dry in mid-April, but was flooded from a subsequent storm and snowmelt in early May. Similar patterns were observed during this study. Along the northeast margin, the playa surface was occasionally moist from small groundwater seeps. North of this playa in the south part of northern Monitor Valley, numerous springs have created several wetland areas and associated aquatic vegetation. The playa covering most of the northern part of Diamond Valley is considered the terminus of the DVFS (Harrill and others, 1983). Similar to the much smaller playa in southern Monitor Valley, this large playa is bordered by phreatophytes. Harrill (1968) reported that fault-controlled warm springs exist along the western margin of the playa, and small, warm groundwater seeps exist along the eastern margin. The presence of numerous seeps and springs surrounding southern Monitor Valley and Diamond Valley playas is indicative of permeability contrasts between alluvial and playa sediments that limit groundwater flow within playas.

## Groundwater

Nearly all groundwater in the DVFS originates from precipitation. Most precipitation falls, and consequently most groundwater recharges, in the higher altitudes of the mountainous regions within the DVFS. Some precipitation runs off as streamflow and eventually infiltrates through coarse channel deposits on alluvial fans. Groundwater in the basin fill generally is unconfined at shallow depths (water table) and confined at greater depths. Basin-fill deposits make up the principal aquifers in the DVFS and occupy structural basins in sedimentary and igneous rocks. Groundwater resides in the rock units that make up the mountain blocks and underlie the basins, but the connection to the basin-fill aquifer is poorly understood. Discharge of warm or hot water from springs or wells indicates deep circulation of groundwater, probably from carbonate or volcanic rock, at depth (Harrill, 1968; Tumbusch and Plume, 2006).

Groundwater flows down gradient from areas of recharge toward areas of discharge, and in the DVFS, groundwater flows toward the playa in northern Diamond Valley. Contours of water-level altitude are used to define the shape and gradient of the groundwater surface to indicate general directions of groundwater movement. As part of this study phase, 2012 groundwater levels (plate 1) were delineated largely on the basis of spring altitudes (fig. 2; table 4) and water-level data collected from wells (fig. 5; table 5). In Diamond Valley, the distribution of transmissivity and aquifer textures developed by Harrill (1968) also was used to guide the development of water-level contours. Most wells were measured in spring 2012; a few wells measured in 2005 could not be re-measured, but these were in areas of limited groundwater development and were assumed to be similar to the 2012 water table. The 2012 water-table surface can be compared to the 2005 water-table map (Tumbusch and Plume, 2006), where overlapping data exist, and to the 1950 pre-development water-table map in Diamond Valley (Harrill, 1968). In general, water-level altitudes and groundwater-flow directions have not changed since 2005 in southern and northern Monitor, Antelope, or Kobeh Valleys owing to the lack of groundwater development in those areas (sites 73, 83, 99, 140, 161; fig. 6).

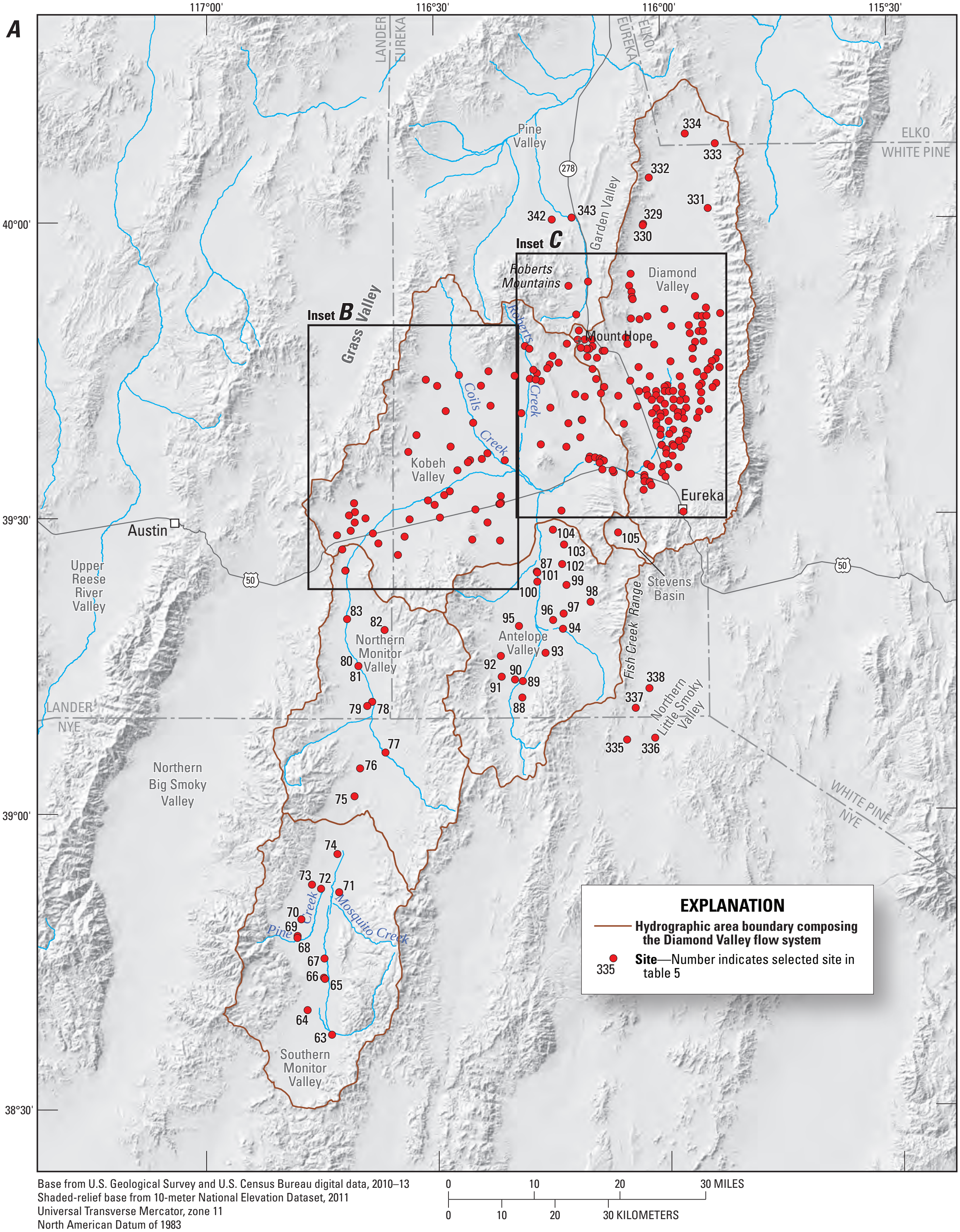


**Figure 5.** Groundwater sites in ***A***, the Diamond Valley flow system, central Nevada; ***B***, parts of northern Monitor and Kobeh Valleys; ***C***, parts of Kobeh and Diamond Valleys.

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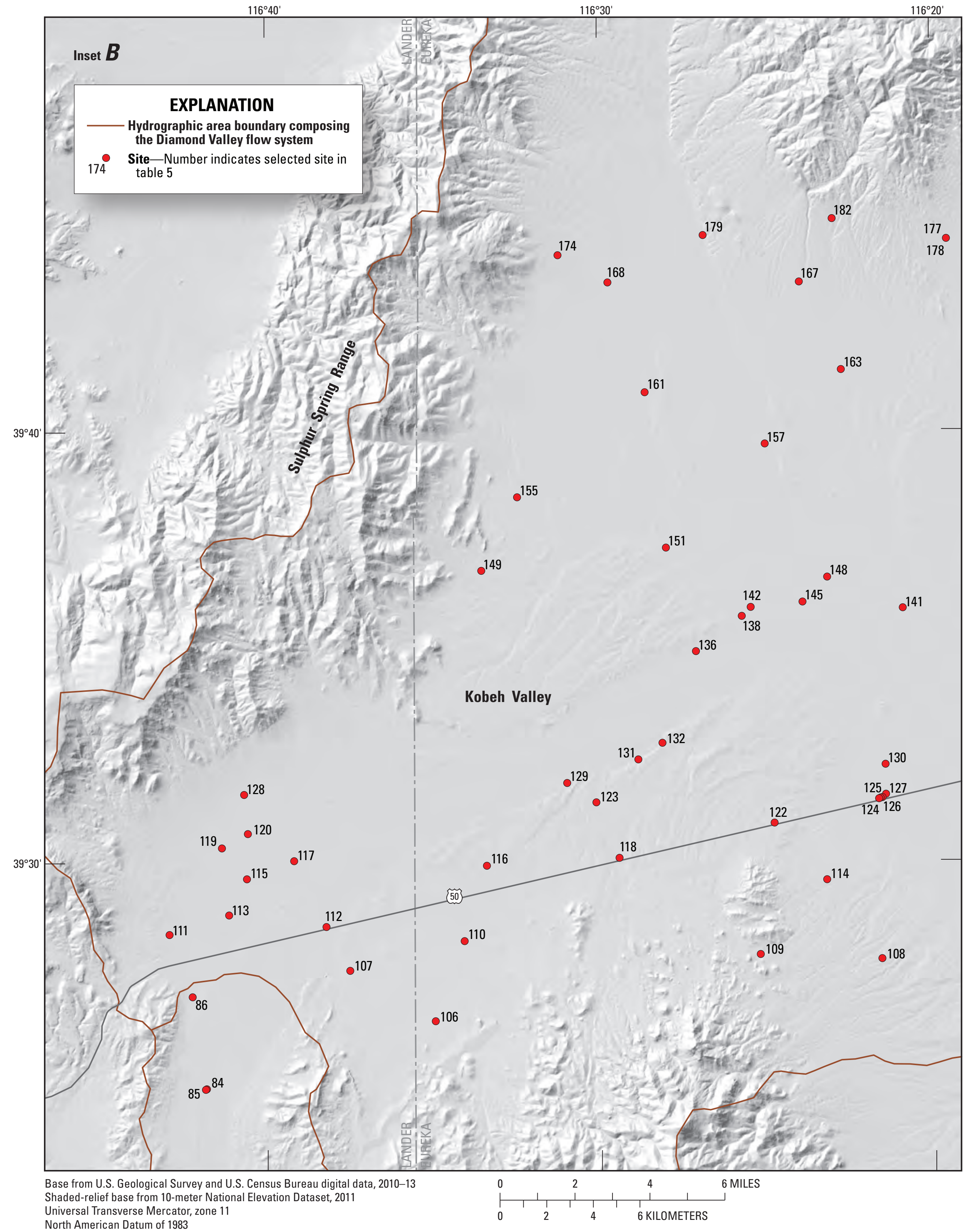


**Figure 5.** Groundwater sites in ***A***, the Diamond Valley flow system, central Nevada; ***B***, parts of northern Monitor and Kobeh Valleys; ***C***, parts of Kobeh and Diamond Valleys.—Continued

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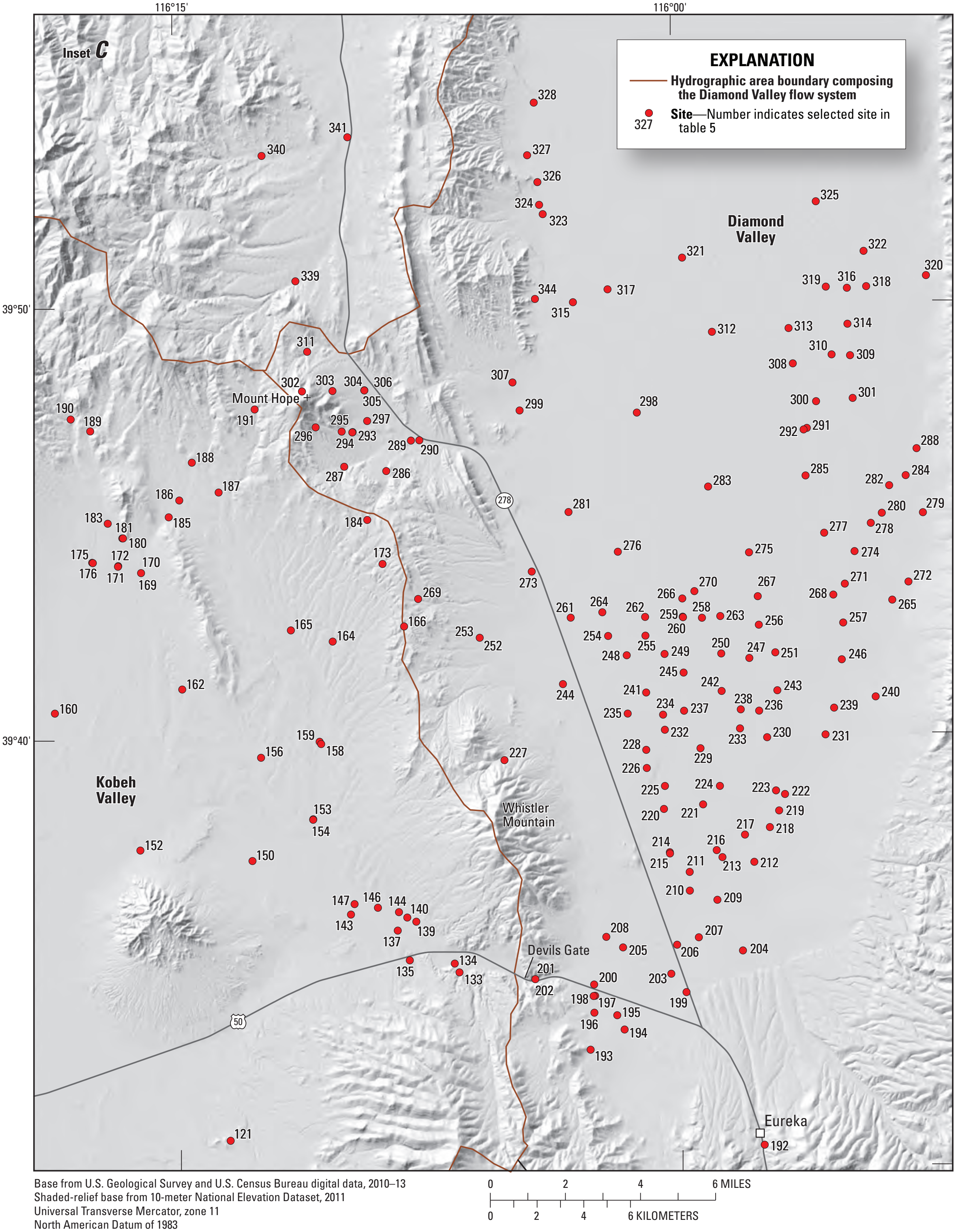


**Figure 5.** Maps showing groundwater sites in ***A***, the Diamond Valley flow system, central Nevada: ***B***, Kobeh Valley; ***C***, Diamond Valley.—Continued

**Table 4.** Location and general information of spring-measurement sites, Diamond Valley flow system, central Nevada.

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. USGS, United States Geological Survey; —, no data; Qm, miscellaneous discharge measurement; Qw, water quality; Pl., Plate]

| Site number | Hydrographic area | USGS station identifier | Nevada State station identifier | Other station identifier | Latitude (degrees) | Longitude (degrees) | Altitude (feet) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Southern Monitor Valley | [1]384930116430000 | — | — | 38.8249 | 116.7176 | 6,836 | Qw | 2, 8 |
| 39 | Northern Monitor Valley | [1]390445116382000 | — | — | 39.0791 | 116.6398 | 6,661 | Qw | 2, 8 |
| 40 | Northern Monitor Valley | [1]390628116320800 | — | — | 39.1077 | 116.5365 | 7,047 | Qw | 2, 8 |
| 41 | Antelope Valley | [1]390508116191800 | — | — | 39.0855 | 116.3226 | 7,346 | Qw | 2, 8 |
| 42 | Antelope Valley | [1]390634116205300 | — | — | 39.1094 | 116.349 | 7,070 | Qw | 2, 8 |
| 43 | Antelope Valley | [1]392417116204801 | — | — | 39.4047 | 116.3476 | 6,342 | Qw | 2, Pl. 1 |
| 44 | Antelope Valley | [1]392418116204700 | — | — | 39.4049 | 116.3473 | 6,342 | Qw | 2, Pl. 1 |
| 45 | Kobeh Valley | [1]393255116280801 | — | — | 39.5485 | 116.4698 | 6,154 | Qm | 2, Pl. 1 |
| 46 | Kobeh Valley | [1]393400116392401 | — | — | 39.5667 | 116.6567 | 6,684 | Qw | 2, 8 |
| 47 | Kobeh Valley | — | [2]139 N20 E50 13ACCA1 | — | 39.6121 | 116.2924 | 6,113 | Qm | 2, Pl. 1 |
| 48 | Kobeh Valley | — | [2]139 N20 E51 06BBB 1 | — | 39.6344 | 116.2832 | 6,139 | Qm | 2, Pl. 1 |
| 49 | Diamond Valley | [1]392904115565501 | — | [3]19/53-25d | 39.4844 | 115.9486 | 6,809 | Qw | 2, 8 |
| 50 | Diamond Valley | [1]393316115540501 | — | — | 39.5544 | 115.9014 | 6,820 | Qw | 2, 8 |
| 51 | Diamond Valley | — | [2]153 N21 E52 25CCCD1 | — | 39.6488 | 116.0757 | 6,425 | Qm | 2, Pl. 1 |
| 52 | Diamond Valley | — | [2]153 N21 E52 03BBBD1 | — | 39.72 | 116.1131 | 6,330 | Qm | 2, Pl. 1 |
| 53 | Diamond Valley | [1]395415115524301 | — | [3]23/54-3db; Taft Spring; Thompson Spring | 39.9008 | 115.8687 | 5,844 | Qm, Qw | 2, 8 |
| 54 | Diamond Valley | [1]395444116040301 | — | Bailey Spring | 39.9122 | 116.0684 | 5,810 | Qm | 2 |
| 55 | Diamond Valley | [1]395552116042301 | — | Indian Camp Spring | 39.9310 | 116.0740 | 5,810 | Qm | 2 |
| 56 | Diamond Valley | [1]395628116042801 | 153 N24 E52 23DCAD1 | [3]24/52-23ca; Shipley Hot Spring | 39.9438 | 116.0734 | 5,800 | Qm, Qw | 2, 8, Pl. 1 |
| 57 | Diamond Valley | [1]395919116023801 | — | Siri Spring | 39.9885 | 116.0448 | 5,810 | Qm | 2 |
| 58 | Diamond Valley | [1]400911116004701 | — | [3]26/53-8a | 40.1531 | 116.0131 | 6,291 | Qw | 2, 8 |
| 59 | Northern Little Smoky Valley | [1]391624116020501 | — | Fish Springs complex south orifice | 39.2733 | 116.0348 | 6,051 | Qw | 2, 8, Pl. 1 |
| 60 | Northern Little Smoky Valley | [1]391638116021601 | — | Fish Springs complex west orifice | 39.2769 | 116.0391 | 6,054 | Qw | 2, 8, Pl. 1 |
| 61 | Northern Little Smoky Valley | [1]391645116020501 | — | Fish Springs complex north orifice | 39.2791 | 116.0347 | 6,053 | Qw | 2, Pl. 1 |
| 62 | Pine Valley | [1]395412116081601 | — | — | 39.9034 | 116.1379 | 6,513 | Qm, Qw | 2, 8, Pl. 1 |

[1]Latitude, longitude, and altitude values are from the USGS National Water Information System (*http://waterdata.usgs.gov/nwis*).

[2]Latitude, longitude, and altitude values are from the State of Nevada Division of Water Resources Database (*http://water.nv.gov/data/streamflow*).

[3]Site name published *in* Harrill, J., 1968, Hydrologic response to irrigation pumping in Diamond Valley, Eureka and Elko Counties, Nevada, 1950–65: State of Nevada, Department of Conservation and Natural Resources, Water Resources Bulletin 35, 85 p. (*http://images.water.nv.gov/images/publications/water%20resources%20bulletins/Bulletin35.pdf*).

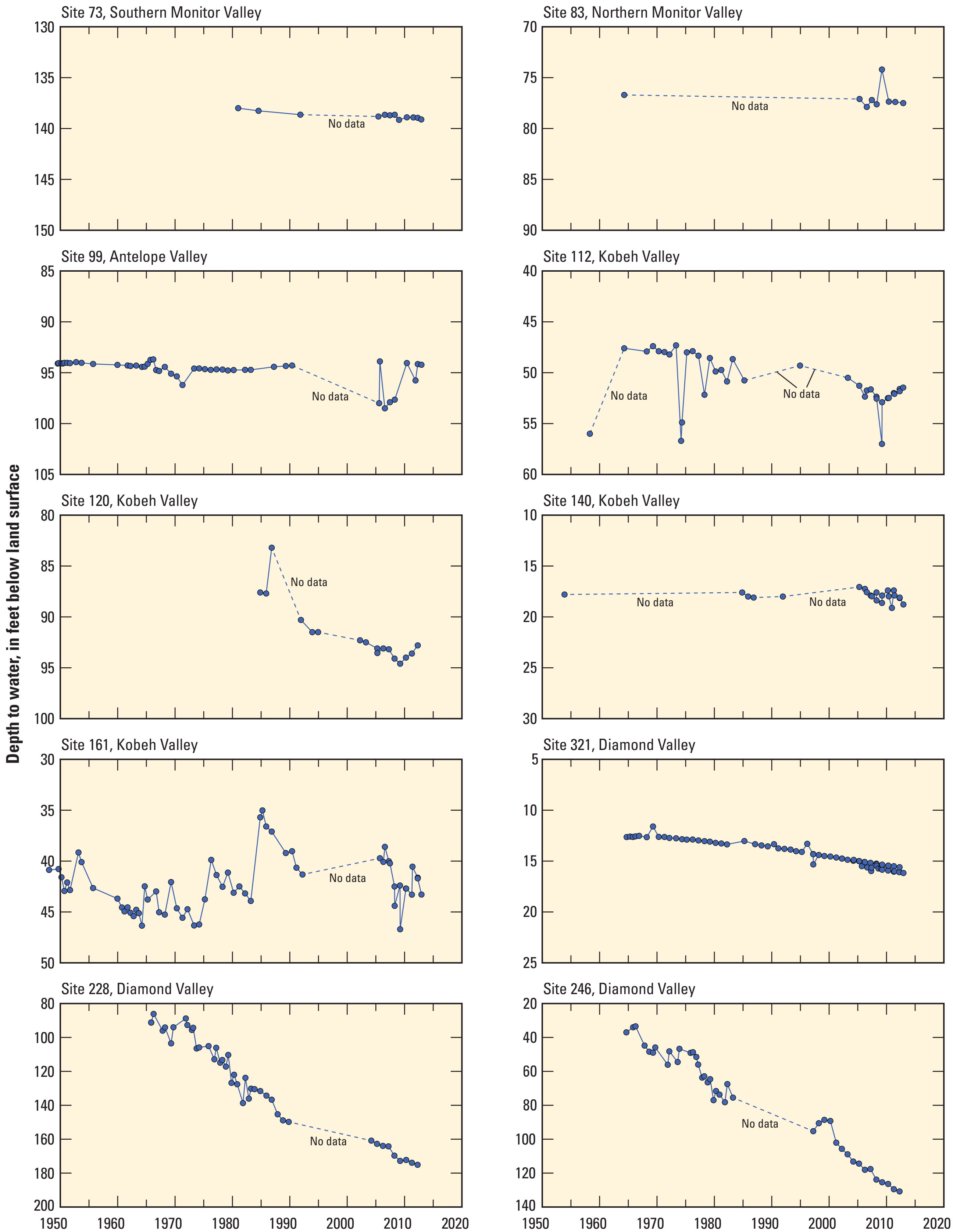


**Figure 6.** Water-level change in selected wells in the Diamond Valley flow system, central Nevada, 1950–2012.

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Water-level declines were observed from 2005 to 2012 in southern Diamond Valley (sites 228 and 246, fig. 6). Although the direction of groundwater flow in Diamond Valley in 2012 was similar to that in 2005, as much as 21 ft of decline was observed in the southern part of Diamond Valley during that 7-year interval (2005–12). A groundwater divide has formed between the area of natural discharge in the north part of Diamond Valley and the area of groundwater development in the south since Harrill's (1968) work in 1966. The groundwater divide has migrated northward since 2005, and its east-west extent has decreased notably (site 321; plate 1; fig. 6). This migration indicates that the cone of depression caused by groundwater withdrawals in southern Diamond Valley expanded radially outward and had not reached equilibrium by 2012.

Since the mid-1960s, numerous springs, mostly along the western margin of the playa in the northern part of Diamond Valley, have declined in discharge or have stopped flowing entirely. Exact timing of the spring-flow decline is mostly unknown. Limited flow measurements at Taft-Thompson Spring (site 53; fig. 2; table 4), along the eastern margin, and at Shipley Hot Spring (site 56; fig. 2; table 4), along the western margin, indicated large flow declines took place in the mid-1980s to early 1990s (fig. 7). Spring-flow measurements collected in 1965–68 at five major springs (sites 53–57; fig. 2; table 4) in northern Diamond Valley ranged from 0.6 to 6.8 cfs. By 2011–12, only Shipley Hot Springs continued to flow, but only at nearly half the flow rate measured in 1990. Observed decreases in spring discharge along the east and west margins of the playa in the northern part of Diamond Valley, in part, could have been induced by groundwater withdrawals in the south. Finger-like zones of relatively more transmissive basin-fill deposits along the west and east sides of Diamond Valley (Harrill, 1968) could provide an avenue for groundwater withdrawals in southern Diamond Valley to propagate northward and affect spring discharge in northern Diamond Valley.

Additional water-level data collected since 2005 and more accurate land-surface altitudes at selected well sites were used to improve estimates of groundwater flow between basins. Water-level data in the area between Kobeh and Diamond Valleys north of Whistler Mountain (sites 166, 173, 184, 269; fig. 5; table 5) indicated no groundwater flow across this boundary. Recent water-level altitudes in northern Little Smoky Valley, southeast of Antelope Valley, were as much as 200 ft lower than water-level altitudes in the southern part of Antelope Valley (sites 94, 96, 97, 335, 337, 338; fig. 5; table 5). This difference in water-level altitude supports an inference by Rush and Everett (1966) that groundwater potentially flows eastward from the southern part of Antelope Valley through carbonate rocks of the southern Fish Creek Range and could be, in part, the source of flow at Fish Creek Springs (site 59–61; fig. 2; table 4), a regionally discharging

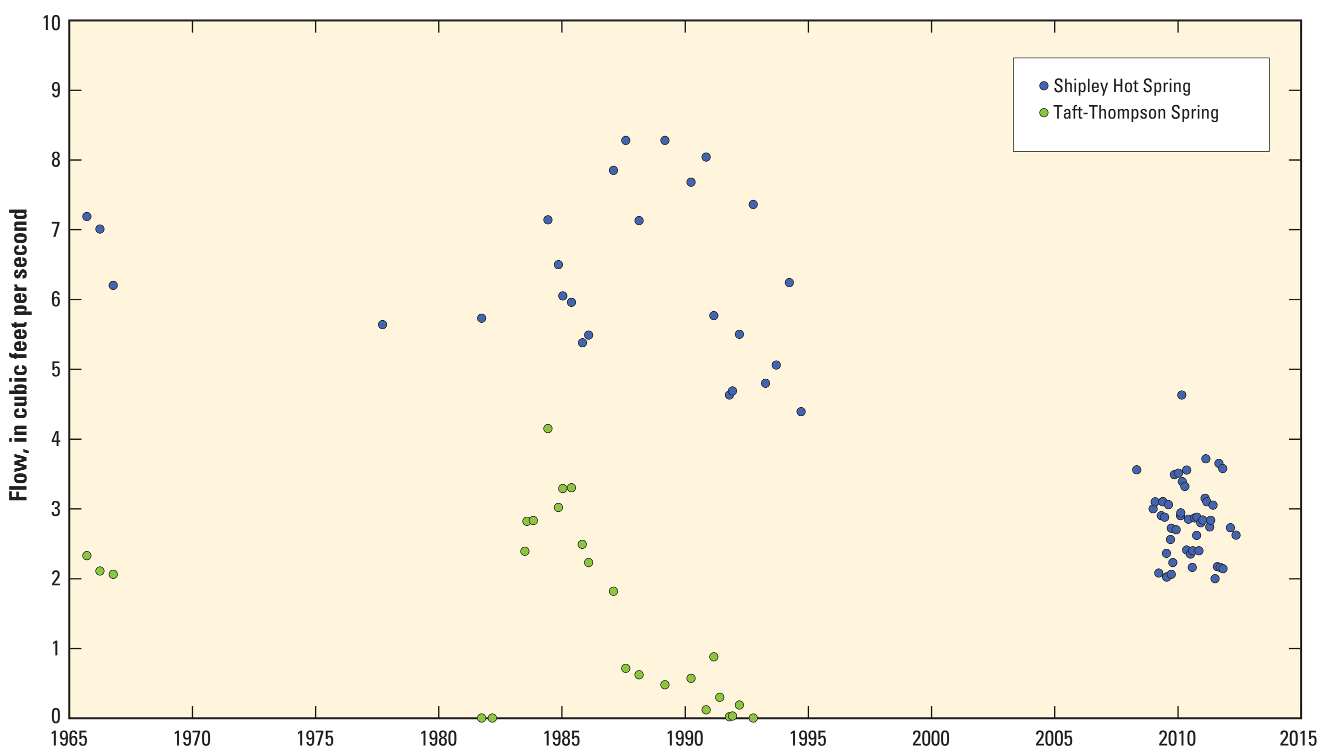


**Figure 7.** Miscellaneous spring-discharge measurements for Shipley Hot Springs and Taft-Thompson Spring, 1965–2012, Diamond Valley flow system, central Nevada. Spring discharge measurements from 2008 to 2012 were obtained from the Nevada Division of Water Resources (2013).

**Table 5.** Location and general information for groundwater-measurement sites, Diamond Valley flow system, central Nevada.

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. mm/dd/yyyy, month/day/year; BLS, below land surface; —, no data; Qw, water quality; Pl., Plate; Wl, water level]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Nevada State station identifier | Other station identifier | Nevada State well log number | Latitude (degrees) | Longitude (degrees) | Land-surface altitude (feet) | Well depth (feet) | Water level BLS[1] (feet) | Date measured (mm/dd/yyyy) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63 | Southern Monitor Valley | [2]383740116434301 | — | — | 35913 | 38.6277 | 116.7295 | 7,095 | 300 | 166.4 | 11/29/2012 | Wl | 5, Pl. 1 |
| 64 | Southern Monitor Valley | [2]384005116480101 | — | — | — | 38.6694 | 116.782 | 7,031 | 136 | 99.13 | 04/19/2012 | Wl | 5, Pl. 1 |
| 65 | Southern Monitor Valley | [2]384320116443700 | — | — | — | 38.7222 | 116.7445 | 6,895 | — | — | — | Qw | 5, 8 |
| 66 | Southern Monitor Valley | [2]384354116450201 | — | — | — | 38.7241 | 116.7465 | 6,894 | 13 | 3.21 | 04/19/2012 | Wl | 5, Pl. 1 |
| 67 | Southern Monitor Valley | [2]384524116444001 | — | — | — | 38.7566 | 116.7454 | 6,873 | — | 3.82 | 04/19/2012 | Wl | 5, Pl. 1 |
| 68 | Southern Monitor Valley | [2]384730116481000 | — | — | — | 38.7916 | 116.8037 | 6,923 | — | — | — | Qw | 5, 8 |
| 69 | Southern Monitor Valley | [2]384736116481801 | — | — | — | 38.7949 | 116.8034 | 6,932 | 154 | 49.37 | 04/19/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 70 | Southern Monitor Valley | [2]384926116474501 | — | — | — | 38.823 | 116.7951 | 6,850 | 30 | 20.61 | 04/19/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 71 | Southern Monitor Valley | [2]385220116435500 | — | — | — | 38.8687 | 116.7132 | 6,809 | 4,353 | — | — | Qw | 5, 8 |
| 72 | Southern Monitor Valley | [2]385229116450501 | — | — | 23482 | 38.8747 | 116.7523 | 6,819 | 380 | 15.18 | 04/19/2012 | Wl | 5, Pl. 1 |
| 73 | Southern Monitor Valley | [2]385819116462301 | — | — | — | 38.8816 | 116.772 | 6,943 | 142 | 138.95 | 04/19/2012 | Wl | 5, Pl. 1 |
| 74 | Southern Monitor Valley | [2]385600116425700 | — | — | — | 38.9333 | 116.7167 | 6,800 | — | — | — | Qw | 5, 8 |
| 75 | Northern Monitor Valley | [2]390150116403801 | — | — | — | 39.0308 | 116.6792 | 6,810 | 192 | 79.46 | 04/19/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 76 | Northern Monitor Valley | [2]390438116394301 | — | — | — | 39.078 | 116.667 | 6,754 | 169 | 76.99 | 11/30/2012 | Wl | 5, Pl. 1 |
| 77 | Northern Monitor Valley | [2]390608116364901 | — | — | 4939 | 39.1047 | 116.6117 | 6,700 | 350 | 6.65 | 04/19/2012 | Wl | 5, Pl. 1 |
| 78 | Northern Monitor Valley | [2]391058116385501 | — | — | — | 39.1835 | 116.6509 | 6,549 | 182 | 118.72 | 04/19/2012 | Wl | 5, Pl. 1 |
| 79 | Northern Monitor Valley | [2]391147116374101 | — | — | 95678 | 39.1905 | 116.6401 | 6,518 | 180 | 99.64 | 04/19/2012 | Wl | 5, Pl. 1 |
| 80 | Northern Monitor Valley | [2]391503116401002 | — | — | 66124 | 39.251 | 116.6698 | 6,458 | 105 | 60.32 | 07/25/2006 | Wl | 5, Pl. 1 |
| 81 | Northern Monitor Valley | [2]391503116401001 | — | [4]16/47-4d1 | — | 39.251 | 116.6698 | 6,458 | 64 | — | — | Qw, Wl | 5, 8 |
| 82 | Northern Monitor Valley | [2]391843116364201 | — | — | — | 39.3119 | 116.6126 | 6,684 | — | 284.07 | 11/30/2012 | Wl | 5, Pl. 1 |

**Table 5.** Location and general information for groundwater-measurment sites, Diamond Valley flow system, central Nevada.—Continued

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. mm/dd/yyyy, month/day/year; BLS, below land surface; —, no data; Qw, water quality; Pl., Plate; Wl, water level]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Nevada State station identifier | Other station identifier | Nevada State well log number | Latitude (degrees) | Longitude (degrees) | Land-surface altitude (feet) | Well depth (feet) | Water level BLS[1] (feet) | Date measured (mm/dd/yyyy) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 83 | Northern Monitor Valley | [2]391951116413301 | — | — | — | 39.3305 | 116.694 | 6,386 | — | 77.5 | 11/30/2012 | Wl | 5, Pl. 1 |
| 84 | Northern Monitor Valley | [2]392445116414802 | — | [4]18/47-20a1 | — | 39.4124 | 116.6976 | 6,321 | — | — | — | Qw | 5, 8 |
| 85 | Northern Monitor Valley | [2]392445116414801 | — | — | — | 39.4126 | 116.6971 | 6,326.37 | — | 92.9 | 04/19/2012 | Wl | 5, Pl. 1 |
| 86 | Northern Monitor Valley | [2]392654116421401 | 140A N18HE47 08BBDC1 | — | — | 39.4483 | 116.704 | 6,310 | 108 | 85.88 | 04/19/2012 | Wl | 5, Pl. 1 |
| 87 | Antelope Valley | [2]392445116414800 | — | [4]18/51-30b1 | — | 39.4075 | 116.2789 | 6,177 | — | — | — | Qw | 5, 8 |
| 88 | Antelope Valley | [2]391114116185101 | — | — | — | 39.1963 | 116.3138 | 6,454.4 | 174 | 123.82 | 04/20/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 89 | Antelope Valley | [2]391330116184101 | — | — | 21374 | 39.2241 | 116.3122 | 6,389.6 | 95 | 62.66 | 04/20/2012 | Wl | 5, Pl. 1 |
| 90 | Antelope Valley | [2]391342116194401 | — | — | — | 39.2268 | 116.3293 | 6,437.7 | 190 | 109.29 | 04/20/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 91 | Antelope Valley | [2]391356116220801 | — | — | — | 39.2318 | 116.3583 | 6,540.3 | — | 210.89 | 04/20/2012 | Wl | 5, Pl. 1 |
| 92 | Antelope Valley | [2]391601116213201 | — | — | — | 39.2668 | 116.3597 | 6,499.5 | — | 170.56 | 04/20/2012 | Wl | 5, Pl. 1 |
| 93 | Antelope Valley | [2]391626116155902 | — | — | 7232 | 39.2716 | 116.2626 | 6,325.7 | 105 | 27.55 | 04/20/2012 | Wl | 5, Pl. 1 |
| 94 | Antelope Valley | [2]391835116163701 | — | — | 212 | 39.312 | 116.2241 | 6,406.3 | 272 | 158.37 | 04/20/2012 | Wl | 5, Pl. 1 |
| 95 | Antelope Valley | [2]391855116191501 | — | — | — | 39.3172 | 116.32 | 6,412 | 160 | 134.03 | 04/20/2012 | Wl | 5, Pl. 1 |
| 96 | Antelope Valley | [2]391935116144901 | — | — | — | 39.327 | 116.2455 | 6,346.3 | 186 | 94.97 | 04/20/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 97 | Antelope Valley | [2]392016116131701 | — | — | 1722 | 39.3378 | 116.2224 | 6,339.3 | 116 | 89.9 | 04/20/2012 | Wl | 5, Pl. 1 |
| 98 | Antelope Valley | [2]392137116094901 | — | — | 211 | 39.3572 | 116.1635 | 6,563.1 | 351 | 320.42 | 04/20/2012 | Wl | 5, Pl. 1 |
| 99 | Antelope Valley | [2]392310116125001 | — | [4]18/51-34d1 | — | 39.3861 | 116.2156 | 6,331.6 | 134 | 94.15 | 04/20/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 100 | Antelope Valley | [2]392331116164201 | — | — | — | 39.392 | 116.2792 | 6,199 | — | 5.71 | 04/07/2011 | Wl | 5, Pl. 1 |
| 101 | Antelope Valley | [2]392433116164500 | — | — | — | 39.4091 | 116.2801 | 6,174 | — | — | — | Qw | 5, 8 |
| 102 | Antelope Valley | [2]392529116133901 | — | — | 1330 | 39.4214 | 116.2248 | 6,235.2 | 130 | 59.95 | 04/20/2012 | Wl | 5, Pl. 1 |
| 103 | Antelope Valley | [2]392716116131001 | — | — | — | 39.4545 | 116.2203 | 6,226.7 | — | 157.67 | 04/20/2012 | Wl | 5, Pl. 1 |
| 104 | Antelope Valley | [2]392847116143901 | — | — | — | 39.4797 | 116.2442 | 6,198.9 | 160 | 129.32 | 04/20/2012 | Wl | 5, Pl. 1 |
| 105 | Stevens Basin | [2]392827116060401 | — | — | — | 39.4741 | 116.102 | 7,113 | 540 | 472.3 | 07/07/1983 | Wl | 5, Pl. 1 |
| 106 | Kobeh Valley | [2]392619116345401 | — | — | — | 39.4386 | 116.5828 | 6,457.6 | — | 173.42 | 04/19/2012 | Wl | 5, Pl. 1 |
| 107 | Kobeh Valley | [2]392703116380401 | — | — | — | 39.4582 | 116.6254 | 6,301 | 176 | 87 | 04/19/2012 | Wl | 5, Pl. 1 |
| 108 | Kobeh Valley | [2]392754116213201 | — | — | — | 39.462 | 116.3597 | 6,309.7 | 167 | 159.87 | 04/19/2012 | Wl | 5, Pl. 1 |
| 109 | Kobeh Valley | [2]392750116251001 | — | — | 9651 | 39.464 | 116.4204 | 6,602.8 | 128 | 104.32 | 12/11/2012 | Wl | 5, Pl. 1 |
| 110 | Kobeh Valley | [2]392811116340201 | — | — | — | 39.4696 | 116.5682 | 6,344 | 146 | 133.85 | 11/29/2012 | Wl | 5, Pl. 1 |
| 111 | Kobeh Valley | [2]392821116425401 | 139 N19 E47 31AADC1 | — | — | 39.4724 | 116.7155 | 6,313.1 | — | 98.9 | 04/19/2012 | Wl | 5, Pl. 1 |
| 112 | Kobeh Valley | [2]392800116380001 | 139 N19 E47 36BBBA1 | — | 7146 | 39.4753 | 116.6371 | 6,264.1 | 102 | 51.82 | 04/19/2012 | Wl | 5, Pl. 1 |

**Table 5.** Location and general information for groundwater-measurment sites, Diamond Valley flow system, central Nevada.—Continued

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. mm/dd/yyyy, month/day/year; BLS, below land surface; —, no data; Qw, water quality; Pl., Plate; Wl, water level]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Nevada State station identifier | Other station identifier | Nevada State well log number | Latitude (degrees) | Longitude (degrees) | Land-surface altitude (feet) | Well depth (feet) | Water level BLS[1] (feet) | Date measured (mm/dd/yyyy) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 113 | Kobeh Valley | [2]392849116405701 | — | — | — | 39.4798 | 116.6857 | 6,282.08 | 150 | 67.4 | 04/19/2012 | Wl | 5, Pl. 1 |
| 114 | Kobeh Valley | [2]392934116231001 | — | — | 9662 | 39.4927 | 116.387 | 6,272.59 | 157 | 126.64 | 04/18/2012 | Wl | 5, Pl. 1 |
| 115 | Kobeh Valley | [2]392938116403301 | 139 N19 E47 21DADD1 | — | 63775 | 39.4938 | 116.6767 | 6,277 | 300 | 71.9 | 04/19/2012 | Wl | 5, Pl. 1 |
| 116 | Kobeh Valley | [2]392956116332201 | 139 N19 E48 22BDDB1 | — | — | 39.4987 | 116.5569 | 6,251.58 | — | 54.22 | 04/19/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 117 | Kobeh Valley | [2]393003116390801 | 139 N19 E47 23BCAA1 | — | 27856 | 39.5008 | 116.6531 | 6,261 | 240 | 59 | 04/19/2012 | Wl | 5, Pl. 1 |
| 118 | Kobeh Valley | — | [3]139 N19 E49 30AA 1 | — | 4893 | 39.5015 | 116.4906 | 6,259 | 223 | 102.5 | 04/19/2012 | Wl | 5, Pl. 1 |
| 119 | Kobeh Valley | [2]393022116414201 | 139 N19 E47 16CD 1 | — | 23278 | 39.5058 | 116.6892 | 6,307 | 320 | 75.3 | 04/19/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 120 | Kobeh Valley | [2]393041116403101 | 139 N19 E47 15CBBB1 | — | 12850 | 39.5113 | 116.6762 | 6,304 | 247 | 92.8 | 04/19/2012 | Wl | 5, Pl. 1 |
| 121 | Kobeh Valley | [2]393043116133201 | — | — | 104186 | 39.5118 | 116.2254 | 6,312.8 | 331 | 227.4 | 04/16/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 122 | Kobeh Valley | [2]393058116244501 | — | — | — | 39.5148 | 116.4131 | 6,260.1 | 124 | 103.45 | 04/18/2012 | Wl | 5, Pl. 1 |
| 123 | Kobeh Valley | 393123116300401 | [3]139 N19 E49 18CABA1 | — | 5515 | 39.523 | 116.502 | 6,201 | 90 | 27.3 | 04/19/2012 | Wl | 5, Pl. 1 |
| 124 | Kobeh Valley | — | [3]139 N19 E50 17DAAB1 | — | 9662 | 39.5239 | 116.3608 | 6,102.41 | 157 | Flowing | 03/01/2012 | Wl | 5, Pl. 1 |
| 125 | Kobeh Valley | [2]393129116212800 | — | — | — | 39.5242 | 116.36 | 6,110 | — | — | — | Qw | 5, 8 |
| 126 | Kobeh Valley | 393129116212901 | [3]139 N19 E50 16BCCC1 | — | — | 39.5244 | 116.3591 | 6,106 | — | Flowing | 04/19/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 127 | Kobeh Valley | 393133116212201 | [3]139 N19 E50 16BCCA1 | — | — | 39.5256 | 116.3573 | 6,098.64 | — | Flowing | 03/01/2012 | Wl | 5, Pl. 1 |
| 128 | Kobeh Valley | [2]393155116411801 | 139 N19 E47 09AD 1 | — | — | 39.5265 | 116.678 | 6,359 | 190 | 141.2 | 04/19/2012 | Wl | 5, Pl. 1 |
| 129 | Kobeh Valley | [2]393155116310301 | — | — | — | 39.5305 | 116.5166 | 6,184.1 | — | 8.62 | 04/20/2012 | Wl | 5, Pl. 1 |
| 130 | Kobeh Valley | [2]393214116212401 | — | — | 114075 | 39.5372 | 116.3574 | 6,098.6 | 35 | 8.66 | 04/18/2012 | Wl | 5, Pl. 1 |
| 131 | Kobeh Valley | [2]393223116284801 | — | — | — | 39.5395 | 116.481 | 6,168.5 | — | 2.32 | 04/20/2012 | Wl | 5, Pl. 1 |
| 132 | Kobeh Valley | [2]393246116280501 | — | — | — | 39.5459 | 116.4688 | 6,178.38 | — | 12.92 | 04/19/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 133 | Kobeh Valley | [2]393434116063801 | — | — | 47428 | 39.576 | 116.1105 | 6,080.47 | 306 | 86.22 | 04/16/2012 | Wl | 5, Pl. 1 |
| 134 | Kobeh Valley | [2]393446116064301 | — | — | — | 39.5794 | 116.1128 | 6,005.7 | — | 8.16 | 04/16/2012 | Wl | 5, Pl. 1 |
| 135 | Kobeh Valley | — | [3]139 N20 E52 20DBBB1 | — | 1676 | 39.5808 | 116.1352 | 6,043 | 120 | Flowing | 03/01/2012 | Wl | 5, Pl. 1 |
| 136 | Kobeh Valley | [2]393453116270301 | — | — | — | 39.5813 | 116.4518 | 6,147.2 | 36 | 1.65 | 04/19/2012 | Wl | 5, Pl. 1 |
| 137 | Kobeh Valley | — | [3]139 N20 E52 17CB 1 | — | 9211 | 39.5923 | 116.1411 | 6,020 | 85 | 2.4 | 04/19/2012 | Wl | 5, Pl. 1 |
| 138 | Kobeh Valley | [2]393542116254101 | — | — | — | 39.5948 | 116.4288 | 6,144.87 | 38 | 10.92 | 04/19/2012 | Wl | 5, Pl. 1 |
| 139 | Kobeh Valley | [2]393545116075101 | — | — | 48875 | 39.5957 | 116.1318 | 6,039.1 | 110 | 33.13 | 04/16/2012 | Wl | 5, Pl. 1 |
| 140 | Kobeh Valley | [2]393544116084801 | 139 N20 E52 17BDDA1 | — | — | 39.5974 | 116.1363 | 6,024.71 | 90 | 18.15 | 04/16/2012 | Wl | 5, Pl. 1 |
| 141 | Kobeh Valley | — | [3]139 N20 E50 21ACCA1 | — | — | 39.5977 | 116.3483 | 6,100.3 | — | Flowing | 02/28/2012 | Wl | 5, Pl. 1 |
| 142 | Kobeh Valley | [2]393554116252801 | — | — | 107001 | 39.5982 | 116.4243 | 6,130.9 | 34 | 3.04 | 04/19/2012 | Wl | 5, Pl. 1 |
| 143 | Kobeh Valley | [2]393555116094801 | — | — | 114074 | 39.5987 | 116.1644 | 6,012.5 | 24 | 3.25 | 04/17/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 144 | Kobeh Valley | [2]393558116082201 | 139 N20 E52 17BCAA1 | — | — | 39.5995 | 116.1404 | 6,019.48 | — | 12.48 | 04/16/2012 | Wl | 5, Pl. 1 |
| 145 | Kobeh Valley | [2]393601116235101 | — | — | — | 39.6002 | 116.3984 | 6,119.52 | — | 6.6 | 04/19/2012 | Wl | 5, Pl. 1 |

**Table 5.** Location and general information for groundwater-measurment sites, Diamond Valley flow system, central Nevada.—Continued

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. mm/dd/yyyy, month/day/year; BLS, below land surface; —, no data; Qw, water quality; Pl., Plate; Wl, water level]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Nevada State station identifier | Other station identifier | Nevada State well log number | Latitude (degrees) | Longitude (degrees) | Land-surface altitude (feet) | Well depth (feet) | Water level BLS[1] (feet) | Date measured (mm/dd/yyyy) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 146 | Kobeh Valley | [2]393546116092301 | — | — | 880 | 39.6013 | 116.1508 | 6,013.6 | 132 | 4.87 | 04/16/2012 | Wl | 5, Pl. 1 |
| 147 | Kobeh Valley | [2]393610116094201 | — | — | — | 39.6027 | 116.1625 | 6,015.9 | — | 6.81 | 04/17/2012 | Wl | 5, Pl. 1 |
| 148 | Kobeh Valley | — | [3]139 N20 E50 18DBBD1 | — | 23425 | 39.6098 | 116.386 | 6,117.89 | 232 | Flowing | 02/29/2012 | Wl | 5, Pl. 1 |
| 149 | Kobeh Valley | [2]393646116332901 | — | — | — | 39.6128 | 116.559 | 6,241.4 | — | 51.4 | 04/18/2012 | Wl | 5, Pl. 1 |
| 150 | Kobeh Valley | [2]393711116124801 | — | — | 107000 | 39.6197 | 116.2133 | 6,051.8 | 43 | 2.04 | 04/16/2012 | Wl | 5, Pl. 1 |
| 151 | Kobeh Valley | — | [3]139 N20 E49 09CC 1 | — | 1887 | 39.6214 | 116.4666 | 6,154 | 250 | 2.8 | 04/19/2012 | Wl | 5, Pl. 1 |
| 152 | Kobeh Valley | [2]393727116160601 | — | — | — | 39.6241 | 116.2692 | 6,144.65 | — | 10.17 | 04/17/2012 | Wl | 5, Pl. 1 |
| 153 | Kobeh Valley | [2]393808116105801 | — | — | 24287 | 39.6354 | 116.1828 | 6,087.9 | 1,100 | 37.46 | 04/17/2012 | Wl | 5, Pl. 1 |
| 154 | Kobeh Valley | [2]393809116105501 | 139 N21 E51 36DCDB2 | — | 24638 | 39.6356 | 116.1828 | 6,088.97 | 842 | 38.46 | 04/17/2012 | Wl | 5, Pl. 1 |
| 155 | Kobeh Valley | [2]393829116322401 | — | — | — | 39.6412 | 116.5409 | 6,210.73 | — | 24.89 | 04/18/2012 | Wl | 5, Pl. 1 |
| 156 | Kobeh Valley | — | [3]139 N21 E51 26B 1 | — | — | 39.6595 | 116.2085 | 6,145 | — | 76.3 | 04/19/2012 | Wl | 5, Pl. 1 |
| 157 | Kobeh Valley | [2]393942116245701 | — | — | — | 39.6615 | 116.4168 | 6,190.7 | 45 | 10.15 | 04/18/2012 | Wl | 5, Pl. 1 |
| 158 | Kobeh Valley | [2]393954116104001 | — | — | 24286 | 39.6646 | 116.1784 | 6,149.62 | 630 | 81.02 | 04/17/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 159 | Kobeh Valley | [2]393957116103001 | — | — | — | 39.6655 | 116.1792 | 6,320 | 201 | — | — | Qw, Wl | 5, 8 |
| 160 | Kobeh Valley | [2]394036116183401 | — | — | — | 39.6772 | 116.3113 | 6,227.1 | 139 | 37.03 | 04/18/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 161 | Kobeh Valley | [2]394059116282901 | 139 N21 E49 16CCBB1 | — | — | 39.6815 | 116.4768 | 6,235.1 | 50 | 41.63 | 04/18/2012 | Wl | 5, Pl. 1 |
| 162 | Kobeh Valley | — | [3]139 N21 E51 16BCDB1 | — | 106644 | 39.6861 | 116.2476 | 6,269.99 | 1,000 | 173.67 | 04/18/2012 | Wl | 5, Pl. 1 |
| 163 | Kobeh Valley | [2]394125116223801 | — | — | 13994 | 39.69 | 116.3784 | 6,225.12 | 124 | 59.11 | 04/18/2012 | Wl | 5, Pl. 1 |
| 164 | Kobeh Valley | [2]394216116101701 | — | — | — | 39.7041 | 116.1722 | 6,263.6 | — | 203.61 | 04/17/2012 | Wl | 5, Pl. 1 |
| 165 | Kobeh Valley | [2]394231116113201 | — | — | — | 39.7086 | 116.1931 | 6,290.5 | — | 204.15 | 04/17/2012 | Wl | 5, Pl. 1 |
| 166 | Kobeh Valley | — | [3]139 N21 E52 05DDBA1 | — | 107060 | 39.7097 | 116.1365 | 6,605.21 | 450 | 311.95 | 05/30/2012 | Wl | 5, Pl. 1 |
| 167 | Kobeh Valley | [2]394327116235401 | — | — | 11032 | 39.724 | 116.3992 | 6,409.9 | 289 | 233.7 | 05/20/2011 | Wl | 5, Pl. 1 |
| 168 | Kobeh Valley | [2]394327116293901 | — | — | — | 39.7241 | 116.4951 | 6,353 | 201 | 142 | 01/01/1981 | Wl | 5, Pl. 1 |
| 169 | Kobeh Valley | — | [3]139 N22 E51 32BCAD1 | — | 105125 | 39.7312 | 116.2677 | 6,381.88 | 585 | 33.71 | 09/05/2012 | Wl | 5, Pl. 1 |
| 170 | Kobeh Valley | — | [3]139 N22 E51 32BCAD2 | — | 105302 | 39.7312 | 116.2677 | 6,381.88 | 230 | 34.07 | 04/18/2012 | Wl | 5, Pl. 1 |
| 171 | Kobeh Valley | — | [3]139 N22 E51 31ABCC1 | — | 107126 | 39.7338 | 116.2792 | 6,406.4 | 900 | 204.8 | 09/05/2012 | Wl | 5, Pl. 1 |
| 172 | Kobeh Valley | — | [3]139 N22 E51 31ABCB1 | — | 106690 | 39.7339 | 116.2791 | 6,406.67 | 999 | 201.54 | 06/06/2012 | Wl | 5, Pl. 1 |
| 173 | Kobeh Valley | — | [3]139 N21HE52 05BBCC1 | — | 107059 | 39.7339 | 116.1469 | 6,746.86 | 378 | 211.89 | 05/30/2012 | Wl | 5, Pl. 1 |
| 174 | Kobeh Valley | [2]394406116310201 | — | [4]22/48-36a1 | — | 39.7347 | 116.52 | 6,501 | — | — | — | Qw | 5, 8 |
| 175 | Kobeh Valley | — | [3]139 N22 E50 36AABD1 | — | 106630 | 39.7352 | 116.2919 | 6,411.88 | 889 | 208.74 | 09/05/2012 | Wl | 5, Pl. 1 |
| 176 | Kobeh Valley | — | [3]139 N22 E50 36AABD2 | — | 107125 | 39.7353 | 116.292 | 6,412.07 | 902 | 209.79 | 06/06/2012 | Wl | 5, Pl. 1 |
| 177 | Kobeh Valley | — | [3]139 N22 E50 26CBCD1 | — | 107627 | 39.7405 | 116.3253 | 6,513.45 | 430 | 71.49 | 06/06/2012 | Wl | 5, Pl. 1 |
| 178 | Kobeh Valley | — | [3]139 N22 E50 26CBCD2 | — | 107628 | 39.7405 | 116.3253 | 6,513.45 | 610 | 152.84 | 06/06/2012 | Wl | 5, Pl. 1 |

**Table 5.** Location and general information for groundwater-measurment sites, Diamond Valley flow system, central Nevada.—Continued

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. mm/dd/yyyy, month/day/year; BLS, below land surface; —, no data; Qw, water quality; Pl., Plate; Wl, water level]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Nevada State station identifier | Other station identifier | Nevada State well log number | Latitude (degrees) | Longitude (degrees) | Land-surface altitude (feet) | Well depth (feet) | Water level BLS[1] (feet) | Date measured (mm/dd/yyyy) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 179 | Kobeh Valley | [2]394420116263101 | — | [4]22/49-27d1 | — | 39.7422 | 116.4472 | 6,343 | — | — | — | Qw | 5, 8 |
| 180 | Kobeh Valley | — | [3]139 N22 E51 30ACDC3 | — | 109889 | 39.7446 | 116.2769 | 6,445.63 | 800 | 114.42 | 09/05/2012 | Wl | 5, Pl. 1 |
| 181 | Kobeh Valley | — | [3]139 N22 E51 30ACDC1 | — | 109890 | 39.7446 | 116.2766 | 6,446.78 | 800 | 97.64 | 05/30/2012 | Wl | 5, Pl. 1 |
| 182 | Kobeh Valley | — | [3]139 N22 E50 29BBCB1 | — | 106508 | 39.7484 | 116.3825 | 6,633.26 | 477 | 170.92 | 06/06/2012 | Wl | 5, Pl. 1 |
| 183 | Kobeh Valley | [2]394514116172301 | — | — | 4274 | 39.7503 | 116.2842 | 6,485.3 | 350 | 136.75 | 04/17/2012 | Wl | 5, Pl. 1 |
| 184 | Kobeh Valley | — | [3]139 N22 E52 31ABBA1 | — | 107061 | 39.7509 | 116.1544 | 6,727.79 | 570 | 229.13 | 05/30/2012 | Wl | 5, Pl. 1 |
| 185 | Kobeh Valley | — | [3]139 N22 E51 20DDDB1 | — | 105126 | 39.7526 | 116.2537 | 6,511.32 | 600 | 58.35 | 05/30/2012 | Wl | 5, Pl. 1 |
| 186 | Kobeh Valley | — | [3]139 N22 E51 21BCDC1 | — | 107632 | 39.7591 | 116.2483 | 6,568.96 | 1,080 | 76.61 | 05/30/2012 | Wl | 5, Pl. 1 |
| 187 | Kobeh Valley | — | [3]139 N22 E51 22BACC1 | — | 108050 | 39.762 | 116.2286 | 6,613.43 | 990 | 87.18 | 09/05/2012 | Wl | 5, Pl. 1 |
| 188 | Kobeh Valley | — | [3]139 N22 E51 16ACCB1 | — | 108051 | 39.7736 | 116.2419 | 6,712.37 | 1,000 | 48.6 | 06/06/2012 | Wl | 5, Pl. 1 |
| 189 | Kobeh Valley | — | [3]139 N22 E50 12DABD1 | — | 108053 | 39.786 | 116.2926 | 6,771.56 | 378 | 97.94 | 06/06/2012 | Wl | 5, Pl. 1 |
| 190 | Kobeh Valley | — | [3]139 N22 E50 12BACC1 | — | 108052 | 39.7907 | 116.3023 | 6,772.96 | 300 | 80.67 | 06/06/2012 | Wl | 5, Pl. 1 |
| 191 | Kobeh Valley | — | [3]139 N22 E51 02CCDD1 | — | 99128 | 39.794 | 116.2102 | 6,921.41 | 80 | 15.59 | 05/30/2012 | Wl | 5, Pl. 1 |
| 192 | Diamond Valley | [2]393030115573000 | — | — | — | 39.5083 | 115.9592 | 6,549 | — | — | — | Qw | 5, 8 |
| 193 | Diamond Valley | [2]393244116024401 | — | — | 104185 | 39.5456 | 116.0455 | 6,211 | 338 | 255.23 | 12/14/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 194 | Diamond Valley | 393327116013601 | [3]153 N20 E53 32BDCC1 | — | 6312 | 39.5533 | 116.0284 | 6,049.87 | 218 | 153.5 | 04/11/2012 | Wl | 5, Pl. 1 |
| 195 | Diamond Valley | 393332116015001 | [3]153 N20 E53 32BBBA1 | — | 9244, 24576 | 39.5588 | 116.032 | 6,023.62 | 240 | 126.5 | 04/11/2012 | Wl | 5, Pl. 1 |
| 196 | Diamond Valley | 393343116023001 | [3]153 N20 E53 30DCCC1 | — | 7352 | 39.5599 | 116.0434 | 6,036.75 | 210 | 129.65 | 04/11/2012 | Wl | 5, Pl. 1 |
| 197 | Diamond Valley | [2]393353116023001 | — | [5]20/53-30db | — | 39.5663 | 116.0437 | 6,009 | — | — | — | Qw, Wl | 5, 8 |
| 198 | Diamond Valley | [2]393400116023101 | — | — | 23722 | 39.5664 | 116.0429 | 6,006.3 | 176 | 108.7 | 03/27/2012 | Wl | 5, Pl. 1 |
| 199 | Diamond Valley | 393408116000301 | [3]153 N20 E53 28ACCD1 | — | 6522 | 39.5674 | 115.9973 | 6,023.62 | — | 237.1 | 04/11/2012 | Wl | 5, Pl. 1 |
| 200 | Diamond Valley | — | [3]153 N20 E53 30ABCC2 | — | 64518 | 39.5708 | 116.0434 | 5,990.81 | 170 | 99.8 | 04/11/2012 | Wl | 5, Pl. 1 |
| 201 | Diamond Valley | [2]393422116042501 | — | — | 108033 | 39.5731 | 116.0727 | 5,983.8 | 181 | 44.52 | 03/27/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 202 | Diamond Valley | [2]393422116042502 | — | — | 108033 | 39.5731 | 116.0727 | 5,983.8 | 101 | 44.36 | 03/27/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 203 | Diamond Valley | 393440116001901 | [3]153 N20 E53 21CDDC1 | — | 7993 | 39.5746 | 116.0048 | 5,980.97 | 248 | 188.4 | 04/11/2012 | Wl | 5, Pl. 1 |
| 204 | Diamond Valley | [2]393500115580500 | — | — | — | 39.5833 | 115.9689 | 6,025 | — | — | — | Qw | 5, 8 |
| 205 | Diamond Valley | — | [3]153 N20 E53 20BC 01 | — | 113748 | 39.585 | 116.0288 | 5,954 | 425 | 162.3 | 04/11/2012 | Wl | 5, Pl. 1 |
| 206 | Diamond Valley | [2]393509116000301 | — | [5]20/53-21ad | 6116 | 39.5858 | 116.0017 | 5,979.04 | 213 | — | — | Qw, Wl | 5, 8 |
| 207 | Diamond Valley | 393519115592401 | [3]153 N20 E53 15CDDD1 | — | 8231 | 39.5885 | 115.9909 | 5,997.38 | 398 | 218 | 04/11/2012 | Wl | 5, Pl. 1 |
| 208 | Diamond Valley | [2]393536116015801 | — | [5]20/53-17cc | 8721 | 39.5891 | 116.037 | 5,952 | 175 | — | — | Qw, Wl | 5, 8 |
| 209 | Diamond Valley | — | [3]153 N20 E53 10DDDD2 | — | 103683 | 39.603 | 115.9814 | 5,958 | 340 | 176.5 | 04/11/2012 | Wl | 5, Pl. 1 |
| 210 | Diamond Valley | 393623115593301 | [3]153 N20 E53 10CACC1 | — | 7402 | 39.6066 | 115.9951 | 5,944.88 | 214 | 161.04 | 04/11/2012 | Wl | 5, Pl. 1 |
| 211 | Diamond Valley | — | [3]153 N20 E53 10BACC1 | — | 7401 | 39.6138 | 115.9951 | 5,938.32 | 214 | 151.64 | 04/11/2012 | Wl | 5, Pl. 1 |

**Table 5.** Location and general information for groundwater-measurment sites, Diamond Valley flow system, central Nevada.—Continued

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. mm/dd/yyyy, month/day/year; BLS, below land surface; —, no data; Qw, water quality; Pl., Plate; Wl, water level]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Nevada State station identifier | Other station identifier | Nevada State well log number | Latitude (degrees) | Longitude (degrees) | Land-surface altitude (feet) | Well depth (feet) | Water level BLS[1] (feet) | Date measured (mm/dd/yyyy) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 212 | Diamond Valley | 393705115574201 | [3]153 N20 E53 02DDDD1 | — | 8114 | 39.6174 | 115.9628 | 5,974.41 | 250 | 183.35 | 04/17/2012 | Wl | 5, Pl. 1 |
| 213 | Diamond Valley | [2]393710115584000 | — | — | — | 39.6194 | 115.9787 | 5,942 | — | — | — | Qw | 5, 8 |
| 214 | Diamond Valley | [2]393714116000301 | — | [5]20/53- 4dd | 6152 | 39.621 | 116.0048 | 5,932 | 177 | — | — | Qw, Wl | 5, 8 |
| 215 | Diamond Valley | — | [3]153 N20 E53 04DDBB2 | — | 90746 | 39.6215 | 116.0048 | 5,934 | 460 | 142.3 | 04/11/2012 | Wl | 5, Pl. 1 |
| 216 | Diamond Valley | [2]393720115585000 | — | — | — | 39.6221 | 115.9814 | 5,942 | — | — | — | Qw | 5, 8 |
| 217 | Diamond Valley | [2]393724115580201 | — | [5]21/53-2ac | — | 39.628 | 115.9673 | 5,936 | 220 | — | — | Qw, Wl | 5, 8 |
| 218 | Diamond Valley | 393731115570301 | [3]153 N20 E53 01BDDA2 | [5]20/53- 1ac | 5542 | 39.6308 | 115.9548 | 5,954.72 | 173 | 168.1 | 04/01/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 219 | Diamond Valley | [2]393814115565700 | — | — | — | 39.6371 | 115.9501 | 5,950 | — | — | — | Qw | 5, 8 |
| 220 | Diamond Valley | [2]393818116002401 | — | [5]21/53-33da | 6156 | 39.6383 | 116.0076 | 5,931.03 | 112 | — | — | Qw, Wl | 5, 8 |
| 221 | Diamond Valley | — | [3]153 N21 E53 34DDB 02 | — | 71737 | 39.6398 | 115.988 | 5,924 | 236 | 139.67 | 04/11/2012 | Wl | 5, Pl. 1 |
| 222 | Diamond Valley | 393844115570601 | [3]153 N21 E53 36AD 1 | — | 6550 | 39.6435 | 115.9471 | 5,948.16 | 300 | 163.1 | 04/11/2012 | Wl | 5, Pl. 1 |
| 223 | Diamond Valley | [2]393842115572201 | — | [5]21/53-36ac | 7286 | 39.6449 | 115.9514 | 5,942.14 | 300 | — | — | Qw, Wl | 5, 8 |
| 224 | Diamond Valley | — | [3]153 N21 E53 35BDBB2 | — | 76990 | 39.6469 | 115.9795 | 5,921 | 362 | 139.3 | 04/11/2012 | Wl | 5, Pl. 1 |
| 225 | Diamond Valley | — | [3]153 N21 E53 33AACC2 | — | — | 39.6471 | 116.007 | 5,928 | — | 140 | 04/11/2012 | Wl | 5, Pl. 1 |
| 226 | Diamond Valley | [2]393915116011001 | — | [5]21/53-28cc | 7652 | 39.6541 | 116.0159 | 5,946 | 186 | — | — | Qw, Wl | 5, 8 |
| 227 | Diamond Valley | [2]393928116051301 | — | — | — | 39.6577 | 116.087 | 6,426 | — | 4.55 | 05/22/2012 | Wl | 5, Pl. 1 |
| 228 | Diamond Valley | 393942116005401 | [3]153 N21 E53 28BBDD1 | — | 8151 | 39.6611 | 116.0161 | 5,944.88 | 185 | 175.1 | 04/11/2012 | Wl | 5, Pl. 1 |
| 229 | Diamond Valley | — | [3]153 N21 E53 27ACAA3 | — | 86190 | 39.6615 | 115.989 | 5,912 | 355 | 137.57 | 04/11/2012 | Wl | 5, Pl. 1 |
| 230 | Diamond Valley | 393956115571101 | [3]153 N21 E53 24CDDD1 | — | 7941 | 39.6655 | 115.9556 | 5,918.64 | 280 | 146.8 | 04/11/2012 | Wl | 5, Pl. 1 |
| 231 | Diamond Valley | 393958115552701 | [3]153 N21 E54 20CCCC1 | — | 6633 | 39.6663 | 115.9264 | 5,935.04 | 230 | 166.3 | 04/12/2012 | Wl | 5, Pl. 1 |
| 232 | Diamond Valley | — | [3]153 N21 E53 21DCAA2 | — | 7208, 109421 | 39.6688 | 116.0067 | 5,919 | 280 | 144.2 | 04/11/2012 | Wl | 5, Pl. 1 |
| 233 | Diamond Valley | 393956115581801 | [3]153 N21 E53 23DACC1 | — | 5544 | 39.669 | 115.9692 | 5,911 | 166 | 142.9 | 04/11/2012 | Wl | 5, Pl. 1 |
| 234 | Diamond Valley | [2]394029116002401 | | [5]21/53-21ad | 6153 | 39.6746 | 116.0076 | 5,910.05 | 182 | — | — | Qw, Wl | 5, 8 |
| 235 | Diamond Valley | — | [3]153 N21 E53 20AACC2 | — | 108792 | 39.6752 | 116.0252 | 5,926 | 510 | 166.1 | 04/11/2012 | Wl | 5, Pl. 1 |
| 236 | Diamond Valley | [2]394025115571701 | 153 N21 E53 24ADBB1 | — | 6287 | 39.6758 | 115.9595 | 5,902 | 186 | 132.8 | 04/11/2012 | Wl | 5, Pl. 1 |
| 237 | Diamond Valley | — | [3]153 N21 E53 22BDBB2 | — | 14340 | 39.676 | 115.997 | 5,908.79 | 210 | 139.3 | 04/11/2012 | Wl | 5, Pl. 1 |
| 238 | Diamond Valley | — | [3]153 N21 E53 23AACC1 | — | 16585 | 39.6763 | 115.9687 | 5,905.51 | 350 | 141.1 | 04/11/2012 | Wl | 5, Pl. 1 |
| 239 | Diamond Valley | — | [3]153 N21 E54 20BACC2 | — | 107013 | 39.6766 | 115.922 | 5,925 | 500 | 162.45 | 04/12/2012 | Wl | 5, Pl. 1 |
| 240 | Diamond Valley | [2]394049115535901 | | [5]21/54-16cd | 7324 | 39.6808 | 115.9012 | 5,984 | 240 | — | — | Qw, Wl | 5, 8 |
| 241 | Diamond Valley | — | [3]153 N21 E53 16CCAA3 | — | 31823 | 39.6833 | 116.0159 | 5,915.35 | 253 | 149.75 | 04/11/2012 | Wl | 5, Pl. 1 |
| 242 | Diamond Valley | — | [3]153 N21 E53 14CACC2 | — | 18082 | 39.6835 | 115.9781 | 5,902.23 | 385 | 136.05 | 04/11/2012 | Wl | 5, Pl. 1 |
| 243 | Diamond Valley | 394058115565701 | [3]153 N21 E53 13DA 1 | [5]21/53-13da | 6630 | 39.6835 | 115.9503 | 5,898.95 | 250 | 132.6 | 04/11/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 244 | Diamond Valley | [2]394112116032301 | — | — | — | 39.6868 | 116.0574 | 5,935.1 | — | 130.79 | 04/20/2012 | Wl | 5, Pl. 1 |

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**Table 5.** Location and general information for groundwater-measurment sites, Diamond Valley flow system, central Nevada.—Continued

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. mm/dd/yyyy, month/day/year; BLS, below land surface; —, no data; Qw, water quality; Pl., Plate; Wl, water level]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Nevada State station identifier | Other station identifier | Nevada State well log number | Latitude (degrees) | Longitude (degrees) | Land-surface altitude (feet) | Well depth (feet) | Water level BLS[1] (feet) | Date measured (mm/dd/yyyy) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 245 | Diamond Valley | — | [3]153 N21 E53 15BACC2 | — | 31821 | 39.6908 | 115.997 | 5,898.95 | 414 | 132.5 | 04/12/2012 | Wl | 5, Pl. 1 |
| 246 | Diamond Valley | 394141115552601 | [3]153 N21 E54 08CDDD1 | — | 8061 | 39.6952 | 115.9178 | 5,892.39 | 203 | 130.8 | 04/12/2012 | Wl | 5, Pl. 1 |
| 247 | Diamond Valley | — | [3]153 N21 E53 12CCBC2 | — | 103817 | 39.6961 | 115.9641 | 5,897 | 425 | 129.7 | 04/12/2012 | Wl | 5, Pl. 1 |
| 248 | Diamond Valley | — | [3]153 N21 E53 08DCAA1 | — | 6669 | 39.6977 | 116.0253 | 5,898.95 | 184 | 131.3 | 04/12/2012 | Wl | 5, Pl. 1 |
| 249 | Diamond Valley | 394149116003201 | [3]153 N21 E53 09DBDD1 | — | 6149 | 39.698 | 116.0064 | 5,895.67 | 182 | 126.25 | 04/12/2012 | Wl | 5, Pl. 1 |
| 250 | Diamond Valley | — | [3]153 N21 E53 11CDBB2 | — | 18083 | 39.698 | 115.9781 | 5,895.67 | 406 | 129.7 | 04/12/2012 | Wl | 5, Pl. 1 |
| 251 | Diamond Valley | — | [3]153 N21 E53 12DCAA2 | — | 105354 | 39.6982 | 115.9511 | 5,894 | 380 | 127.8 | 04/12/2012 | Wl | 5, Pl. 1 |
| 252 | Diamond Valley | [2]394220116055002 | — | — | 108031 | 39.705 | 116.0987 | 6,098.1 | 375 | 267.03 | 04/20/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 253 | Diamond Valley | [2]394220116055001 | — | — | 108031 | 39.705 | 116.0987 | 6,098.1 | 499 | 270.8 | 04/20/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 254 | Diamond Valley | — | [3]153 N21 E53 08BACC1 | — | 16175 | 39.7052 | 116.0345 | 5,895.67 | 294 | 125.45 | 04/12/2012 | Wl | 5, Pl. 1 |
| 255 | Diamond Valley | — | [3]153 N21 E53 09BBDD2 | — | 49701 | 39.7052 | 116.0159 | 5,895.67 | 373 | 121.2 | 04/11/2012 | Wl | 5, Pl. 1 |
| 256 | Diamond Valley | 394232115572701 | [3]153 N21 E53 01CDCC2 | — | 6155, 12396 | 39.7089 | 115.9592 | 5,892.39 | 182 | 123.8 | 04/12/2012 | Wl | 5, Pl. 1 |
| 257 | Diamond Valley | 394232115545701 | [3]153 N21 E54 05DCCC1 | — | 6641, 13799 | 39.7094 | 115.917 | 5,879.27 | 360 | 118.2 | 04/12/2012 | Wl | 5, Pl. 1 |
| 258 | Diamond Valley | [2]394238115593301 | — | [5]21/53-3db | 6166 | 39.7119 | 115.9876 | 5,888 | 182 | — | — | Qw, Wl | 5, 8 |
| 259 | Diamond Valley | [2]394230115594401 | — | [5]21/53-3cd | 8149 | 39.7121 | 115.997 | 5,891 | 182 | — | — | Qw, Wl | 5, 8 |
| 260 | Diamond Valley | — | [3]153 N21 E53 03CDBB2 | — | 88101 | 39.7123 | 115.9971 | 5,889.11 | 400 | 119.08 | 04/12/2012 | Wl | 5, Pl. 1 |
| 261 | Diamond Valley | — | [3]153 N21 E53 06CDBB2 | — | 29955 | 39.7124 | 116.0531 | 5,879.27 | 353 | 108.78 | 04/12/2012 | Wl | 5, Pl. 1 |
| 262 | Diamond Valley | — | [3]153 N21 E53 04CDBB1 | — | 7425 | 39.7124 | 116.0159 | 5,889.11 | 188 | 115.52 | 04/12/2012 | Wl | 5, Pl. 1 |
| 263 | Diamond Valley | 394232115584201 | [3]153 N21 E53 02CCAA1 | — | 6061 | 39.7124 | 115.9784 | 5,889.11 | 182 | 120 | 04/12/2012 | Wl | 5, Pl. 1 |
| 264 | Diamond Valley | [2]394240116021101 | — | [5]21/53- 5cb | — | 39.7144 | 116.0373 | 5,883.01 | — | — | — | Qw, Wl | 5, 8 |
| 265 | Diamond Valley | [2]394240115532901 | — | [5]21/54-4ad | 981 | 39.718 | 115.8923 | 5,904.13 | 73 | — | — | Qw, Wl | 5, 8 |
| 266 | Diamond Valley | 394310115594702 | [3]153 N21 E53 03BBDD2 | — | 9743 | 39.7194 | 115.9973 | 5,885.83 | 198 | 114.85 | 04/12/2012 | Wl | 5, Pl. 1 |
| 267 | Diamond Valley | 394248115572701 | [3]153 N21 E53 01BCAA1 | — | 6721 | 39.7199 | 115.9595 | 5,885.83 | 210 | 115.35 | 04/12/2012 | Wl | 5, Pl. 1 |
| 268 | Diamond Valley | 394312115551601 | [3]153 N21 E54 05BDBB1 | — | 7700 | 39.7202 | 115.9217 | 5,875.98 | 150 | 108.25 | 04/12/2012 | Wl | 5, Pl. 1 |
| 269 | Diamond Valley | — | [3]153 N21 E52 04BBAA1 | — | 106991 | 39.7202 | 116.1293 | 6,545.28 | 318 | 56.47 | 05/30/2012 | Wl | 5, Pl. 1 |
| 270 | Diamond Valley | [2]394301115593301 | — | [5]21/53- 3ab | 6060 | 39.7221 | 115.9912 | 5,886.07 | 182 | — | — | Qw, Wl | 5, 8 |
| 271 | Diamond Valley | — | [3]153 N21HE54 32DCC 2 | — | 108134 | 39.7244 | 115.9159 | 5,877 | 540 | 107.4 | 04/12/2012 | Wl | 5, Pl. 1 |
| 272 | Diamond Valley | — | [3]153 N21HE54 34CCD 1 | — | 103695 | 39.7249 | 115.8841 | 5,903 | 475 | 139.8 | 04/11/2012 | Wl | 5, Pl. 1 |
| 273 | Diamond Valley | [2]394342114385402 | 153 N21HE52 35ADD 2 | — | 24865 | 39.7304 | 116.0723 | 5,889.7 | 160 | 100.6 | 04/20/2012 | Wl | 5, Pl. 1 |
| 274 | Diamond Valley | 394416115542201 | [3]153 N22 E54 32DDCD1 | — | 7423 | 39.7369 | 115.9109 | 5,869.42 | 250 | 94.7 | 04/12/2012 | Wl | 5, Pl. 1 |
| 275 | Diamond Valley | [2]394413115574601 | — | [5]22/53-36cc | — | 39.7369 | 115.9637 | 5,876 | 56 | — | — | Qw, Wl | 5, 8 |
| 276 | Diamond Valley | [2]394416116014201 | — | [5]22/53-32ca | — | 39.7377 | 116.0292 | 5,871 | 45 | — | — | Qw, Wl | 5, 8 |
| 277 | Diamond Valley | 394439115552901 | [3]153 N22 E54 32BCCC1 | — | 14490 | 39.7441 | 115.9259 | 5,866.14 | 259 | 88.9 | 04/14/2011 | Wl | 5, Pl. 1 |

**Table 5.** Location and general information for groundwater-measurments sites, Diamond Valley flow system, central Nevada.—Continued

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. mm/dd/yyyy, month/day/year; BLS, below land surface; —, no data; Qw, water quality; Pl., Plate; Wl, water level]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Nevada State station identifier | Other station identifier | Nevada State well log number | Latitude (degrees) | Longitude (degrees) | Land-surface altitude (feet) | Well depth (feet) | Water level BLS[1] (feet) | Date measured (mm/dd/yyyy) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 278 | Diamond Valley | 394452115540801 | [3]153 N22 E54 33BBDD1 | — | 7291 | 39.7477 | 115.9026 | 5,862.86 | 300 | 90.7 | 04/12/2012 | Wl | 5, Pl. 1 |
| 279 | Diamond Valley | [2]394431115520601 | — | [5]22/54-34ab | — | 39.7516 | 115.8764 | 5,889 | 50 | — | — | Qw, Wl | 5, 8 |
| 280 | Diamond Valley | — | [3]153 N22 E54 28DCCC2 | — | 39256 | 39.7516 | 115.897 | 5,862.86 | 315 | 86.68 | 04/12/2012 | Wl | 5, Pl. 1 |
| 281 | Diamond Valley | [2]394512116031001 | — | [5]22/53-30cc | — | 39.7533 | 116.0537 | 5,863 | 45 | — | — | Qw, Wl | 5, 8 |
| 282 | Diamond Valley | 394542115533001 | [3]153 N22 E54 28AACC1 | — | 4389 | 39.7621 | 115.8931 | 5,856.3 | 184 | 84.32 | 04/12/2012 | Wl | 5, Pl. 1 |
| 283 | Diamond Valley | [2]394545115585801 | — | [5]22/53-27aa | — | 39.7624 | 115.9837 | 5,863 | 22 | — | — | Qw, Wl | 5, 8 |
| 284 | Diamond Valley | 394558115525801 | [3]153 N22 E54 22CCDD1 | — | 7157 | 39.766 | 115.8848 | 5,859.58 | 120 | 84.26 | 04/12/2012 | Wl | 5, Pl. 1 |
| 285 | Diamond Valley | — | [3]153 N22 E54 19DC 01 | — | 91852 | 39.7663 | 115.9349 | 5,856 | 285 | 70.95 | 04/12/2012 | Wl | 5, Pl. 1 |
| 286 | Diamond Valley | — | [3]153 N22 E52 20CBDC1 | — | 99132 | 39.7698 | 116.1446 | 6,374.91 | 60 | 51.6 | 05/30/2012 | Wl | 5, Pl. 1 |
| 287 | Diamond Valley | — | [3]153 N22 E52 19CBBC1 | — | 99116 | 39.7716 | 116.1656 | 6,464.44 | 125 | 47.12 | 05/30/2012 | Wl | 5, Pl. 1 |
| 288 | Diamond Valley | [2]394611115525101 | — | [5]22/54-22bd | 6726 | 39.7763 | 115.8792 | 5,867 | 200 | — | — | Qw, Wl | 5, 8 |
| 289 | Diamond Valley | 394653116075201 | [3]153 N22 E52 17DDCA1 | — | 15462 | 39.7814 | 116.1321 | 6,142.98 | 175 | 31.31 | 05/30/2012 | Wl | 5, Pl. 1 |
| 290 | Diamond Valley | [2]394654116073801 | 153 N22 E52 16CCCB1 | — | — | 39.7815 | 116.1279 | 6,126.46 | — | 28.67 | 04/20/2012 | Wl | 5, Pl. 1 |
| 291 | Diamond Valley | 394703115560401 | [3]153 N22 E54 18CADD1 | — | 6639 | 39.7841 | 115.9356 | 5,849.74 | 258 | 64.15 | 04/12/2012 | Wl | 5, Pl. 1 |
| 292 | Diamond Valley | [2]394613115553701 | — | [5]22/54-18db | — | 39.7846 | 115.9339 | 5,852 | 222 | — | — | Qw, Wl | 5, 8 |
| 293 | Diamond Valley | — | [3]153 N22 E52 18CBDD1 | — | 105632 | 39.7848 | 116.1614 | 6,587.21 | 1,058 | 180.86 | 05/30/2012 | Wl | 5, Pl. 1 |
| 294 | Diamond Valley | — | [3]153 N22 E52 18CBDD2 | — | 105633 | 39.7848 | 116.1613 | 6,586.75 | 456 | 50.98 | 05/30/2012 | Wl | 5, Pl. 1 |
| 295 | Diamond Valley | — | [3]153 N22 E51H13DADB1 | — | 99130 | 39.7851 | 116.1668 | 6,728.4 | 120 | 92.86 | 05/30/2012 | Wl | 5, Pl. 1 |
| 296 | Diamond Valley | — | [3]153 N22 E51 12ADCD1 | — | 99717, 99718 | 39.7868 | 116.1797 | 7,075.28 | 199 | 138.55 | 05/30/2012 | Wl | 5, Pl. 1 |
| 297 | Diamond Valley | — | [3]153 N22 E52 18ACDB1 | — | 105635 | 39.7891 | 116.154 | 6,398.96 | 425 | 14.55 | 50/30/2012 | Wl | 5, Pl. 1 |
| 298 | Diamond Valley | [2]394729116011201 | — | [5]22/53-17aa | — | 39.7913 | 116.0189 | 5,850 | 22 | — | — | Qw, Wl | 5, 8 |
| 299 | Diamond Valley | [2]394717116044901 | — | — | 78983 | 39.7926 | 116.0776 | 5,866.7 | 83 | 72.83 | 04/20/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 300 | Diamond Valley | 394743115554302 | [3]153 N22 E54 07DDCD2 | — | 5416 | 39.7949 | 115.9292 | 5,846.46 | 107 | 48.7 | 04/12/2012 | Wl | 5, Pl. 1 |
| 301 | Diamond Valley | [2]394806115541701 | — | [5]22/54-8dd | — | 39.796 | 115.9109 | 5,846 | 150 | — | — | Qw, Wl | 5, 8 |
| 302 | Diamond Valley | — | [3]153 N22 E51 01DBBB1 | — | 106421 | 39.8007 | 116.1864 | 7,743.25 | 1,000 | 409.52 | 06/06/2012 | Wl | 5, Pl. 1 |
| 303 | Diamond Valley | — | [3]153 N22 E51 01DBBB2 | — | 106718 | 39.8007 | 116.1864 | 7,743.25 | 855 | 524.02 | 06/06/2012 | Wl | 5, Pl. 1 |
| 304 | Diamond Valley | — | [3]153 N22 E51H12DBBC1 | — | 107046 | 39.8008 | 116.1712 | 6,976.42 | 1,000 | 297.37 | 06/06/2012 | Wl | 5, Pl. 1 |
| 305 | Diamond Valley | — | [3]153 N22 E52 07DBBD2 | — | 105630 | 39.8009 | 116.1552 | 6,467.14 | 588 | 43.95 | 05/30/2012 | Wl | 5, Pl. 1 |
| 306 | Diamond Valley | — | [3]153 N22 E52 07DBBD1 | — | 105631 | 39.801 | 116.1552 | 6,467.44 | 1,038 | 158.42 | 05/30/2012 | Wl | 5, Pl. 1 |
| 307 | Diamond Valley | — | [3]153 N22 E52 11ACCB1 | — | 99127 | 39.8034 | 116.081 | 5,897.51 | 125 | 106.15 | 05/30/2012 | Wl | 5, Pl. 1 |
| 308 | Diamond Valley | 394835115561801 | [3]153 N22 E54 06CCCC1 | — | 7975 | 39.8096 | 115.9406 | 5,843.18 | 250 | 51.5 | 04/12/2012 | Wl | 5, Pl. 1 |
| 309 | Diamond Valley | — | [3]153 N22 E54 05DDBB2 | — | 93218 | 39.8125 | 115.9119 | 5,839 | 500 | 49.42 | 04/12/2012 | Wl | 5, Pl. 1 |
| 310 | Diamond Valley | — | [3]153 N22 E54 05CDBB2 | — | 76995 | 39.8129 | 115.9212 | 5,839 | 475 | 48.8 | 04/12/2012 | Wl | 5, Pl. 1 |

**Table 5.** Location and general information for groundwater-measurments sites, Diamond Valley flow system, central Nevada.—Continued

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. mm/dd/yyyy, month/day/year; BLS, below land surface; —, no data; Qw, water quality; Pl., Plate; Wl, water level]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Nevada State station identifier | Other station identifier | Nevada State well log number | Latitude (degrees) | Longitude (degrees) | Land-surface altitude (feet) | Well depth (feet) | Water level BLS[1] (feet) | Date measured (mm/dd/yyyy) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 311 | Diamond Valley | — | [3]153 N23 E51 36ACDC1 | — | 99129 | 39.816 | 116.1837 | 6,798.07 | 460 | Flowing | 05/30/2012 | Wl | 5, Pl. 1 |
| 312 | Diamond Valley | [2]394920115584801 | — | [5]23/53-34dd | — | 39.8221 | 115.9809 | 5,836.04 | 22 | — | — | Qw, Wl | 5, 8 |
| 313 | Diamond Valley | [2]394903115565801 | — | [5]22/53-1aa | — | 39.8233 | 115.9426 | 5,839 | 22 | — | — | Qw, Wl | 5, 8 |
| 314 | Diamond Valley | — | [3]153 N23 E54 32CDD 01 | — | 39813 | 39.8246 | 115.913 | 5,834 | 493 | 43 | 04/12/2012 | Wl | 5, Pl. 1 |
| 315 | Diamond Valley | [2]395003116030101 | — | — | 106999 | 39.8341 | 116.0503 | 5,817.1 | 59 | 22.74 | 04/20/2012 | Wl | 5, Pl. 1 |
| 316 | Diamond Valley | — | [3]153 N23 E54 29CDDD2 | — | — | 39.8385 | 115.9131 | 5,830.05 | — | 37.4 | 04/12/2012 | Wl | 5, Pl. 1 |
| 317 | Diamond Valley | [2]395020116030001 | 153 N23 E53 29CCCA1 | [5]23/53-30dd | — | 39.839 | 116.033 | 5,820 | 22 | 17.26 | 03/20/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 318 | Diamond Valley | [2]395021115540901 | — | [5]23/54-29dd | 7862 | 39.8391 | 115.9034 | 5,834 | 320 | — | — | Qw, Wl | 5, 8 |
| 319 | Diamond Valley | — | [3]153 N23 E54 30DDD 2 | — | 69258 | 39.8391 | 115.9237 | 5,826.77 | 452 | 37.5 | 04/12/2012 | Wl | 5, Pl. 1 |
| 320 | Diamond Valley | — | [3]153 N23 E54 27ACC 1 | — | — | 39.843 | 115.8734 | 5,830.05 | — | 68.7 | 04/12/2012 | Wl | 5, Pl. 1 |
| 321 | Diamond Valley | [2]395100115593001 | 153 N23 E53 27BB 1 | [5]23/53-27bb | — | 39.8509 | 115.9955 | 5,826 | 22 | 16.09 | 03/20/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 322 | Diamond Valley | — | [3]153 N23 E54 20DD 1 | — | 7834 | 39.8527 | 115.9045 | 5,823.49 | 245 | 27.51 | 04/12/2012 | Wl | 5, Pl. 1 |
| 323 | Diamond Valley | [2]395147116043901 | — | — | — | 39.8683 | 116.0651 | 5,804 | — | 17.3 | 12/13/2012 | Wl | 5, Pl. 1 |
| 324 | Diamond Valley | [2]395156116043901 | — | [5]23/52-13ca | — | 39.8719 | 116.0667 | 5,813.92 | — | — | — | Qw | 5, 8 |
| 325 | Diamond Valley | [2]395220115561001 | — | — | — | 39.8721 | 115.9282 | 5,800 | 32 | 15.6 | 03/20/2012 | Wl | 5, Pl. 1 |
| 326 | Diamond Valley | — | [3]153 N23 E52 13BBA 1 | — | 90915 | 39.8806 | 116.0675 | 5,818 | 360 | 19.85 | 04/12/2012 | Wl | 5, Pl. 1 |
| 327 | Diamond Valley | [2]395255116051101 | — | — | — | 39.891 | 116.0726 | 5,805 | 98 | 10.68 | 12/13/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 328 | Diamond Valley | [2]395441116040501 | — | — | — | 39.9113 | 116.069 | 5,810 | — | 14.49 | 12/13/2012 | Wl | 5, Pl. 1 |
| 329 | Diamond Valley | — | [3]153 N24 E53 06BDAB1 | — | 5527 | 39.993 | 116.0412 | 5,800.52 | 175 | 8.3 | 04/12/2012 | Wl | 5, Pl. 1 |
| 330 | Diamond Valley | [2]395914116023301 | — | [5]24/53-6ac | — | 39.9952 | 116.0403 | 5,792 | 190 | — | — | Qw | 5, 8 |
| 331 | Diamond Valley | 400116115534801 | [3]153 N25 E54 28BCBC1 | [5]25/54-28bc | 1349 | 40.0209 | 115.8979 | 5,813.65 | 55 | 14.1 | 04/12/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 332 | Diamond Valley | [2]400426116015001 | — | [5]25/53-5cb2 | 943 | 40.0735 | 116.0267 | 5,838.9 | 131 | — | — | Qw, Wl | 5, 8 |
| 333 | Diamond Valley | [2]400726115525901 | — | [5]26/54-15cd | — | 40.1302 | 115.8806 | 5,788 | 10 | 6.03 | 04/08/1966 | Qw, Wl | 5, 8, Pl. 1 |
| 334 | Diamond Valley | [2]400834115564401 | — | — | — | 40.1474 | 115.9465 | 5,786.81 | 13 | 8.5 | 04/08/1966 | Wl | 5, Pl. 1 |
| 335 | Northern Little Smoky Valley | [2]390753116051701 | — | — | — | 39.1236 | 116.0871 | 6,443.3 | 500 | 383.51 | 12/14/2012 | Wl | 5, Pl. 1 |
| 336 | Northern Little Smoky Valley | [2]390734116013101 | — | — | 2405 | 39.1263 | 116.026 | 6,233.4 | 300 | 218.8 | 12/14/2012 | Wl | 5, Pl. 1 |
| 337 | Northern Little Smoky Valley | [2]391037116040001 | — | — | — | 39.1772 | 116.0675 | 6,404.9 | 467 | 347.46 | 04/06/2011 | Wl | 5, Pl. 1 |
| 338 | Northern Little Smoky Valley | [2]384048114341001 | — | — | — | 39.2103 | 116.0373 | 6,179.7 | 166 | 136.45 | 12/14/2012 | Qw, Wl | 5, 8, Pl. 1 |
| 339 | Pine Valley | [2]395036116111801 | — | — | 1036 | 39.8433 | 116.1892 | 6,604 | 60 | 10 | 08/05/1949 | Wl | 5, Pl. 1 |
| 340 | Pine Valley | [2]395330116122001 | — | — | 117015 | 39.8918 | 116.2056 | 6,548 | 120 | 14.75 | 06/06/2012 | Wl | 5, Pl. 1 |
| 341 | Pine Valley | [2]395355116094501 | — | — | — | 39.8987 | 116.1626 | 6,276 | 53 | 16.94 | 06/06/2012 | Wl | 5, Pl. 1 |

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**Table 5.** Location and general information for groundwater-measurments sites, Diamond Valley flow system, central Nevada.—Continued

[Latitude and longitude values are in the North American Datum 1983. Altitude values are in the North American Vertical Datum 1988. mm/dd/yyyy, month/day/year; BLS, below land surface; —, no data; Qw, water quality; Pl., Plate; Wl, water level]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Nevada State station identifier | Other station identifier | Nevada State well log number | Latitude (degrees) | Longitude (degrees) | Land-surface altitude (feet) | Well depth (feet) | Water level BLS[1] (feet) | Date measured (mm/dd/yyyy) | Available data | Figure(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 342 | Pine Valley | [2]400015116142501 | — | — | 9349 | 40.0041 | 116.2412 | 5,804 | 195 | 134.12 | 08/15/2006 | Wl | 5, Pl. 1 |
| 343 | Pine Valley | [2]400026116114801 | — | — | 4249 | 40.0071 | 116.1976 | 5,814 | 69 | 24.95 | 04/28/1982 | Wl | 5, Pl. 1 |
| 344 | Diamond Valley | [2]395008116040701 | — | — | — | 39.8356 | 116.0694 | 5,823.6 | — | 34.03 | 12/13/2012 | Wl | 5, Pl. 1 |

[1]Water-level values used to determine contours on plate.

[2]Latitude, longitude, and altitude values are from the USGS National Water Information System (*http://waterdata.usgs.gov/nwis*).

[3]Latitude, longitude, and altitude values are from the State of Nevada Division of Water Resources Database (*http://water.nv.gov/data/waterlevel*).

[4]Site name published *in* Rush, F.E., and Everett, D.E., 1964, Groundwater appraisal of Monitor, Antelope, and Kobeh Valleys, Nevada: Nevada Department of Conservation and Natural Resources, Ground-Water Resources-Reconnaissance Report 30, 45 p. (*http://images.water.nv.gov/images/publications/Recon%20Reports/rpt30 -monitor_antelope_kobeh_valley.pdf*).

[5]Site name published *in* Harrill, J., 1968, Hydrologic response to irrigation pumping in Diamond Valley, Eureka and Elko Counties, Nevada, 1950–65: State of Nevada, Department of Conservation and Natural Resources, Nevada Department of Conservation and Natural Resources, Water Resources Bulletin 35, 85 p. (*http://images.water.nv.gov/images/publications/water%20resources%20bulletins/Bulletin35.pdf*).

spring complex. With the exception of potential outflow from the southern part of Antelope Valley, groundwater from southern and northern Monitor and Antelope Valleys moves northward toward Kobeh Valley and eastward from Kobeh Valley towards Devil's Gate (plate 1). Devil's Gate is a narrow canyon cut into carbonate rock south of Whistler Mountain and restricts groundwater flow into Diamond Valley. Residual groundwater flow (in excess of that discharged by ET) from valleys upgradient of Diamond Valley converge west of Devil's Gate in Kobeh Valley and flow into the south part of Diamond Valley. Digital Geographic Information System (GIS) data representing the groundwater-level contours shown on plate 1 are described in appendix 1.

# Chemical Characterization of Groundwater

The chemical composition of groundwater is influenced primarily by the mineral makeup of the hydrogeologic units through which the water flows. Weathering and dissolution of these minerals provides a record in the major-ion chemical composition of groundwater, which can be used to characterize groundwater and evaluate flow paths. Stable isotopes of oxygen-18 and deuterium in precipitation and groundwater also can aid with evaluating the groundwater source and its evolution along a flow path.

Groundwater in basin-fill aquifers in the DVFS was characterized on the basis of water samples from 14 valley springs and from 76 wells representing the upper 250 ft of the aquifer (fig. 8; table 6). All spring and well sites were sampled for major-ion chemistry, and a subset of 32 sites were sampled for stable isotopes. Of the 90 sites sampled, 21 were sampled in 2008 (Knochenmus and others, 2011), and 11 were sampled between late 2010 and 2012. A spring sample from Garden Valley (site 62) and a groundwater sample from Antelope Valley (site 96) were collected in 2008 and again in 2012 (fig. 8; table 6). Major-ions at site 62 were stable between 2008 and 2012 (coefficient of variation within 6 percent), but decreased at site 96 over the same period (coefficient of variation within 36 percent). In addition to groundwater samples, 21 precipitation samples were collected from bulk precipitation collectors co-located with the 4 ET sites (sites 1–4; fig. 2; table 6) and were analyzed for stable isotopes. Appendix 2 provides details about the laboratories used for the chemical analysis and about quality-assurance protocols and analyses used during the 2010–12 sampling events.

To expand spatial coverage in the study area, samples from 60 additional sites reported in previous investigations, the majority of which were in southern Diamond Valley, were incorporated in this analysis (Rush and Everett, 1964; Harrill, 1968; U.S. Geological Survey National Water Information System database (*http://waterdata.usgs.gov/nwis*). Well-construction information related to the sites of these historical samples was often unavailable; therefore, evaluation of chemical gradients between neighboring wells with more recent samples was limited because the different chemical compositions could be related to sampling depth. Sites 125 and 321 in Kobeh Valley and Diamond Valley, respectively, were sampled in the mid-1960s and again in 2008 (table 6), however. Comparisons indicated that most major-ion concentrations from these two sites remained relatively consistent from the mid-1960s to 2008 (coefficient of variation within 23 percent) and that the use of older samples in the recent chemical characterization was appropriate. At site 321, an increase in calcium and decrease in sulfate concentrations (coefficient of variation 38 and 77 percent, respectively) was observed between the datasets. Given the extended length of time between collecting the sample, it is unclear if the changes in calcium and sulfate are valid, or if sampling, analytical laboratory techniques, or both could have contributed to the differences. Groundwater pumping also has caused substantial groundwater-level declines in areas near many of the historical water-chemistry sampling sites in southern Diamond Valley; however, the 1960s data provide the best water-chemistry dataset available for the area.

## Major-Ion Chemistry

The chemical signature of groundwater reflects general hydrogeologic-unit mineralogy and can be used to infer groundwater flow paths. In the DVFS, major-ion chemistry was used to group groundwater samples into water types and to evaluate groundwater evolution. Groundwater samples collected from sites 62, 126, and 160 were not evaluated for bicarbonate concentrations by the analytical laboratory (table 6); therefore, bicarbonate alkalinity (converted from the alkalinity concentration of calcium carbonate in milligrams per liter, or mg/L, $CaCO_3$, assuming the concentration was entirely bicarbonate; table 8 in Hem, 1985) was used for anion comparisons. The cation chemistry of natural waters typically is dominated by calcium, magnesium, sodium, and potassium (Hem, 1985). The chemistry of water samples collected as part of this study is summarized in figure 9. The majority of samples (roughly 90 percent) consisted of 10 to 80 percent calcium; 15 to 90 percent sodium, with little potassium present relative to sodium; and 10 to 60 percent magnesium. There was greater variability in cation chemistry in Diamond, Kobeh, and southern Monitor Valleys than northern Monitor and Antelope Valleys (fig. 9). The anion chemistry of most samples collected as part of this study consisted of 60 to 90 percent bicarbonate, 5 to 35 percent sulfate, and 5 to 40 percent chloride. Calcium-bicarbonate water type was represented in 58 percent of samples, sodium-bicarbonate in 22 percent of samples, and magnesium-bicarbonate in 11 percent of samples (fig. 9). Anion chemistry was dominated by bicarbonate in all water samples collected, with a few noted exceptions; sites 46, 252, 253, 218, and 74 were dominated by sulfate in areas down gradient of siliciclastic sedimentary rocks (sulfate-bearing), while sites 298, 312, and 317 were dominated by chloride near the Diamond Valley playa (flow system terminus). No clear differences were observed in the general water types of the individual basins.

Carbonate rocks are composed of various calcium-carbonate minerals and are present in most mountain ranges in the DVFS, predominately, in the Diamond Mountains and the Sulphur Springs, Fish Creek, and Antelope Ranges (fig. 8; Tumbush and Plume, 2006). Accordingly, the majority of groundwater samples from central and southern Diamond, Antelope, northern Little Smoky Valley, southern and northern Monitor Valleys, and northern Kobeh Valley were a calcium-bicarbonate type (figs. 8, 9). Groundwater samples from throughout southern Kobeh Valley, central Diamond Valley, and southern Monitor Valley were a sodium-bicarbonate type. Greater sodium proportions in southern Kobeh Valley and southern Monitor Valley groundwater (sites 70, 119, 121, 125, 126, 132; figs. 8, 9; table 6) likely resulted from plagioclase-rich andesitic and ash-flow tuff volcanic rocks present in the recharge source areas in the Simpson Park Mountains and the Toquima and northern Monitor Ranges (fig. 1; Roberts and others, 1967). Sulfate water types with various cation proportions were found in the northern part of southern Monitor Valley (site 74; figs. 8, 9; table 6), the western part of Kobeh Valley (site 46; figs. 8, 9; table 6), and west-central Diamond Valley (sites 252 and 253; figs. 8, 9; table 6). The source of sulfate is probably related to clastic rocks consisting of black shale of the Vinnini Formation (Roberts and others, 1967).

The chemical signature of groundwater in Diamond Valley largely was determined from samples collected in the mid-1960s by Harrill (1968) and indicated changes in water type along groundwater-flow paths. Groundwater near valley edges generally was calcium- or magnesium-dominated bicarbonate water (fig. 8) with slightly elevated (compared to 500 mg/L secondary drinking water standard) total dissolved solids concentrations (TDS; 338 mg/L average, table 7). During pre-development and at least through the 1960s, groundwater generally flowed from southern to northern Diamond Valley, discharging near the large playa (Harrill, 1968). Groundwater in playa deposits was documented as chemically distinct from that in the fresh basin-fill aquifer (Huntington and others, 2014). As would be expected at the terminus of a groundwater-flow system, sodium and chloride content increased from averages of 32 and 24 mg/L, respectively, near southern Diamond Valley to about 340 mg/L (table 7) near the southern playa edge because of continued enrichment as groundwater moved along this northerly flow path toward the playa. The groundwater evolved from a calcium-bicarbonate to a sodium-bicarbonate to a more concentrated sodium-chloride water (sites 298, 312, and 317 from figs. 8, 9; table 6; similar to Arakel and others, 1990), likely owing to ion exchange of calcium for sodium and the release of sodium bound in clays in basin-fill deposits (Harrill, 1968). The post-development groundwater divide, near sites 317 and 321, has caused a reversal of the direction of groundwater flow, which eventually can result in the southward migration of higher TDS and sodium-rich groundwater.

Groundwater in the DVFS was evaluated with respect to national primary and secondary drinking-water standards. Primary standards (maximum contaminant levels, or MCLs) have been established by the U.S. Environmental Protection Agency (EPA) for constituents that pose potential health risks to humans (U.S. Environmental Protection Agency, 2009). Secondary standards generally are non-enforceable guidelines designed to ensure water quality with desirable cosmetic or aesthetic characteristics, such as taste and odor (U.S. Environmental Protection Agency, 2009); however, the Nevada Division of Environmental Projection enforces Nevada-specific secondary standards (Nevada Administrative Code 445A.455).

Groundwater quality in the DVFS generally was within acceptable drinking water standards, with only a few exceptions. The pH was measured outside the acceptable range (6.6–8.5) in three samples; Diamond and Kobeh Valleys each contained one sample above 8.5 and Southern Monitor Valley contained one sample below 6.5 (table 6). The secondary MCL for chloride and sulfate (both 250 mg/L) was exceeded in three and six samples, respectively (table 6). Chloride exceedances occurred only within Diamond Valley whereas sulfate exceedances occurred in Diamond (4), Southern Monitor (1) and Kobeh Valleys (1). Total dissolved solids concentrations ranged from 77 to 1,520 mg/L, with a median concentration of 320 mg/L. Concentrations in nine samples, seven of which were collected in Diamond Valley, exceeded the 500 mg/L TDS secondary MCL. No samples exceeded the natural fluoride MCL of 4 mg/L; however, samples from two sites in Kobeh Valley exceeded the Nevada secondary MCL of 2 mg/L.

## Stable Isotopes

Stable isotope data were used to gain insight about precipitation distributions, the source and timing of groundwater recharge, and interbasin flow beyond the DVFS. The stable isotopes of oxygen-18 and deuterium in water are affected by meteorological processes and exhibit a strong correlation with air temperature (Friedman, 1953). A global meteoric water line (GMWL; Craig, 1961) represents the relationship between oxygen-18 and deuterium of fresh water on a global scale and provides a reference for interpreting isotopic data of groundwater. Craig (1961) observed that isotopically depleted groundwater (more negative values) was associated with cool temperatures, whereas isotopically enriched groundwater (less negative values) was associated with warm temperatures. From this correlation, the source and season of groundwater recharge can be evaluated.

Stable isotope data were collected from well and spring sites throughout the DVFS (1981, 2008, and 2012) and were compared to isotope data from local precipitation (table 6). Precipitation was sampled for isotopic analysis from bulk-precipitation gages in 2012 and early 2013 during warm (July, Aug., and Sept.) and cool months (Oct., Nov., and Feb.). Bulk-precipitation gages collocated at ET sites in Kobeh Valley were filled with at least one-half inch of mineral oil to minimize evaporative losses. Isotopic signatures of locally sampled precipitation were used to define a local meteoric water line (LMWL; fig. 10).

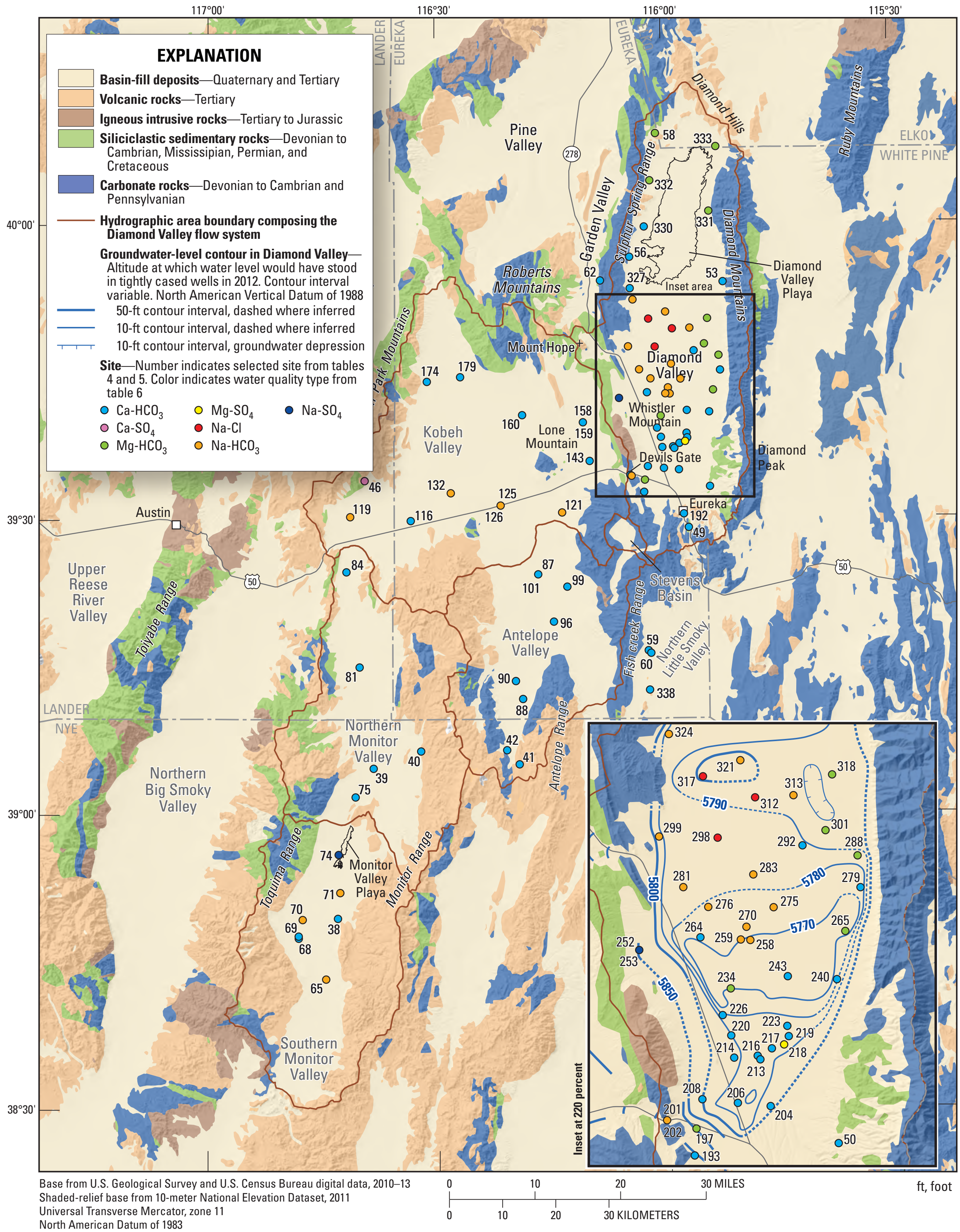


**Figure 8.** Geology, groundwater-level contours, and sites sampled for groundwater chemistry and chemical typing, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2012.

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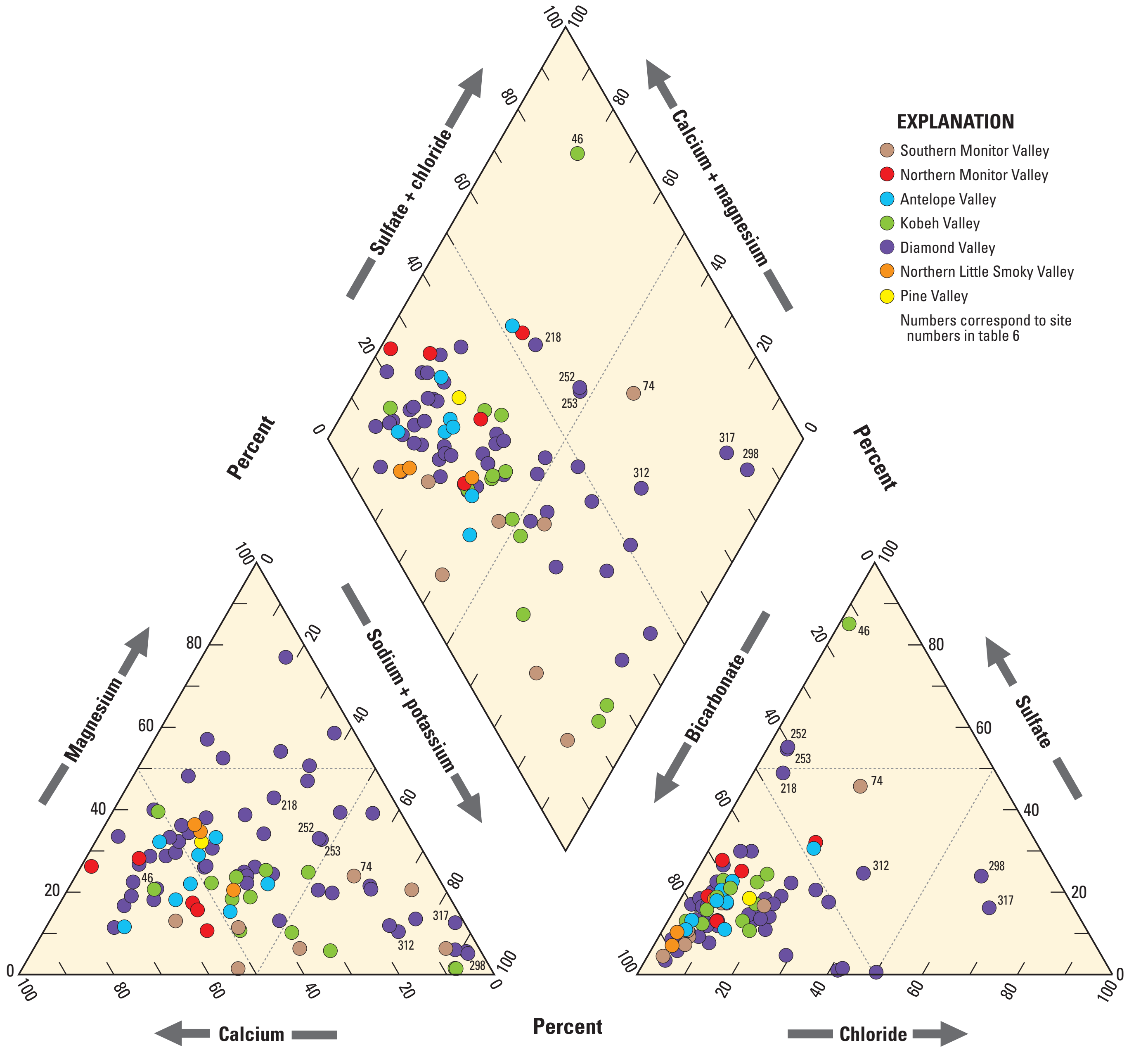


**Figure 9.** Chemical type of groundwater in the Diamond Valley flow system, central Nevada. Relative concentrations of cations and anions are presented in the lower left and right triangles, respectively; relative concentrations are projected onto the central diamond to illustrate the combined major-ion chemistry.

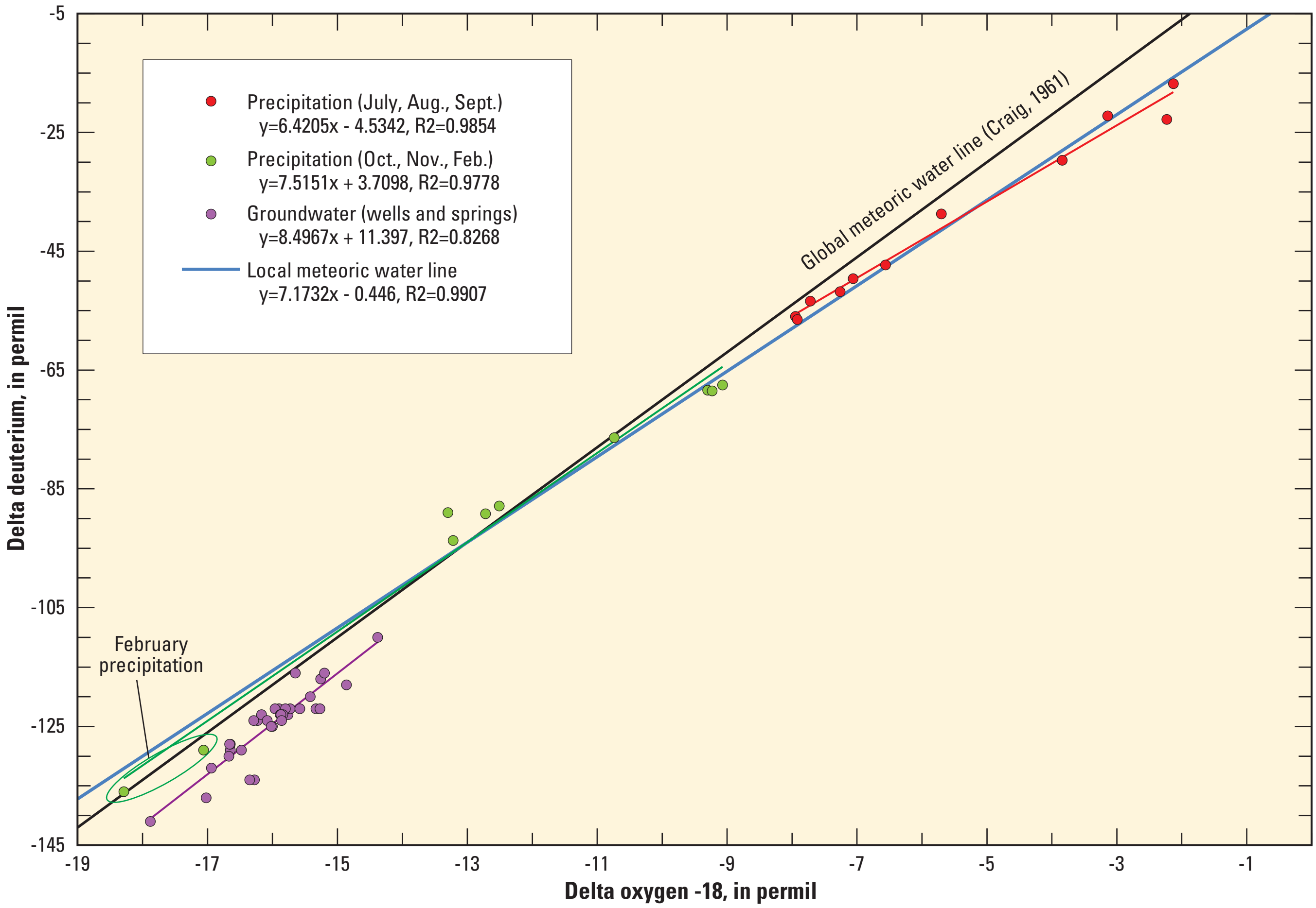


**Figure 10.** Relation between oxygen-18 and deuterium for precipitation, groundwater, and spring water samples, Diamond Valley flow system and adjacent valleys, central Nevada.

Generally, the LMWL indicated precipitation that falls in the DVFS was isotopically similar to the GMWL, with only slight evaporative enrichment during the warmer months, as evidenced by the shallower slope in those data (fig. 10). Precipitation data collected in warmer months in the DVFS exhibited a seasonal variation due to evaporation when compared with samples collected during cooler months. The trend line defined by warmer temperature data exhibited a shallower slope than either the GMWL or the trend line defined by the cooler temperature data. The isotopic signature from cool-month data was comparable to the GMWL.

Most groundwater signatures (including springs) are similar to cool-season precipitation but slightly enriched in oxygen-18 compared to the GMWL and the LMWL (fig. 10). Similar signatures among groundwater and cool-season precipitation indicates that groundwater is, in part, derived from cool-season precipitation under current climate conditions. The slight enrichment in oxygen-18 relative to deuterium could reflect groundwater interaction with warmer waters along deep flow paths (Drever, 1988, Clark and Fritz, 1997). Increased temperature can increase the solubility of minerals and cause a shift in oxygen-18 (Palmer and Cherry, 1984; Thomas and others, 1996).

Isotopic and major-ion data collected from Fish Creek Springs water in northern Little Smoky Valley were compared to isotopic and major-ion data collected from wells in southern Antelope Valley to assess interbasin flow. Although groundwater-level altitudes in southern Antelope Valley indicated the potential for flow toward northern Little Smoky Valley, the isotopic and major-ion data were inconclusive, and therefore could not be used to support this inference.

**Table 6.** Selected water-chemistry data, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2013.

[Site locations are shown in figures 2, 5, and 8. mm/dd/yyyy, month/day/year; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; N/A, not applicable; —, no data; permil, parts per thousands; <, less than; M, presence verified but not quantified]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Site type | Sample date (mm/dd/yyyy) | Well depth, below land surface, (feet) | Water temperature (°C) | pH, field standard units | Specific conductance (µS/cm) | Dissolved, oxygen (mg/L) | Alkalinity, as $CaCO_3$ (mg/L) | Calcium, dissolved (mg/L) | Magnesium, dissolved (mg/L) | Sodium, dissolved (mg/L) | Potassium, dissolved (mg/L) | Bicarbonate, as $HCO_3$ (mg/L) | Chloride, dissolved (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Kobeh Valley | 393214116212402 | atmospheric | 07/17/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 08/20/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 09/10/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 10/17/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 11/27/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| 2 | Kobeh Valley | 393711116124501 | atmospheric | 07/16/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 08/21/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 09/11/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 10/17/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 11/28/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 02/0)8/2013 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| 3 | Kobeh Valley | 393553116252401 | atmospheric | 08/20/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 09/10/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 10/17/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 11/27/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 02/08/2013 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| 4 | Kobeh Valley | 393555116094802 | atmospheric | 07/16/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 08/21/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 09/11/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 10/17/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| | | | | 11/28/2012 | N/A | N/A | — | — | — | — | — | — | — | — | — | — |
| 38 | Southern Monitor Valley | 384930116430000 | spring | 05/07/1967 | N/A | 35.0 | 7.5 | 250 | — | — | 6.4 | 0.1 | 5.2 | 1.9 | 110 | 7.9 |
| 39 | Northern Monitor Valley | 390445116382000 | spring | 05/09/1967 | N/A | 44.5 | 7.7 | 550 | — | — | 51 | 11 | 1.5 | 13 | 266 | 10 |
| | | | | 06/22/1967 | N/A | 50.0 | — | 553 | — | — | 49 | 11 | 1.5 | 0.13 | 268 | 11 |
| 40 | Northern Monitor Valley | 390628116320800 | spring | 05/09/1967 | N/A | 15.5 | 7.4 | 267 | — | — | 29 | 3.5 | 18 | 4.7 | 125 | 9.8 |
| 41 | Antelope Valley | 390508116191800 | spring | 08/05/1967 | N/A | — | 7.4 | 260 | — | — | 26 | 4.9 | 20 | 4.8 | 120 | 12 |
| 42 | Antelope Valley | 390634116205300 | spring | 08/05/1967 | N/A | 17.0 | 7.7 | 332 | — | — | 39 | 14 | 9.5 | 2.9 | 178 | 6.3 |
| 46 | Kobeh Valley | 393400116392401 | spring | [1]08/05/2008 | N/A | 15.0 | 7.0 | 1,760 | 1.3 | 143 | 260 | 53.3 | 88 | 1.23 | 174 | 17.2 |
| 49 | Diamond Valley | 392904115565501 | spring | [2]05/07/1958 | N/A | 8.9 | 7.6 | 476 | — | — | 69 | 10 | 15 | 1.2 | 242 | 6.7 |
| 50 | Diamond Valley | 393316115540501 | spring | [1]08/07/2008 | N/A | 11.0 | 7.6 | 425 | 7.8 | 219 | 63.7 | 6 | 13.5 | 0.91 | 267 | 6.66 |

**Table 6.** Selected water-chemistry data, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2013.—Continued

[Site locations are shown in figures 2, 5, and 8. mm/dd/yyyy, month/day/year; °C, degrees Celsius; N/A, not applicable; mg/L, milligrams per liter; µg/L, micrograms per liter; permil, parts per thousands; <, less than; —, no data; M, presence verified but not quantified]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Sulfate dissolved (mg/L) | Total dissolved solids (mg/L) | Aluminum, dissolved (µg/L) | Arsenic, dissolved (µg/L) | Fluoride, dissolved (mg/L) | Iron, dissolved (µg/L) | Lithium, dissolved (µg/L) | Barium, dissolved (µg/L) | Boron, dissolved (µg/L) | Silica, dissolved (mg/L) | Strontium, dissolved (mg/L) | Nitrate (mg/L) | Hydrogen 2/1 ratio (permil) | Oxygen 18/16 ratio (permil) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Kobeh Valley | 393214116212402 | — | — | — | — | — | — | — | — | — | — | — | — | −47.30 | −6.56 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −22.80 | −2.23 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −56.00 | −7.95 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −76.40 | −10.74 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −89.20 | −12.72 |
| 2 | Kobeh Valley | 393711116124501 | — | — | — | — | — | — | — | — | — | — | — | — | −49.60 | −7.06 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −29.70 | −3.84 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −56.50 | −7.92 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −68.50 | −9.23 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −93.70 | −13.22 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −136 | −18.29 |
| 3 | Kobeh Valley | 393553116252401 | — | — | — | — | — | — | — | — | — | — | — | — | −16.80 | −2.13 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −51.80 | −7.26 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −68.40 | −9.30 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −89.00 | −13.30 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −129 | −17.06 |
| 4 | Kobeh Valley | 393555116094802 | — | — | — | — | — | — | — | — | — | — | — | — | −38.70 | −5.70 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −22.20 | −3.14 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −53.40 | −7.72 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −67.50 | −9.07 |
| | | | — | — | — | — | — | — | — | — | — | — | — | — | −87.90 | −12.51 |
| 38 | Southern Monitor Valley | 384930116430000 | 20 | 187 | <0.1 | — | 1.9 | <0.01 | M | — | M | 56 | M | 1.1 | — | — |
| 39 | Northern Monitor Valley | 390445116382000 | 55 | 348 | <0.1 | — | 2 | <0.01 | M | — | M | 35 | M | <0.1 | — | — |
| | | | 53 | 380 | <0.1 | M | 2.1 | M | M | — | M | 35 | M | <0.1 | — | — |
| 40 | Northern Monitor Valley | 390628116320800 | 16 | 147 | <0.1 | — | 0.2 | <0.01 | M | — | M | 42 | M | 1.5 | — | — |
| 41 | Antelope Valley | 390508116191800 | 13 | 223 | M | — | 0.5 | M | M | — | M | 56 | M | <0.023 | — | — |
| 42 | Antelope Valley | 390634116205300 | 17 | 218 | M | — | 0.2 | M | M | — | M | 26 | M | 0.34 | — | — |
| 46 | Kobeh Valley | 393400116392401 | 889 | 1,520 | — | — | 2.99 | — | — | — | — | — | — | — | −129 | −16.48 |
| 49 | Diamond Valley | 392904115565501 | 41 | 303 | — | — | 0.4 | 0 | — | — | 0.1 | 39 | — | 1.5 | — | — |
| 50 | Diamond Valley | 393316115540501 | 8.84 | 245 | — | — | 0.19 | — | — | — | — | — | — | — | −117 | −15.26 |

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**Table 6.** Selected water-chemistry data, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2013.

[Site locations are shown in figures 2, 5, and 8. mm/dd/yyyy, month/day/year; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; N/A, not applicable; —, no data; permil, parts per thousands; <, less than; M, presence verified but not quantified]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Site type | Sample date (mm/dd/yyyy) | Well depth, below land surface, (feet) | Water temperature (°C) | pH, field standard units | Specific conductance (µS/cm) | Dissolved, oxygen (mg/L) | Alkalinity, as $CaCO_3$ (mg/L) | Calcium, dissolved (mg/L) | Magnesium, dissolved (mg/L) | Sodium, dissolved (mg/L) | Potassium, dissolved (mg/L) | Bicarbonate, as $HCO_3$ (mg/L) | Chloride, dissolved (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | Diamond Valley | 395415115524301 | spring | [2]05/17/1966 | N/A | 20.6 | 7.8 | 583 | — | — | 73 | 22 | 23 | 5.1 | 318 | 6.5 |
| | | | | 07/14/1981 | N/A | 21.0 | 6.9 | 555 | 3.1 | — | 69 | 22 | 21 | 4.6 | 320 | 6.9 |
| 56 | Diamond Valley | 395628116042801 | spring | [2]04/16/1963 | N/A | 34.4 | 7.6 | 529 | — | — | 55 | 21 | 30 | 6 | 288 | 17 |
| | | | | 07/13/1981 | N/A | 39.0 | 6.7 | 515 | 1.4 | — | 54 | 18 | 30 | 6.1 | 270 | 15 |
| 58 | Diamond Valley | 400911116004701 | spring | [2]09/03/1965 | N/A | 9.4 | 8.2 | 631 | — | — | 8.8 | 78 | 33 | — | 345 | 14 |
| 59 | Northern Little Smoky Valley | 391624116020501 | spring | 07/19/2012 | N/A | 19.4 | 7.0 | 637 | 3.2 | 302 | 65.1 | 31 | 30.4 | 7.21 | 368 | 8.31 |
| 60 | Northern Little Smoky Valley | 391638116021601 | spring | 70/19/2012 | N/A | 15.6 | 7.4 | 618 | 9.0 | 301 | 65.1 | 31.3 | 27.2 | 6.81 | 366 | 8.58 |
| 62 | Pine Valley | 395412116081601 | spring | [1]11/03/2008 | N/A | 11.0 | 7.0 | 460 | 4.9 | 236 | 61.1 | 25.6 | 33 | 2.14 | 288 | 24 |
| | | | | 09/22/2010 | N/A | 12.3 | 7.3 | 570 | 4.2 | 243 | 59.8 | 24.4 | 32.8 | 2.03 | — | 24.3 |
| | | | | 06/27/2011 | N/A | 11.9 | 7.6 | 545 | 4.4 | — | 58.9 | 25.1 | 31.6 | 1.96 | — | 24.5 |
| | | | | 09/21/2011 | N/A | 12.8 | 7.7 | 535 | 4.1 | 233 | 57.8 | 24.6 | 31 | 2.06 | — | 24.2 |
| | | | | 06/12/2012 | N/A | 10.6 | 7.5 | 585 | 3.8 | 240 | 63.9 | 27.9 | 34.4 | 2.11 | [6]197 | 24.2 |
| | | | | 09/12/2012 | N/A | 12.3 | 7.5 | 572 | 3.6 | 241 | 61.6 | 25.9 | 33.1 | 2.02 | — | 24.6 |
| 65 | Southern Monitor Valley | 384320116443700 | well | 05/07/1967 | — | 6.0 | 7.5 | 437 | — | — | 4.1 | 7.1 | 43 | 6.5 | 240 | 10 |
| 68 | Southern Monitor Valley | 384730116481000 | well | 05/07/1967 | — | 6.5 | 7.1 | 98 | — | — | 12 | 1.6 | 5.5 | 0.8 | 51 | 1.8 |
| 69 | Southern Monitor Valley | 384736116481801 | well | [1]08/04/2008 | 154 | 11.5 | 6.5 | 120 | 6.3 | 54 | 11.8 | 1.7 | 10.7 | 1.12 | 66 | 1.3 |
| 70 | Southern Monitor Valley | 384926116474501 | well | [1]08/04/2008 | 30 | 11.5 | 7.2 | 485 | 2.5 | 154 | 34.4 | 3.59 | 53.9 | 7.05 | 187 | 30.5 |
| 71 | Southern Monitor Valley | 385220116435500 | well | 07/25/1967 | 4,353 | — | 8.5 | 615 | — | — | 8.6 | 5 | 108 | 29 | 310 | 13 |
| 74 | Southern Monitor Valley | 385600116425700 | well | 05/09/1967 | — | 8.5 | 7.6 | 1430 | — | — | 52 | 43 | 195 | 6.3 | 263 | 121 |
| 75 | Northern Monitor Valley | 390150116403801 | well | 07/18/2012 | 192 | 17.1 | 7.7 | 362 | 5.8 | 125 | 48.3 | 13.7 | 9.23 | 1.44 | 153 | 5.04 |
| 81 | Northern Monitor Valley | 391503116401001 | well | [3]04/14/1964 | — | 15.6 | 7.6 | 460 | — | — | 50 | 8.8 | 31 | — | 182 | 15 |
| 84 | Northern Monitor Valley | 392445116414802 | well | [3]04/14/1964 | — | 21.7 | 7.8 | 579 | — | — | 62 | 12 | 36 | — | 160 | 43 |
| 87 | Antelope Valley | 392445116414800 | well | 05/09/1967 | — | 13.5 | 7.7 | 551 | — | — | 55 | 14 | 25 | 8 | 155 | 41 |
| 88 | Antelope Valley | 391114116185101 | well | 07/17/2012 | 174 | 15.2 | 7.7 | 361 | 5.6 | 124 | 53.9 | 5.29 | 10.8 | 5.26 | 151 | 10.9 |
| 90 | Antelope Valley | 391342116194401 | well | 07/17/2012 | 190 | 16.8 | 7.7 | 408 | 2.4 | 149 | 51 | 9.72 | 21.3 | 4.51 | 180 | 10.6 |
| 96 | Antelope Valley | 391935116144901 | well | [1]11/06/2008 | 186 | 12.5 | 7.6 | 530 | 0.6 | 229 | 55.6 | 18 | 27.2 | 8.98 | 280 | 14 |
| | | | | 07/17/2012 | 186 | 14.0 | 7.8 | 415 | 2.7 | 151 | 42.7 | 15.8 | 19.9 | 6.53 | 183 | 11 |
| 99 | Antelope Valley | 392310116125001 | well | [3]04/16/1964 | — | 16.1 | 8.2 | 355 | — | — | 31 | 15 | 21 | — | 164 | 13 |

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**Table 6.** Selected water-chemistry data, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2013.—Continued

[Site locations are shown in figures 2, 5, and 8. mm/dd/yyyy, month/day/year; °C, degrees Celsius; N/A, not applicable; mg/L, milligrams per liter; µg/L, micrograms per liter; permil, parts per thousands; <, less than; —, no data; M, presence verified but not quantified]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Sulfate dissolved (mg/L) | Total dissolved solids (mg/L) | Aluminum, dissolved (µg/L) | Arsenic, dissolved (µg/L) | Fluoride, dissolved (mg/L) | Iron, dissolved (µg/L) | Lithium, dissolved (µg/L) | Barium, dissolved (µg/L) | Boron, dissolved (µg/L) | Silica, dissolved (mg/L) | Strontium, dissolved (mg/L) | Nitrate (mg/L) | Hydrogen 2/1 ratio (permil) | Oxygen 18/16 ratio (permil) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | Diamond Valley | 395415115524301 | 51 | 358 | — | — | 0.4 | 0.01 | — | — | 0 | 19 | — | 1.1 | — | — |
| | | | 53 | 356 | — | — | 0.4 | <10 | 80 | 90 | 70 | 21 | 380 | — | −122 | −15.90 |
| 56 | Diamond Valley | 395628116042801 | 33 | 330 | — | — | 0.5 | 0 | — | — | 0.1 | 30 | — | 0.6 | — | — |
| | | | 35 | 328 | — | — | 0.4 | <10 | 50 | 180 | 110 | 36 | 220 | — | −125 | −16.00 |
| 58 | Diamond Valley | 400911116004701 | 106 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 59 | Northern Little Smoky Valley | 391624116020501 | 34 | 370 | 2.2 | 2.8 | 0.53 | 3.2 | 73.7 | 82.1 | 99 | 21.5 | 422 | — | −120 | −15.42 |
| 60 | Northern Little Smoky Valley | 391638116021601 | 24.4 | 354 | 2.2 | 1.3 | 0.45 | 7.3 | 70 | 107 | 89 | 16.2 | 414 | — | −123 | −15.76 |
| 62 | Pine Valley | 395412116081601 | 43.1 | 348 | — | — | 0.28 | — | — | — | — | — | — | — | −122 | −15.33 |
| | | | 42.6 | 342 | — | — | 0.26 | <6.0 | — | — | — | — | — | 3.51 | — | — |
| | | | 43.2 | 354 | — | — | 0.26 | <3.2 | — | 100 | — | 25 | 203 | 3.55 | — | — |
| | | | 42.5 | 349 | 4.3 | 4.3 | 0.3 | 8.7 | 22.8 | 101 | 124 | — | 213 | 3.48 | — | — |
| | | | 43 | 347 | <3.8 | 4.3 | 0.24 | <3.2 | 21.4 | 100 | 146 | — | 221 | 3.67 | −122 | −15.27 |
| | | | 43.1 | 352 | 10.8 | 4.2 | 0.23 | <3.2 | 19.9 | 102 | 144 | — | 215 | — | — | — |
| 65 | Southern Monitor Valley | 384320116443700 | 21 | 311 | <0.1 | — | 0.7 | <0.01 | M | — | M | 52 | M | <0.1 | — | — |
| 68 | Southern Monitor Valley | 384730116481000 | 5.2 | 77 | <0.1 | — | <0.1 | M | <0.01 | — | M | 25 | M | <0.1 | — | — |
| 69 | Southern Monitor Valley | 384736116481801 | 2.51 | 97 | — | — | 0.12 | — | — | — | — | — | — | — | −116 | −15.65 |
| 70 | Southern Monitor Valley | 384926116474501 | 38.4 | 342 | — | — | 0.36 | — | — | — | — | — | — | — | −110 | −14.38 |
| 71 | Southern Monitor Valley | 385220116435500 | 21 | 388 | <0.1 | — | 2.3 | M | M | — | M | 33 | M | 0.1 | — | — |
| 74 | Southern Monitor Valley | 385600116425700 | 315 | 988 | <0.1 | — | 0.2 | M | M | — | M | 23 | M | 0.1 | — | — |
| 75 | Northern Monitor Valley | 390150116403801 | 49.5 | 224 | 2.2 | — | 0.08 | 3.2 | 7.17 | 50.6 | 36 | 23.2 | 218 | — | −124 | −16.23 |
| 81 | Northern Monitor Valley | 391503116401001 | 55 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 84 | Northern Monitor Valley | 392445116414802 | 88 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 87 | Antelope Valley | 392445116414800 | 79 | 375 | 1 | — | 0.3 | <0.01 | M | — | M | 50 | M | 0.61 | — | — |
| 88 | Antelope Valley | 391114116185101 | 39.4 | 255 | 11.1 | 4 | 0.13 | 23.5 | 9.19 | 52.4 | 57 | 43.7 | 275 | — | −116 | −15.20 |
| 90 | Antelope Valley | 391342116194401 | 34.4 | 273 | 4.6 | 1.5 | 0.09 | 3.2 | 10.7 | 195 | 71 | 36.3 | 244 | — | −122 | −15.96 |
| 96 | Antelope Valley | 391935116144901 | 24.9 | 373 | — | — | 0.62 | — | — | — | — | — | — | — | −123 | −16.17 |
| | | | 41.6 | 289 | 2.5 | 2.9 | 0.23 | 14.3 | 17.3 | 112 | 70 | 48.2 | 291 | — | −124 | −16.08 |
| 99 | Antelope Valley | 392310116125001 | 32 | — | — | — | — | — | — | — | — | — | — | — | — | — |

**Table 6.** Selected water-chemistry data, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2013.

[Site locations are shown in figures 2, 5, and 8. mm/dd/yyyy, month/day/year; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; N/A, not applicable; —, no data; permil, parts per thousands; <, less than; M, presence verified but not quantified]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Site type | Sample date (mm/dd/yyyy) | Well depth, below land surface, (feet) | Water temperature (°C) | pH, field standard units | Specific conductance (µS/cm) | Dissolved, oxygen (mg/L) | Alkalinity, as $CaCO_3$ (mg/L) | Calcium, dissolved (mg/L) | Magnesium, dissolved (mg/L) | Sodium, dissolved (mg/L) | Potassium, dissolved (mg/L) | Bicarbonate, as $HCO_3$ (mg/L) | Chloride, dissolved (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 101 | Antelope Valley, | 392433116164500 | well | 06/23/1967 | — | 21.0 | 7.9 | 294 | — | — | 22 | 7.8 | 23 | 8.9 | 148 | 5 |
| | | | | 08/05/1967 | — | 21.0 | 7.7 | 288 | — | — | 22 | 8.1 | 23 | 9.4 | 146 | 4.8 |
| 116 | Kobeh Valley | 392956116332201 | well | [1]08/05/2008 | — | 13.0 | 7.2 | 293 | 3.2 | 92 | 27.8 | 3.77 | 23.6 | 6.33 | 112 | 15.7 |
| 119 | Kobeh Valley | 393022116414201 | well | [1]08/05/2008 | 320 | 16.0 | 6.8 | 277 | 5.8 | 98 | 19.1 | 3.18 | 27.3 | 5.26 | 120 | 15.1 |
| 121 | Kobeh Valley | 393043116133201 | well | [1]11/05/2008 | 331 | 10.5 | 7.9 | 448 | — | 152 | 24.9 | 14.1 | 48 | 6.3 | 185 | 27.6 |
| 125 | Kobeh Valley | 393129116212800 | well | 05/09/1967 | — | 17.0 | 8.3 | 320 | — | — | 4.8 | 0.7 | 59 | 11 | 148 | 5.5 |
| | | | | 06/23/1967 | — | 16.5 | 8.2 | 321 | — | — | 6.6 | 0.7 | 57 | 11 | 149 | 5.3 |
| | | | | [1]08/06/2008 | — | 16.5 | 8.2 | 306 | 0.8 | 110 | 4.26 | 0.562 | 55.6 | 8.98 | 134 | 6.64 |
| 126 | Kobeh Valley | 393129116212901 | well | 06/13/2012 | — | 17.7 | 8.8 | 319 | 0.0 | 130 | 5.17 | 0.694 | 65.1 | 11.6 | [6]107 | 6.13 |
| | | | | [4]9/10/2012 | — | — | — | — | — | 249 | 5.13 | 0.696 | 63.9 | 11.9 | — | 6.06 |
| 132 | Kobeh Valley | 393246116280501 | well | [1]08/06/2008 | — | 13.0 | 7.6 | 603 | 6.2 | 243 | 41.8 | 4.89 | 90.8 | 6.42 | 297 | 15.7 |
| 143 | Kobeh Valley | 393555116094801 | well | 07/18/2012 | 24 | 10.7 | 7.7 | 505 | 2.7 | 148 | 45.1 | 15.4 | 37.4 | 5.85 | 176 | 25.4 |
| 158 | Kobeh Valley | 393954116104001 | well | [1]11/06/2008 | 630 | 13.0 | 8.2 | 426 | 2.7 | 131 | 43.4 | 12.1 | 26.7 | 5.76 | 160 | 20.4 |
| 159 | Kobeh Valley | 393957116103001 | well | [1]11/06/2008 | 201 | 13.5 | 7.6 | 443 | 0.4 | 154 | 33.2 | 14.5 | 37.4 | 8.11 | 187 | 10.1 |
| 160 | Kobeh Valley | 394036116183401 | well | 06/14/2012 | 139 | 15.1 | 7.7 | 411 | 0.0 | 205 | 47.6 | 22.4 | 9.06 | 1.39 | [6]168 | 4.19 |
| 174 | Kobeh Valley | 394406116310201 | well | [3]05/19/1964 | — | — | 7.8 | 186 | — | — | 16 | 4.4 | 17 | — | 80 | 6 |
| 179 | Kobeh Valley | 394420116263101 | well | [3]05/19/1964 | — | — | 8.2 | 280 | — | — | 26 | 6.3 | 23 | — | 132 | 10 |
| 192 | Diamond Valley | 393030115573000 | well | 05/09/1967 | — | 8.5 | — | 489 | — | — | 64 | 17 | 12 | 3.3 | 226 | 9.8 |
| 193 | Diamond Valley | 393244116024401 | well | [1]11/05/2008 | 338 | 10.0 | 7.4 | 389 | 5.3 | 188 | 45 | 21.2 | 7.62 | 1.16 | 229 | 4.29 |
| 197 | Diamond Valley | 393353116023001 | well | [2]08/19/1965 | — | 0.0 | 7.5 | 389 | — | — | 37 | 27 | 12 | — | 237 | 7.4 |
| 201 | Diamond Valley | 393422116042501 | well | [1]08/06/2008 | 181 | 18.0 | 7.0 | 828 | 2.3 | 303 | 66.8 | 28.5 | 69.8 | 8.54 | 370 | 54.2 |
| 202 | Diamond Valley | 393422116042502 | well | [1]08/06/2008 | 101 | 12.5 | 7.4 | 1,100 | 4.6 | 285 | 56.4 | 28.1 | 142 | 12 | 347 | 124 |
| 204 | Diamond Valley | 393500115580500 | well | 05/09/1967 | — | 13.0 | 7.8 | 650 | — | — | 73 | 22 | 17 | 3.4 | 193 | 49 |
| 206 | Diamond Valley | 393509116000301 | well | [2]05/09/1966 | 213 | 14.4 | 7.6 | 467 | — | — | 51 | 20 | 17 | 5.1 | 220 | 14 |
| 208 | Diamond Valley | 393536116015801 | well | [2]05/05/1966 | 175 | 18.3 | 7.8 | 760 | — | — | 72 | 25 | 62 | 8.2 | 398 | 31 |
| 213 | Diamond Valley | 393710115584000 | well | 08/05/1967 | — | — | 7.6 | 368 | — | — | 50 | 8.9 | 16 | 2.6 | 210 | 7.5 |
| 214 | Diamond Valley | 393714116000301 | well | [2]08/19/1965 | 177 | 12.2 | 7.6 | 806 | — | — | 77 | 28 | 79 | — | 382 | 59 |
| 216 | Diamond Valley | 393720115585000 | well | 08/05/1967 | — | — | 7.6 | 369 | — | — | 47 | 9.8 | 15 | 2.4 | 189 | 11 |
| 217 | Diamond Valley | 393724115580201 | well | [2]07/12/1966 | | 15.6 | 8.0 | 411 | — | — | 45 | 20 | 20 | — | 210 | 17 |
| 218 | Diamond Valley | 393731115570301 | well | [2]08/17/1965 | 173 | 11.1 | 7.8 | 335 | — | — | 21 | 22 | 31 | — | 116 | 9 |
| 219 | Diamond Valley | 393814115565700 | well | 08/05/1967 | — | — | 7.7 | 469 | — | — | 66 | 14 | 14 | 1.2 | 211 | 13 |

**Table 6.** Selected water-chemistry data, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2013.—Continued

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| Site number | Hydrographic area | U.S. Geological Survey station identifier | Sulfate dissolved (mg/L) | Total dissolved solids (mg/L) | Aluminum, dissolved (µg/L) | Arsenic, dissolved (µg/L) | Fluoride, dissolved (mg/L) | Iron, dissolved (µg/L) | Lithium, dissolved (µg/L) | Barium, dissolved (µg/L) | Boron, dissolved (µg/L) | Silica, dissolved (mg/L) | Strontium, dissolved (mg/L) | Nitrate (mg/L) | Hydrogen 2/1 ratio (permil) | Oxygen 18/16 ratio (permil) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 101 | Antelope Valley | 392433116164500 | 21 | 314 | <0.1 | M | 0.5 | M | M | — | M | 75 | M | 0.2 | — | — |
| | | | 19 | 248 | M | — | 0.7 | M | M | — | M | 71 | M | 0.2 | — | — |
| 116 | Kobeh Valley | 392956116332201 | 22.9 | 231 | — | — | 0.18 | — | — | — | — | — | — | — | −125 | −16.02 |
| 119 | Kobeh Valley | 393022116414201 | 17.5 | 207 | — | — | 0.16 | — | — | — | — | — | — | — | −124 | −16.29 |
| 121 | Kobeh Valley | 393043116133201 | 22.3 | 283 | — | — | 0.48 | — | — | — | — | — | — | — | −132 | −16.94 |
| 125 | Kobeh Valley | 393129116212800 | 22 | 229 | <0.1 | 0 | 3.4 | <0.01 | M | — | M | 62 | — | <0.1 | — | — |
| | | | 22 | 259 | <0.01 | M | 3.4 | <0.03 | M | — | M | M | — | <0.1 | — | — |
| | | | 21.8 | 234 | — | — | 3.23 | — | — | — | — | — | — | — | −129 | −16.65 |
| 126 | Kobeh Valley | 393129116212901 | 21.7 | 249 | 2.9 | 27.5 | 2.79 | 3.2 | 21.2 | 96.1 | 213 | — | 75.8 | — | −130 | −16.67 |
| | | | 21.0 | 249 | 3.6 | 26.8 | 0.29 | <3.2 | 23.7 | 95.4 | 210 | — | 74.5 | <0.001 | — | — |
| 132 | Kobeh Valley | 393246116280501 | 36.8 | 411 | — | — | 0.76 | — | — | — | — | — | — | — | −122 | −15.73 |
| 143 | Kobeh Valley | 393555116094801 | 56.1 | 329 | 2.2 | 8.3 | 0.31 | 5.8 | 21.1 | 39.3 | 99 | 43.9 | 306 | — | −128 | −16.65 |
| 158 | Kobeh Valley | 393954116104001 | 44.6 | 313 | — | — | 0.31 | — | — | — | — | — | — | — | −137 | −17.02 |
| 159 | Kobeh Valley | 393957116103001 | 48.3 | 277 | — | — | 0.54 | — | — | — | — | — | — | — | −141 | −17.88 |
| 160 | Kobeh Valley | 394036116183401 | 21.2 | 241 | 5.4 | 2.9 | 0.07 | 29 | 4.49 | 138 | 31 | — | 157 | — | −128 | −16.66 |
| 174 | Kobeh Valley | 394406116310201 | 19 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 179 | Kobeh Valley | 394420116263101 | 18 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 192 | Diamond Valley | 393030115573000 | 56 | 338 | <0.1 | — | 0.2 | <0.01 | M | — | M | 33 | M | 0.97 | — | — |
| 193 | Diamond Valley | 393244116024401 | 17.9 | 207 | — | — | 0.07 | — | — | — | — | — | — | — | −122 | −15.80 |
| 197 | Diamond Valley | 393353116023001 | 25 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 201 | Diamond Valley | 393422116042501 | 54.8 | 434 | — | — | 0.28 | — | — | — | — | — | — | — | −123 | −15.88 |
| 202 | Diamond Valley | 393422116042502 | 96.1 | 654 | — | — | 0.19 | — | — | — | — | — | — | — | −123 | −15.84 |
| 204 | Diamond Valley | 393500115580500 | 11 | 448 | <0.1 | — | 0.1 | <0.01 | <0.01 | — | M | 33 | M | 0.02 | — | — |
| 206 | Diamond Valley | 393509116000301 | 45 | 302 | — | — | 0.3 | 0 | — | — | 0 | 39 | — | 2.7 | — | — |
| 208 | Diamond Valley | 393536116015801 | 52 | 475 | — | — | 0.5 | 0.01 | — | — | 0.1 | 28 | — | 0.5 | — | — |
| 213 | Diamond Valley | 393710115584000 | 11 | 248 | <0.1 | — | 0.2 | <0.01 | <0.01 | — | M | 27 | M | 0.27 | — | — |
| 214 | Diamond Valley | 393714116000301 | 80 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 216 | Diamond Valley | 393720115585000 | 17 | 246 | <0.1 | — | 0.2 | M | M | — | M | 29 | M | 0.77 | — | — |
| 217 | Diamond Valley | 393724115580201 | 40 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 218 | Diamond Valley | 393731115570301 | 100 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 219 | Diamond Valley | 393814115565700 | 50 | 302 | <0.1 | — | 0.1 | M | M | — | M | 17 | M | 1 | — | — |

**Table 6.** Selected water-chemistry data, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2013.

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| Site number | Hydrographic area | U.S. Geological Survey station identifier | Site type | Sample date (mm/dd/yyyy) | Well depth, below land surface, (feet) | Water temperature (°C) | pH, field standard units | Specific conductance (µS/cm) | Dissolved, oxygen (mg/L) | Alkalinity, as $CaCO_3$ (mg/L) | Calcium, dissolved (mg/L) | Magnesium, dissolved (mg/L) | Sodium, dissolved (mg/L) | Potassium, dissolved (mg/L) | Bicarbonate, as $HCO_3$ (mg/L) | Chloride, dissolved (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 220 | Diamond Valley | 393818116002401 | well | [2]07/11/1966 | 112 | 14.4 | 7.8 | 878 | — | — | 78 | 26 | 73 | 12 | 406 | 54 |
| 223 | Diamond Valley | 393842115572201 | well | [2]05/20/1966 | 300 | 11.7 | 7.7 | 400 | — | — | 57 | 10 | 13 | 1.2 | 204 | 8 |
| 226 | Diamond Valley | 393915116011001 | well | [2]05/17/1966 | 186 | 15.6 | 7.8 | 709 | — | — | 74 | 25 | 43 | 6.8 | 368 | 30 |
| 234 | Diamond Valley | 394029116002401 | well | [2]08/18/1965 | 182 | 16.7 | 7.3 | 806 | — | — | 60 | 40 | 75 | — | 406 | 54 |
| 240 | Diamond Valley | 394049115535901 | well | [2]07/12/1966 | — | 11.7 | 7.8 | 198 | — | — | 28 | 9.2 | 2.1 | — | 109 | 6.8 |
| 243 | Diamond Valley | 394058115565701 | well | [2]05/17/1966 | 250 | 12.2 | 7.5 | 406 | — | — | 46 | 16 | 17 | 2.2 | 207 | 6 |
| 252 | Diamond Valley | 394220116055002 | well | [1]11/04/2008 | 375 | 12.5 | 7.8 | 1,020 | 1.9 | 226 | 45.4 | 45.2 | 118 | 3.32 | 276 | 15.9 |
| 253 | Diamond Valley | 394220116055001 | well | [1]11/04/2008 | 499 | 10.5 | 8.2 | 997 | 1.4 | 230 | 45.6 | 45.4 | 121 | 3.34 | 281 | 16.1 |
| 258 | Diamond Valley | 394238115593301 | well | [2]08/17/1965 | 182 | 11.1 | 7.8 | 569 | — | — | 16 | 30 | 69 | — | 216 | 47 |
| 259 | Diamond Valley | 394230115594401 | well | [2]07/11/1966 | 182 | 12.8 | 8.2 | 749 | — | — | 26 | 22 | 121 | — | 264 | 80 |
| 264 | Diamond Valley | 394240116021101 | well | [2]05/18/1966 | — | 12.2 | 7.8 | 758 | — | — | 66 | 25 | 60 | 8.8 | 312 | 50 |
| 265 | Diamond Valley | 394240115532901 | well | [2]08/20/1965 | — | 11.7 | 7.3 | 907 | — | — | 66 | 69 | 41 | — | 400 | 34 |
| 270 | Diamond Valley | 394301115593301 | well | [2]07/11/1966 | 182 | 12.2 | 7.8 | 788 | — | — | 63 | 13 | 85 | 8.8 | 302 | 60 |
| 275 | Diamond Valley | 394413115574601 | well | [2]12/08/1965 | 56 | 11.7 | 7.8 | 506 | — | — | 32 | 15 | 72 | — | 244 | 40 |
| 276 | Diamond Valley | 394416116014201 | well | [2]09/02/1965 | — | 12.2 | 8.1 | 680 | — | — | 9.5 | 37 | 98 | — | 300 | 55 |
| 279 | Diamond Valley | 394431115520601 | well | [2]03/10/1954 | 50 | 12.2 | 7.4 | 709 | — | — | 78 | 36 | 27 | 5.5 | 356 | 16 |
| 281 | Diamond Valley | 394512116031001 | well | [2]05/17/1966 | 45 | 13.3 | 8.6 | 635 | — | — | 21 | 17 | 88 | 16 | 262 | 48 |
| 283 | Diamond Valley | 394545115585801 | well | [2]05/17/1966 | 22 | 13.3 | 8.1 | 1,430 | — | — | 46 | 21 | 224 | 22 | 354 | 180 |
| 288 | Diamond Valley | 394611115525101 | well | [2]08/18/1965 | 200 | 12.8 | 7.9 | 444 | — | — | 16 | 29 | 43 | — | 195 | 12 |
| 292 | Diamond Valley | 394613115553701 | well | [2]08/18/1965 | 222 | 13.9 | 8.1 | 325 | — | — | 32 | 18 | 18 | — | 190 | 7.4 |
| 298 | Diamond Valley | 394729116011201 | well | [2]09/02/1965 | 22 | 12.2 | 8.2 | 4110 | — | — | 24 | 27 | 873 | — | 396 | 883 |
| 299 | Diamond Valley | 394717116044901 | well | [1]08/07/2008 | 83 | 13.5 | 7.4 | 818 | 1.9 | 293 | 56 | 24.1 | 71 | 9.88 | 357 | 53.9 |
| 301 | Diamond Valley | 394806115541701 | well | [2]08/18/1965 | — | 15.6 | 8.0 | 427 | — | — | 18 | 33 | 32 | — | 231 | 11 |
| 312 | Diamond Valley | 394920115584801 | well | [2]05/17/1966 | 22 | 11.1 | 7.9 | 1300 | — | — | 26 | 22 | 216 | 26 | 374 | 220 |
| 313 | Diamond Valley | 394903115565801 | well | [2]09/02/1965 | 22 | 11.7 | 8.5 | 1,740 | — | — | 11 | 13 | 382 | — | 600 | 264 |
| 317 | Diamond Valley | 395020116030001 | well | [2]09/02/1965 | 22 | 12.8 | 8.2 | 3,890 | — | — | 15 | 61 | 768 | — | 427 | 912 |
| 318 | Diamond Valley | 395021115540901 | well | [2]09/02/1965 | 320 | 14.4 | 8.0 | 382 | — | — | 12 | 27 | 36 | — | 204 | 10 |
| 321 | Diamond Valley | 395100115593001 | well | [2]09/02/1965 | 22 | 12.8 | 8 | 1,230 | — | — | 23 | 13 | 244 | — | 352 | 231 |
| | | | | [1]11/05/2008 | 22 | 10.5 | 8.2 | 1,340 | 0.6 | 390 | 40.2 | 17.3 | 218 | 20.6 | 476 | 200 |
| 324 | Diamond Valley | 395156116043901 | well | [2]09/02/1965 | 87 | 13.3 | 8.0 | 555 | — | — | 7.5 | 5.5 | 122 | 39 | 244 | 45 |
| | | | | 05/05/1966 | 87 | 16.7 | 8.3 | 560 | — | — | 41 | 27 | 39 | — | 264 | 25 |

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**Table 6.** Selected water-chemistry data, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2013.—Continued

[Site locations are shown in figures 2, 5, and 8. mm/dd/yyyy, month/day/year; °C, degrees Celsius; N/A, not applicable; mg/L, milligrams per liter; µg/L, micrograms per liter; permil, parts per thousands; <, less than; —, no data; M, presence verified but not quantified]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Sulfate dissolved (mg/L) | Total dissolved solids (mg/L) | Aluminum, dissolved (µg/L) | Arsenic, dissolved (µg/L) | Fluoride, dissolved (mg/L) | Iron, dissolved (µg/L) | Lithium, dissolved (µg/L) | Barium, dissolved (µg/L) | Boron, dissolved (µg/L) | Silica, dissolved (mg/L) | Strontium, dissolved (mg/L) | Nitrate (mg/L) | Hydrogen 2/1 ratio (permil) | Oxygen 18/16 ratio (permil) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 220 | Diamond Valley | 393818116002401 | 68 | 549 | — | — | 0.6 | 0 | — | — | 0.1 | 37 | — | 0.6 | — | — |
| 223 | Diamond Valley | 393842115572201 | 34 | 242 | — | — | 0.1 | 0.01 | — | — | 0 | 16 | — | 2.8 | — | — |
| 226 | Diamond Valley | 393915116011001 | 45 | 444 | — | — | 0.4 | 0 | — | — | 0.1 | 38 | — | 0.2 | — | — |
| 234 | Diamond Valley | 394029116002401 | 68 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 240 | Diamond Valley | 394049115535901 | 13 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 243 | Diamond Valley | 394058115565701 | 39 | 257 | — | — | 0.1 | 0 | — | — | 0 | 28 | — | 0.4 | — | — |
| 252 | Diamond Valley | 394220116055002 | 295 | 659 | — | — | 0.72 | — | — | — | — | — | — | — | −134 | −16.28 |
| 253 | Diamond Valley | 394220116055001 | 295 | 679 | — | — | 0.7 | — | — | — | — | — | — | — | −134 | −16.35 |
| 258 | Diamond Valley | 394238115593301 | 67 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 259 | Diamond Valley | 394230115594401 | 83 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 264 | Diamond Valley | 394240116021101 | 71 | 478 | — | — | 0.5 | 0.01 | — | — | 0.1 | 42 | — | 1 | — | — |
| 265 | Diamond Valley | 394240115532901 | 156 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 270 | Diamond Valley | 394301115593301 | 76 | 500 | — | — | 0.3 | 0 | — | — | 0.2 | 44 | — | 0.8 | — | — |
| 275 | Diamond Valley | 394413115574601 | 39 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 276 | Diamond Valley | 394416116014201 | 65 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 279 | Diamond Valley | 394431115520601 | 77 | 458 | — | — | 0.6 | 0.13 | — | — | 0.12 | 37 | — | 5.5 | — | — |
| 281 | Diamond Valley | 394512116031001 | 34 | 371 | — | — | 0.3 | 0.01 | — | — | 0.3 | 8.4 | — | 0.6 | — | — |
| 283 | Diamond Valley | 394545115585801 | 173 | 854 | — | — | 0.7 | 0.18 | — | — | 0.6 | 11 | — | 1.9 | — | — |
| 288 | Diamond Valley | 394611115525101 | 73 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 292 | Diamond Valley | 394613115553701 | 25 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 298 | Diamond Valley | 394729116011201 | 480 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 299 | Diamond Valley | 394717116044901 | 62.8 | 469 | — | — | 0.28 | — | — | — | — | — | — | — | −122 | −15.58 |
| 301 | Diamond Valley | 394806115541701 | 42 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 312 | Diamond Valley | 394920115584801 | 5 | 718 | — | — | 0.6 | 0.02 | — | — | 0.5 | 15 | — | 2.5 | — | — |
| 313 | Diamond Valley | 394903115565801 | 15 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 317 | Diamond Valley | 395020116030001 | 308 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 318 | Diamond Valley | 395021115540901 | 35 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 321 | Diamond Valley | 395100115593001 | 26 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | | | 7.74 | 757 | — | — | 0.57 | — | — | — | — | — | — | — | −118 | −14.86 |
| 324 | Diamond Valley | 395156116043901 | 42 | 346 | — | — | 0.4 | 0.01 | — | — | 0.1 | 26 | — | 0.6 | — | — |
| | | | 45 | — | — | — | — | — | — | — | — | — | — | — | — | — |

JA1108

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**Table 6.** Selected water-chemistry data, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2013.

[Site locations are shown in figures 2, 5, and 8. mm/dd/yyyy, month/day/year; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; N/A, not applicable; —, no data; permil, parts per thousands; <, less than; M, presence verified but not quantified]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Site type | Sample date (mm/dd/yyyy) | Well depth, below land surface, (feet) | Water temperature (°C) | pH, field standard units | Specific conductance (µS/cm) | Dissolved, oxygen (mg/L) | Alkalinity, as $CaCO_3$ (mg/L) | Calcium, dissolved (mg/L) | Magnesium, dissolved (mg/L) | Sodium, dissolved (mg/L) | Potassium, dissolved (mg/L) | Bicarbonate, as $HCO_3$ (mg/L) | Chloride, dissolved (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 327 | Diamond Valley | 395255116051101 | well | [1]11/03/2008 | 98 | 16.5 | 7.8 | 550 | — | 250 | 58.2 | 24.7 | 34 | 7.64 | 306 | 23.8 |
| 330 | Diamond Valley | 395914116023301 | well | [2]05/05/1966 | — | 35.0 | 8.0 | 449 | — | — | 51 | 20 | 15 | 3.4 | 255 | 10 |
| 331 | Diamond Valley | 400116115534801 | well | [2]08/18/1965 | — | — | 8.1 | 506 | — | — | 5.1 | 42 | 50 | — | 268 | 15 |
| 332 | Diamond Valley | 400426116015001 | well | [2]05/05/1966 | 91 | 26.7 | 7.7 | 419 | — | — | 33 | 36 | 13 | — | 267 | 10 |
| 333 | Diamond Valley | 400726115525901 | well | [2]09/03/1965 | 9.5 | 11.1 | 8.1 | 588 | — | — | 35 | 25 | 34 | — | 263 | 21 |
| 338 | Northern Little Smoky Valley | 384048114341001 | well | 07/18/2012 | 166 | 16.2 | 7.9 | 302 | 6.6 | 109 | 28.4 | 7.95 | 21.4 | 6.64 | 132 | 7.23 |
| | | | N/A | [5]07/16/2012 | N/A | N/A | N/A | <5 | N/A | N/A | 0.919 | 0.102 | 0.08 | 0.03 | — | 0.37 |

**Table 6.** Selected water-chemistry data, Diamond Valley flow system and adjacent basins, central Nevada, 1954–2013.—Continued

[Site locations are shown in figures 2, 5, and 8. mm/dd/yyyy, month/day/year; °C, degrees Celsius; N/A, not applicable; mg/L, milligrams per liter; µg/L, micrograms per liter; permil, parts per thousands; <, less than; —, no data; M, presence verified but not quantified]

| Site number | Hydrographic area | U.S. Geological Survey station identifier | Sulfate dissolved (mg/L) | Total dissolved solids (mg/L) | Aluminum, dissolved (µg/L) | Arsenic, dissolved (µg/L) | Fluoride, dissolved (mg/L) | Iron, dissolved (µg/L) | Lithium, dissolved (µg/L) | Barium, dissolved (µg/L) | Boron, dissolved (µg/L) | Silica, dissolved (mg/L) | Strontium, dissolved (mg/L) | Nitrate (mg/L) | Hydrogen 2/1 ratio (permil) | Oxygen 18/16 ratio (permil) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 327 | Diamond Valley | 395255116051101 | 41.7 | 366 | — | — | 0.42 | — | — | — | — | — | — | — | −123 | −15.87 |
| 330 | Diamond Valley | 395914116023301 | 25 | 210 | — | — | 0.4 | 0 | — | — | 0 | 25 | — | 0.5 | — | — |
| 331 | Diamond Valley | 400116115534801 | 52 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 332 | Diamond Valley | 400426116015001 | 23 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 333 | Diamond Valley | 400726115525901 | 20 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 338 | Northern Little Smoky Valley | 384048114341001 | 25.8 | 214 | 7.1 | 4.9 | 0.34 | 4.8 | 21.7 | 35.3 | 104 | 50.8 | 240 | — | −124 | −15.86 |
| | | | <0.09 | <20 | 4.5 | — | <0.04 | 21.7 | 0.26 | 1.93 | — | 0.126 | 74.5 | — | −117 | −15.16 |

[1]Sample values first published *in* Knochenmus, L.A., Berger, D.L., Moreo, M.T., and Smith, J.L., 2011, Data network, collection, and analysis in the Diamond Valley flow system, central Nevada: U.S. Geological Survey Open-File Report 2011–1089, 24 p. (*http://pubs.usgs.gov/of/2011/1089/*).

[2]Sample values first published *in* Harrill, J., 1968, Hydrologic Response to Irrigation Pumping in Diamond Valley, Eureka, and Elko Counties, Nevada, 1950–65: State of Nevada, Department of Conservation and Natural Resources, Water Resources Bulletin 35, 85 p. (*http://images.water.nv.gov/images/publications/water%20resources%20bulletins/Bulletin35.pdf*).

[3]Sample values first published *in* Rush, F.E., and Everett, D.E., 1964, Ground-water appraisal of Monitor, Antelope, and Kobeh Valleys, Nevada: Nevada Department of Conservation and Natural Resources, Ground-Water Resources - Reconnaissance Report 30, 45 p. (*http://images.water.nv.gov/images/publications/recon%20reports/rpt30-monitor_antelope_kobeh_valley.pdf*).

[4]Quality control sample, replicate.

[5]Quality control sample, field blank

[6]Value calculated by multiplying alkalinity concentration by conversion factor (Hem, 1985, table 8).

**Table 7.** Specific conductance, sodium, chloride, and total dissolved-solids concentrations from selected sites along northerly flowpath in southern Diamond Valley, central Nevada, 1965–67.

[µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; —, no data]

| Site number | Specific conductance (µS/cm) | Sodium dissolved (mg/L) | Chloride dissolved (mg/L) | Total dissolved solids (mg/L) |
|---|---|---|---|---|
| **Upgradient sites** | | | | |
| 197 | 389 | 12 | 7.4 | — |
| 204 | 650 | 17 | 49 | 448 |
| 206 | 467 | 17 | 14 | 302 |
| 213 | 368 | 16 | 7.5 | 248 |
| 214 | 806 | 79 | 59 | — |
| 216 | 369 | 15 | 11 | 246 |
| 217 | 411 | 20 | 17 | — |
| 218 | 335 | 31 | 9 | — |
| 219 | 469 | 14 | 13 | 302 |
| 220 | 878 | 73 | 54 | 549 |
| 223 | 400 | 13 | 8 | 242 |
| 226 | 709 | 43 | 30 | 444 |
| 234 | 806 | 75 | 54 | — |
| 243 | 406 | 17 | 6 | 257 |
| Average | 533 | 32 | 24 | 338 |
| **Mid-gradient sites** | | | | |
| 258 | 569 | 69 | 47 | — |
| 259 | 749 | 121 | 80 | — |
| 264 | 758 | 60 | 50 | 478 |
| 270 | 788 | 85 | 60 | 500 |
| 275 | 506 | 72 | 40 | — |
| 276 | 680 | 98 | 55 | — |
| 281 | 635 | 88 | 48 | 371 |
| Average | 669 | 85 | 54 | 450 |
| **Down-gradient sites** | | | | |
| 283 | 1,430 | 224 | 180 | 854 |
| 292 | 325 | 18 | 7.4 | — |
| 298 | 4,110 | 873 | 883 | — |
| 312 | 1,300 | 216 | 220 | 718 |
| 313 | 1,740 | 382 | 264 | — |
| 317 | 3,890 | 768 | 912 | — |
| 318 | 382 | 36 | 10 | — |
| 321 | 1,340 | 218 | 200 | 757 |
| Average | 1,815 | 342 | 335 | 776 |

## Estimation of Groundwater-Budget Components

Groundwater budgets describe the balance of water moving into and out of a groundwater system. Groundwater budgets include components of outflow, components of inflow, and the change in aquifer storage (equation 1). Basin-scale groundwater-inflow components include precipitation-derived mountain-block recharge (in place), infiltration of streamflow and runoff, and subsurface inflow. Groundwater-outflow components include groundwater ET, groundwater withdrawals, and subsurface outflow.

$$Recharge + GW_i - ET_{gw} - GW_o - P = \Delta Storage \quad (1)$$

where

- *Recharge* is groundwater recharge from direct precipitation and infiltration of streamflow and runoff,
- $GW_i$ is subsurface inflow of groundwater,
- $ET_{gw}$ is groundwater discharge by evapotranspiration,
- $GW_o$ is subsurface outflow of groundwater,
- *P* is groundwater withdrawals, and
- $\Delta Storage$ is the change in aquifer storage.

Groundwater discharge through springs and seeps is eventually lost as $ET_{gw}$, or it reenters the groundwater system as recharge; therefore, it was not considered a separate outflow component in undeveloped basins. The accuracy of a groundwater budget depends on the accuracy of the rates estimated for each of the components; small differences in some rates can produce large differences in annual-budget estimates.

Groundwater budgets in mostly undeveloped basins, such as southern and northern Monitor, Antelope, and Kobeh Valleys and Stevens Basin, were assumed to be in a general state of dynamic equilibrium, where inflow equals outflow, and net changes in storage are negligible. In contrast, substantial groundwater development in the southern part of Diamond Valley has altered the hydrologic flow system by substantially reducing groundwater storage and generating a groundwater cone of depression. Declining groundwater levels, especially in the southern part of Diamond Valley, have likely contributed to spring-flow loss in northern Diamond Valley and have induced a groundwater divide that could draw poor-quality water south toward the major groundwater development area. The groundwater budget for Diamond Valley must consider pumping and changes in $ET_{gw}$ and groundwater storage.

## Groundwater Discharge

Groundwater discharge by ET from areas of phreatophytes and by evaporation from playas is the largest natural outflow component in the DVFS. Groundwater predominantly discharges from topographically low areas, where groundwater is at or near the land surface, that are referred to as groundwater discharge areas (GDA). Groundwater withdrawals for irrigation, which were almost entirely in the southern part of Diamond Valley, represented the largest groundwater-outflow component of the post-development budget.

### Evapotranspiration

Evapotranspiration was measured and $ET_{gw}$ was estimated at four sites in Kobeh Valley using eddy-covariance and other micrometeorological data (Swinbank, 1951; Campbell and Norman, 1998; Foken and others, 2012). Groundwater discharge was computed as annual ET minus precipitation plus the change in soil-water storage. Most, if not all, precipitation falling directly onto the land surface in a GDA is eventually consumed by ET and, therefore, was assumed not to contribute to the regional groundwater-flow system. Surface-water contributions to ET in a GDA were assumed to be negligible. Site-based data were scaled to the basin and flow system using remote sensing and 30-year (1981–2010) PRISM precipitation model data.

#### Surface Energy Budget

Incoming and outgoing energy fluxes that constrain the energy available for ET describe the land-surface energy budget. The energy budget generally is partitioned into four principle components: net radiation ($R_n$), latent- ($\lambda E$) and sensible-heat (H) fluxes, and the soil-heat flux at land surface (G). Based on the principle of energy conservation, available energy (difference between net radiation, $R_n$, and soil heat flux, G) is equal to additive turbulent fluxes of $\lambda E$ and H (equation 2):

$$R_n - G = \lambda E + H \quad (2)$$

where all components are in units of calories per second per square foot. Net radiation is the energy that drives ET and represents the difference between incoming and outgoing shortwave and longwave radiation. The latent-heat flux ($\lambda E$) is defined as the energy consumed during ET. The latent heat of vaporization ($\lambda$) is the amount of energy needed to evaporate a unit mass of water, and the E component of the latent-heat flux term is the mass flux of water vapor, or ET in ounces per second per square foot. Evapotranspiration can be converted to a rate of surface discharge by dividing by the density of water. Sensible-heat flux (H) is the heat energy convectively removed from the surface owing to temperature differences between the surface and atmosphere. The soil-heat flux at land surface (G) is positive when heat moves from the surface to the subsurface.

Latent- and sensible-heat fluxes were measured and computed using the eddy-covariance method, which measures the one-dimensional net transport of heat, mass, and momentum by eddies between surface and atmospheric boundaries (Foken and others, 2012). Eddies are turbulent air movements caused by wind, surface roughness, and convective heat flow at these boundaries (Swinbank, 1951; Campbell and Norman, 1998). The eddy-covariance method relies on high-frequency (10 Hertz, or Hz, in this study) measurements of fluctuations in vertical wind speed, air temperature, and water-vapor density to measure latent- and sensible-heat fluxes.

## Site Selection and Characteristics

Groundwater discharge was estimated at four sites. These sites were selected and instrumented to measure ET and energy-budget components, groundwater levels, precipitation, soil-water content, and other variables affecting $ET_{gw}$ (sites 1–4; fig. 2; table 1). All sites were in undisturbed vegetated areas on the valley floor in Kobeh Valley; three sites were in phreatophytic shrubland, and one site was in grassland (figs. 11***A***, ***B***). The line-transect method (Smith, 1974) was used during spring 2012 to document plant-species dominance and measure canopy height and the percentage of canopy cover at the three shrubland sites. Surveys summarized measurements from four 328-ft transects extending north, west, south, and east from a point near each eddy-covariance instrument tripod (see “Instrumentation” section). Canopy height was computed as the average plant height measured across all transects (table 8). The length of the vertical projection of green (active) plant canopies along line transects was used to compute the percentage of canopy cover. Bare-soil cover included gaps between plants and under plant canopies. Percentage of canopy cover was computed as the ratio of the sum of individual measured canopy lengths across all transects to the total transect length (1,312 ft) and was assumed to represent the predominant ET measurement source area (table 8). Vegetation and soil characteristics were subsequently monitored at all ET sites during site visits, and photographs were taken periodically to document the greenness and vigor of vegetation and the presence or absence of soil moisture.

Site 1 was established at an altitude of about 6,099 ft on June 7, 2011, in an area of sparse shrubland (fig. 2; table 1). Vegetation density was evaluated in terms of vegetation cover and height. The site was characterized by about 15-percent vegetation cover (about 12-percent phreatophyte cover) and 85 percent bare soil (figs. 11***A***, ***B***; table 8). The vegetation was composed of greasewood (*Sarcobatus vermiculatus*, 16-percent relative canopy cover) and rabbitbrush (*Chrysothamnus spp*., 62-percent relative canopy cover), with lesser amounts of non-phreatophytes (xerophytes, that is, plants adapted to an arid environment), including budsage (*Artemisia spinescens*) and sagebrush (*Artemisia tridentata*). Average canopy heights of greasewood and rabbitbrush were 0.9 and 0.4 ft, respectively. Volumetric soil-water content ranged from about 0.01 to 0.18 $in^3/in^3$ (fig. 12). Depth to groundwater measured in a collocated well (site 130; fig. 5; table 5) averaged 8.8 ft below land surface and ranged from about 8.7 to 9.1 ft (June 2011–September 2012; fig. 13).

Site 2 was established at an altitude of about 6,052 ft on July 8, 2010 (fig. 2; table 1). This site was characterized by about 16-percent vegetation cover (more than 99-percent phreatophytes) and 84 percent bare soil and was considered to represent moderate-to-dense shrubland (figs. 11***A***, ***B***; table 8). Greasewood and rabbitbrush (39- and 35-percent relative canopy cover, respectively) were the dominant vegetation, with a lesser amount of saltgrass (*Distichlis spicata*; 26-percent relative canopy cover). Xerophytic vegetation was predominantly sagebrush. The average canopy heights of greasewood and rabbitbrush were 0.9 and 1.2 ft, respectively, and the average rabbitbrush height was three times that measured at site 1. Volumetric soil-water content ranged from about 0.10 to 0.25 $in^3/in^3$ (fig. 12). Depth to groundwater measured in a collocated well (site 150; fig. 5; table 5) averaged 2.3 ft below land surface and ranged from 1.7 to 2.6 ft (July 2010–September 2012; fig. 13).

Site 3 was established at an altitude of about 6,131 ft on July 7, 2010 (fig. 2; table 1). This site was characterized by about 14-percent vegetation cover (all phreatophytes) and 86-percent bare soil and was considered to represent moderate-to-dense shrubland. Shrubs were composed of greasewood (22-percent relative canopy cover) and rabbitbrush (25-percent relative canopy cover), whereas grasses were composed of undifferentiated bunch grass (25-percent relative canopy cover) and saltgrass (28 percent relative canopy cover; figs. 11***A***, ***B***; table 8). Average canopy heights of greasewood and rabbitbrush were 1.3 and 2.1 ft, respectively, and were more than 1.5 times as tall as the same species measured at site 2. The average bunch grass height was about 0.5 ft.

**Table 8.** Vegetation type, canopy cover, and height measured at four evapotranspiration sites, May 2012, Kobeh Valley, Nevada.

[Bunch grass height represents the average height of the bulk of mass. —, no data]

| Site number | Canopy cover (percent)[1] | | Phreatophyte shrubs | | | | Phreatophyte grasses | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Greasewood | | Rabbitbrush | | Bunch grass | | Saltgrass | | Meadow grass | |
| | All plants | Phreatophytes | Canopy cover (percent)[1] | Average height (feet) | Canopy cover (percent)[1] | Average height (feet) | Canopy cover (percent)[1] | Average height (feet) | Canopy cover (percent)[1] | Average height (feet) | Canopy cover (percent)[1] | Average height (feet) |
| 1 | 14.9 | 11.6 | 2.4 | 0.9 | 9.2 | 0.4 | 0.0 | — | 0.0 | — | 0.0 | — |
| 2 | 15.6 | 15.5 | 6.1 | 0.9 | 5.4 | 1.2 | 0.0 | — | 4.0 | 0.3 | 0.0 | — |
| 3 | 14.1 | 14.1 | 3.1 | 1.3 | 3.5 | 2.1 | 3.5 | 0.5 | 4.0 | 0.3 | 0.0 | — |
| 4 | 100.0 | 100.0 | 0.0 | — | 0.0 | — | 0.0 | — | 0.0 | — | 100.0 | [2]0.5 |

[1] Total canopy cover for all four transects divided by the total transect length (1,312 feet); canopy cover was estimated from additive measurements of the vertical projection of green (active) plant canopies overlying line transects.

[2] Value represents the maximum height. Meadow grass height varied seasonally and with grazing practices.

***A***

Site 1, sparse shrubland, August 31, 2011

Site 2, moderate-to-dense shrubland, July 21, 2011

Site 3, moderate-to-dense shrubland, August 31, 2011

Site 4, grassland, July 20, 2011

Photographs by C. Justin Mayers

**Figure 11.** Evapotranspiration sites, Kobeh Valley, central Nevada photographed ***A***, laterally to show instrumentation and vegetation at sites 1–4, and, ***B***, aerially from a location approximately 328 feet west of sites 1–3 to show vegetation distribution in an approximately 28-foot square footprint.

***B***

Site 1, sparse shrubland, July 19, 2012

Site 2, moderate-to-dense shrubland, July 18, 2012

Site 3, moderate-to-dense shrubland, September 10, 2012

Aerial photographs by C. Justin Mayers and David W. Smith using a camera mounted on a 40-foot tripod.

**Figure 11.** Evapotranspiration sites, Kobeh Valley, central Nevada photographed ***A***, laterally to show instrumentation and vegetation at sites 1–4, and, ***B***, aerially from a location approximately 328 feet west of sites 1–3 to show vegetation distribution in an approximately 28-foot square footprint.—Continued

Volumetric soil-water content ranged from about 0.05 to 0.36 $in^3/in^3$ (fig. 12). Depth to groundwater measured in a collocated well (site 142; fig. 5; table 5) averaged 3.5 ft below land surface and ranged from about 2.5 to 4.1 ft (July 2010–September 2013; fig. 13).

Site 4 (fig. 2; table 1) was established at an altitude of about 6,013 ft on June 8, 2011. This site was composed of phreatophytic meadow grasses that covered 100 percent of the measurement area (figs. 11***A***, ***B***; table 8). The area was heavily grazed by cattle; therefore, grass height typically was within 0.5 ft of the land surface. The site was fenced in to protect sensors from grazing cattle; therefore, grass in the fenced area was periodically mowed to mimic grazed conditions beyond the fenced area. Volumetric soil-water content ranged from about 0.11 to 0.37 $in^3/in^3$ (fig. 12). Depth to groundwater measured in a collocated well (site 143; fig. 5; table 5) averaged 4.1 ft below land surface and ranged from about 3.2 to 5.1 ft (June 2011–September 2012; fig. 13).

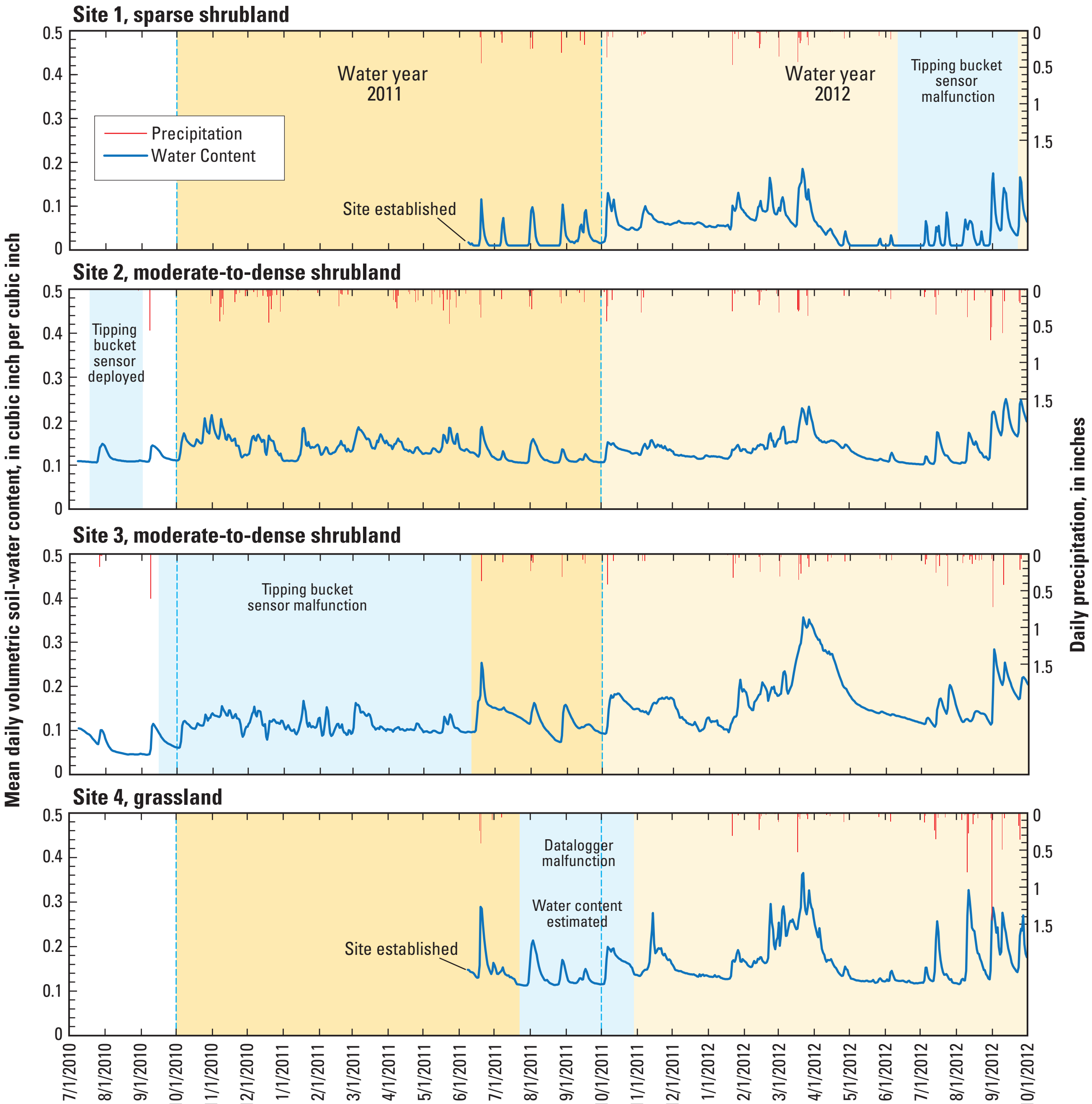


**Figure 12.** Continuously measured precipitation and near-surface (0.8–2.4-inches below land surface) volumetric soil-water content at evapotranspiration sites, October 2010 through September 2012, central Nevada.

## Instrumentation

Each ET site was equipped with identical data recording and sensor arrays, with eddy-covariance instruments and net radiometers deployed on 10-ft steel tripods. Sites also were equipped with aboveground volumetric and tipping-bucket precipitation gauges and belowground energy-flux sensors. Observation wells were equipped with pressure transducers to provide continuous groundwater-level data. Most sensors were powered with a combination of 10- and 64-watt solar panels and multiple deep-cycle marine batteries.

Turbulent fluxes were measured at high frequency (10 Hz) intervals using multiple sensors. Water-vapor measurements were obtained using a krypton hygrometer (KH2O, Campbell Scientific, Inc.), and wind-speed vectors and sonic temperature measurements were obtained with a three-dimensional (3-D) sonic anemometer (CSAT3, Campbell Scientific, Inc.). Absolute water-vapor density was measured with a temperature/humidity probe (HMP45C, Campbell Scientific, Inc.). These high frequency data were recorded using an electronic datalogger (CR5000, Campbell Scientific, Inc.). The datalogger

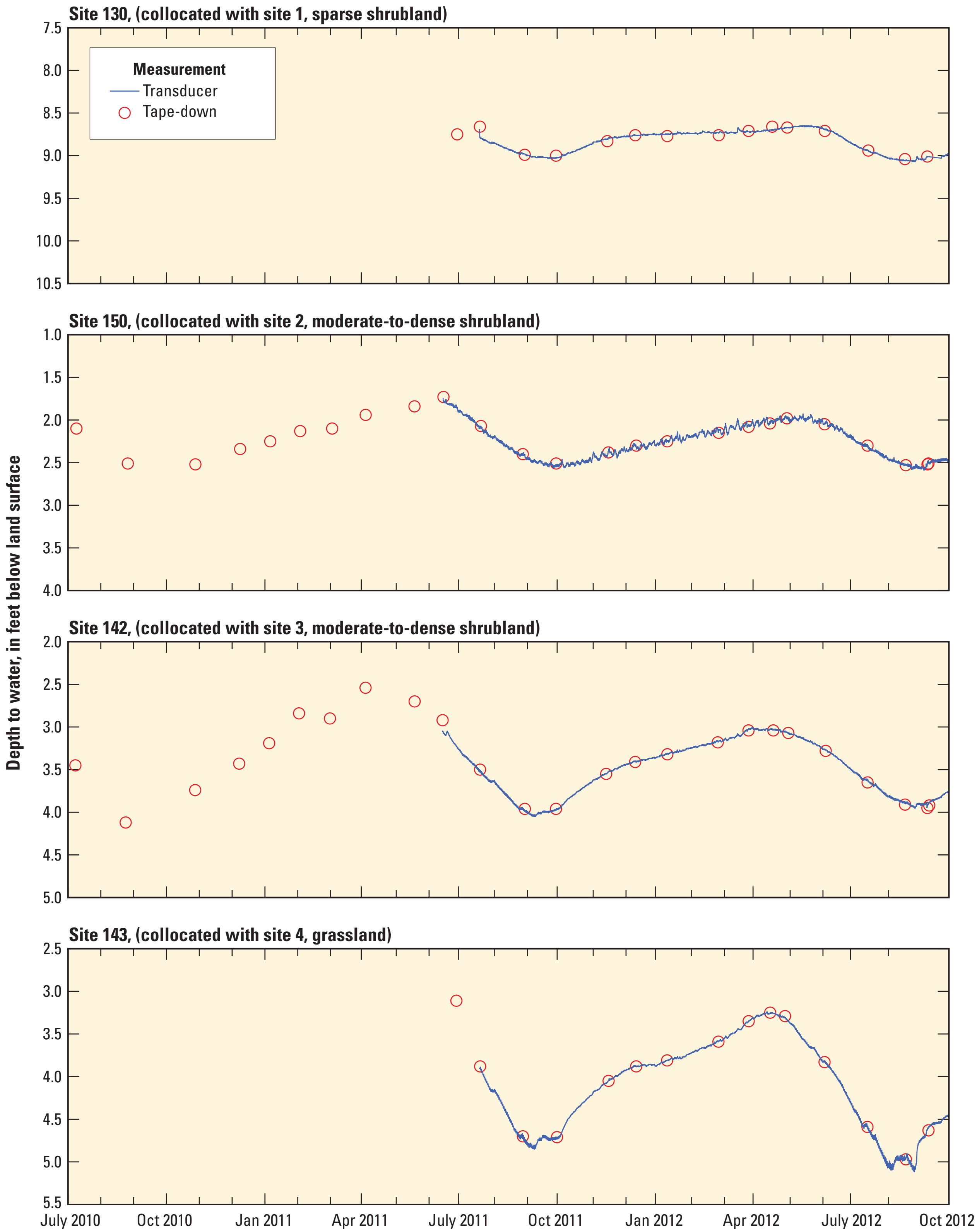


**Figure 13.** Wells collocated with evapotranspiration sites, Kobeh Valley, central Nevada; sites 130, 150, 142, and 143 were collocated with sites 1–4, respectively.

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received sensor readings 10 times per second and computed means, variances, and covariances every 30 minutes. The hygrometer and sonic anemometer were positioned about 4 in. apart, directed into the prevailing wind direction (west), and deployed at about 5 ft or more above the plant canopy (table 9).

Net radiation was measured with a net radiometer (NR Lite, Kipp and Zonen) deployed at about 8 ft or more above the plant canopy (table 9). Soil-heat flux was measured using the calorimetric method (Fuchs, 1987) and two heat-flux plates (HFP01, Hukseflux), eight averaging soil-temperature probes (TCAV, Campbell Scientific, Inc.), and a water-content reflectometer (CS616, Campbell Scientific, Inc.). Heat-flux plates were installed at 3.1-in depths, with replicate temperature probes placed above it at 0.8- and 2.4-in depths. The water-content reflectometer was installed horizontally, and it integrated measurements between two horizontal rods at 0.8- and 2.4-in depths. Flux plate, temperature, and water-content sensor spatial locations were chosen so the mean degree of shading from vegetation approximated the degree of shading across each site. The change in soil temperature and soil-water content above heat-flux plates was converted to a heat flux and added to the heat-flux plate measurements (Fuchs, 1987) to compute soil-heat flux at the soil surface. Available energy was computed as net radiation minus soil-heat flux.

Precipitation was measured at each site with a National Weather Service approved standard 8-in diameter volumetric rain gauge (NovaLynx). A tipping-bucket rain gauge (TE525, Campbell Scientific, Inc.) was collocated with each volumetric rain gauge to record the timing and intensity of rainfall events. The precipitation accumulated in volumetric gauges was measured monthly. Volumetric rain gauges were drained seasonally, wiped dry, and refilled with a half-inch layer of mineral oil to prevent evaporative losses of the subsequently collected precipitation. During winter, the orifice funnel of the volumetric rain gauge was removed and 5 inches of antifreeze were added in combination with mineral oil (1 inch) to prevent freezing of accumulated water and to quickly melt collected snow. A wind monitor (05106, R M Young Company) also was collocated with and deployed at the same height as rain gauges. Wind-speed data were used to correct precipitation measurements for wind-related undercatch (Yang and others, 1996). Installation heights of all aboveground sensors are listed in table 9.

Instruments were checked and evaluated monthly and repaired or replaced as necessary. The horizontal level of net radiometers and sonic anemometers was checked and adjusted if necessary, and both the net radiometer and krypton hygrometer were cleaned with distilled water or isopropyl alcohol. Solar panels and precipitation gauge orifices were cleaned of dust and debris, and batteries were refilled with distilled water routinely.

## Data Correction and Processing

Turbulent flux, available energy, and other site-specific data were processed to reduce errors, and data gaps were identified and filled in a manner similar to Moreo and others, 2007; Shoemaker and others, 2011; and Garcia and others, 2014. Gap-filling procedures varied with the variable and the length and timing of the gap. Volumetric water-content measurements taken with CS616 probes were calibrated using soil-moisture measurements collected from soil cores. Raw latent- and sensible-heat-flux data were corrected to compensate for limitations in eddy-covariance theory and equipment design (discussed in the “Turbulent Fluxes” section ). Data were filtered to identify poor-quality data. Precipitation measurements were corrected for wind-related undercatch (Yang and others, 1996).

### Turbulent Fluxes

High-frequency (10 Hz) latent- and sensible-heat fluxes were processed and corrected using LI-COR’s EddyPro® software (*www.licor.com/eddypro*) and summarized in 30-minute fluxes. Spikes in the datasets representing more than six times the standard deviation for a given 30-minute averaging period were removed and replaced with the running mean. Coordinate rotation of the 3-D wind components was applied to account for imperfect leveling of the CSAT anemometer, such that its horizontal axis is perpendicular to the mean wind streamline. Frequency response errors resulting from flux losses or attenuation at high (fast) and low (slow) frequencies also were corrected (Moore, 1986; Massman, 2000). Additional corrections to the latent-heat flux included the Webb, Pearman, and Leuning (WPL)-correction (Webb and others, 1980) to account for variations in air density resulting from fluctuating temperature (thermal expansion) and humidity (vapor dilution) and the krypton hygrometer oxygen-sensitivity correction (Tanner and Greene, 1989).

Occasional spikes in turbulent-flux data from electronic and physical noise were censored. Water accumulation on the hygrometer from liquid and solid precipitation, and possibly dew and frost, accounted for a large portion of the physical noise. Data were considered poor and rejected when this was observed. Additional data filtering followed procedures described in Garcia and others (2014).

**Table 9.** Above-ground sensor heights, in feet, at four evapotranspiration stations, Kobeh Valley, Nevada.

[3D, three-dimensional]

| Site number | Sensor | | | | |
|---|---|---|---|---|---|
| | CSAT3 3D sonic anemometer | KH2O krypton hygrometer | NR lite net radiometer | Tipping bucket rain gage | Volumetric rain gage |
| 1 | 6.6 | 6.6 | 9.2 | 2.6 | 2.6 |
| 2 | 6.5 | 6.5 | 7.9 | 2.4 | 2.4 |
| 3 | 7.1 | 7.1 | 9.2 | 3.9 | 3.9 |
| 4 | 4.9 | 4.9 | 9.6 | 2.6 | 2.6 |

Data gaps from discarded poor-quality data or sensor malfunction were filled using estimated values based on the time of day, seasonal variability, and gap length. Gaps of 2 hours or less were interpolated for all sensors between previous and subsequent measurements. Air-temperature (HMP45C) data gaps of more than 2 hours were filled using ordinary least-squares regressions with sonic temperature output from the CSAT anemometer, where available, followed by regressions with air temperature measured at the nearest site using the HMP45C. Gaps in latent- and sensible-heat-flux data of more than 2 hours were filled using the following methods. Nighttime gaps (net radiation less than 5 watts per square meter, $W/m^2$) in the latent-heat flux were set equal to zero unless they followed or preceded a gap in daytime data. Daytime gaps and those lasting several days were filled using multivariate regression between turbulent fluxes and micrometeorological data (Garcia and others, 2014). The proportion of gap-filled latent-heat-flux data ranged from 8 percent at sites 1 and 3 to 21 percent at site 4. The proportion of gap-filled sensible-heat-flux data ranged from 2 percent at sites 1 and 3 to 13 percent at site 4.

### Available Energy

Net-radiation data measured with the NR Lite sensor were corrected for wind-speed sensitivity. These sensors are calibrated at zero wind speed; therefore, at any other wind speed, the sensor sensitivity decreases (Campbell Scientific, Inc., 2010). All available energy data were filtered during periods when sensors were cleaned and serviced and when datalogger programs were revised. Data gaps typically spanned 2 hours or less and were filled using linear interpolation. Gaps in net radiation and soil-heat flux lasting several hours to days were filled using ordinary least-squares regression with data from an alternate site ($r^2$ greater than 0.92). At ET site 4, the datalogger malfunctioned from late July through August 2011 and from early September through October 2011, causing complete loss of all data during these periods. Available energy data during September through October 2011 (9 percent of the available energy record) were gap filled using data from ET site 2 and the multivariate-regression technique (Garcia and others, 2014).

Near-surface water-content measurements collected with the CS616 probe were calibrated against volumetric water content measurements (cubic inch per cubic inch, or $in^3/in^3$) of soil samples periodically collected near the CS616 probes. Shallow burial of the CS616 instrument control box (1–2.7-in depths) resulted in thermal loading that was observed as diurnal fluctuations in water content. Therefore, similar to Garcia and others (2014), 30-minute measurements were averaged over 24-hour intervals (from midnight to midnight); the 24-hour average was assigned to the 12:00 PM 30-minute measurement interval; and these values were linearly interpolated from day to day to compute a continuous 30-minute dataset. Calibration equations were based on average daily measurements and had reasonable coefficients of determination, ranging from 0.76 at site 3 to 0.78 at site 1.

### Energy-Balance Ratio

The fundamental criterion of the conservation of energy is that the energy balance is satisfied, and available energy is equal to the turbulent flux. This concept is commonly referred to as energy-balance closure. The energy imbalance in this study was evaluated over the period of record (water years 2011 and 2012) using the energy-balance ratio (equation 3) and the ordinary least-squares regression of the turbulent flux against available energy (table 10). The energy-balance ratio is the ratio of the turbulent flux to available energy:

$$EBR = \frac{\lambda E + H}{R_n - G} \tag{3}$$

The energy balance was evaluated using mean turbulent flux and available-energy components in equation (1) computed from 30-minute data over the period of record. Thirty-minute turbulent-flux data were corrected using respective energy-balance ratios (table 10). Daily-average turbulent-flux and available-energy measurements were used in regressions to avoid potential inaccuracies in soil-heat-flux estimates (Leuning and others, 2012). These regressions were forced through a y-intercept of zero. Analyses only included days during which 48 good 30-minute measurements were collected (that is, no data gaps) in order to remove potential day or night time bias (table 10).

Energy-balance ratios ranged from 0.87 at ET site 1 to 0.91 at ET sites 2 and 4 (table 10). Regression slopes comparing turbulent-flux and available-energy measurements were nearly equal to energy-balance ratios and largely explained the variability in the relation between turbulent flux and available energy (coefficients of determination ranged from 0.95 to 0.97).

In this study, measured turbulent fluxes were considered to be a probable minimum. A probable maximum was computed by dividing 30-minute measured and gap-filled turbulent fluxes by the energy-balance ratio for the respective water

**Table 10.** Energy-balance ratio (EBR), slope and coefficient of determination from ordinary least squares regressions comparing turbulent flux and available energy measurements, and percent good (non-gap filled) half-hour and daily data at four evapotranspiration sites, Kobeh Valley, Nevada.

[**EBR**: the energy-balance ratio or ratio of turbulent flux to available energy computed using average turbulent flux and available energy components. **Slope**; only includes data where 48 good measurements were made over a 24-hour interval in order to remove potential day- or night-time bias. **Daily "Good data"**: indicative of 48 good half-hour measurements during a 24-hour interval]

| Site number | EBR | Slope | Coefficient of determination, $r^2$ | Good data (percent) | |
|---|---|---|---|---|---|
| | | | | Daily | Half hour |
| 1 | 0.87 | 0.87 | 0.96 | 87 | 94 |
| 2 | 0.91 | 0.90 | 0.95 | 65 | 88 |
| 3 | 0.90 | 0.90 | 0.96 | 76 | 93 |
| 4 | 0.91 | 0.90 | 0.97 | 46 | 74 |

year to achieve full energy-balance closure. This approach maintains the eddy-covariance measured Bowen ratio, or ratio of sensible-to-latent heat flux (Bowen, 1926). The best (most probable) estimate of the latent-heat (evaporative) flux in this study is the mean of the probable minimum and probable maximum estimates. The most probable estimate (Moreo and Swancar, 2013) is referred to as energy-balance corrected ET ($ET_c$) for the remainder of this report.

### Precipitation

Point measurements of precipitation can have deficiencies in catch as a result of wind (Larson and Peck, 1974; Yang and others, 1996; Nešpor and Sevruk, 1999). Using an unshielded precipitation gage similar to those used in this study, Yang and others (1996) determined that undercatch deficiency increases exponentially with wind speed and estimated a 14 percent deficiency at 10 miles per hour for liquid precipitation (rain) and a 65 percent deficiency for solid precipitation (snow). Precipitation measurements were corrected for wind-related undercatch using relations developed for rain, snow, and mixed precipitation by Yang and others (1996). Wind-speed measurements taken at the same height as precipitation collectors were used for corrections when sensors were deployed (sites 2 and 3 during water year 2011 and all sites during water year 2012). Prior to deploying a wind monitor at sites 2 and 3, wind speed at the height of the collector was estimated (1) by relating CSAT3 anemometer measurements to wind-monitor measurements, when available, using ordinary least-squares regression and (2) by adjusting CSAT3 anemometer measurements to the height of the precipitation collector. Coefficients of determination ($r^2$) describing regressions at sites 2 and 3 were strong (greater than 0.98).

Tipping-bucket precipitation measurements collected over a 30-minute interval were gap-filled and corrected to match monthly volumetric measurements prior to applying undercatch corrections. Volumetric-gauge corrections to tipping-bucket measurements increased values by 35 percent at site 1, 14 percent at site 2, 15 percent at site 3, and 32 percent at site 4 over the period of record. Wind-related undercatch corrections increased volumetric-corrected tipping-bucket measurements by 19 percent at site 1, about 12 percent at site 2, 12 percent at site 3, and 18 percent at site 4 over the period of record (table 11). During periods when the tipping-bucket sensor malfunctioned and concurrent measurements of continuous precipitation and wind speed were unavailable, volumetric-gauge data were increased for wind undercatch using the geometric mean of corrections taken when all sensors were functioning properly and for precipitation type (liquid, mixed, or snow). Uncertainty associated with using the geometric mean was evaluated using the standard deviation of these corrections and was incorporated into the uncertainty presented in table 12.

Discrepancies between volumetric gauge and tipping-bucket measurements could reflect unrecorded precipitation by the tipping-bucket gauge during small events (where water accumulation in the bucket evaporated before tipping) or unrecorded snowfall by the tipping bucket. Larger discrepancies at sites 1 and 4 than at sites 2 and 3 likely reflected unrecorded snowfall due to wind-removal of the snow overtopping tipping-bucket gauges. Wind speeds at sites 1 and 4 were substantially greater than at sites 2 and 3 (table 11) because the precipitation collector orifices at sites 2 and 3 were positioned closer to the height of the vegetation canopy, where wind is greatly reduced, whereas the collector orifices at sites 1 and 4 were positioned well above the short canopy, minimizing the canopy effects on wind.

Snowfall measurement errors were assumed to minimally affect water-year precipitation measurements because volumetric gauge orifice funnels were removed during winter, and antifreeze was added to the gauges to minimize the amount of snowfall potentially overtopping the collectors. Wind-related undercatch corrections for snowfall, however, could bias estimates, because tipping buckets do not reliably measure snowfall. Snowfall typically accumulates in the tipping-bucket gage orifice while temperatures remain below freezing and is not measured by the tipping-bucket gauge until it is melted. Measurement of this precipitation at a later time and altered wind speed could bias undercatch corrections. Similarly, if snowfall exceeds a few inches before melting, it can overtop tipping-bucket gauges and not be measured, biasing measurements low.

### Source-Area Measurements

Source areas for turbulent-flux and available-energy measurements vary according to instrument height and placement, the component being measured, wind speed and direction, and the vegetation canopy height and roughness characteristics. The source area for eddy-covariance turbulent-flux measurements (λE and H), often referred to as footprint, is the dynamic

**Table 11.** Annual mean wind speed measured at two heights, liquid fraction of total precipitation, and measured and corrected precipitation at four evapotranspiration sites, Kobeh Valley, Nevada, 2011 and 2012.

[Sensor heights are reported in table 9. IR, incomplete record]

| Site number | Water year | Mean wind speed (miles per hour) | | Liquid fraction of total precipitation | Precipitation (inches) | |
|---|---|---|---|---|---|---|
| | | Station anemometer (CSAT3) | Precipitation gage | | Measured | Corrected |
| 1 | 2012 | [1]6.4 | [1]4.3 | IR | 5.7 | 6.8 |
| 2 | 2011 | 4.1 | 2.4 | 0.50 | 11.1 | 12.3 |
| | 2012 | 4.9 | 3.0 | 0.55 | 7.1 | 8.0 |
| 3 | 2011 | [2]3.9 | [2]2.5 | IR | 9.6 | 10.7 |
| | 2012 | 4.4 | 3.0 | 0.58 | 5.9 | 6.6 |
| 4 | 2012 | 5.6 | 5.2 | 0.50 | 6.8 | 8.0 |

[1]Values likely are biased because data were unavailable from early June through September 2012.

[2]Values likely are biased because data were unavailable from October 2010 through early June 2011.

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**Table 12.** Measured annual precipitation, energy-balance evapotranspiration ($ET_c$), soil-water storage change, groundwater evapotranspiration ($ET_{gw}$) and associated uncertainties at four evapotranspiration (ET) sites, Kobeh Valley, central Nevada, 2011–12.

[**Date range:** dates over which groundwater ET was evaluated. **Precipitation:** measured precipitation corrected for wind related undercatch. **Precipitation uncertainty:** includes measurement uncertainty, additive RMS error when wind was not measured at the height of the precipitation collector (2011 data only), and uncertainty associated with using the geometric mean of the undercatch uncertainty when the tipping bucket was offline. **$ET_C$:** computed as the mean of annual measured ET and the maximum potential ET as detrmined by adjusting annual turbulent fluxes upward to achieve full energy balance closure. **$ET_C$ uncertainty:** includes gapfilling and systematic uncertainty associated with energy balance closure. **Soil-water storage change:** applied over the upper 6 inches of soil, assuming that measured near-surface (0.8–2.4 inches below land surface) water content decreased linearly over the upper 6 inches of soil. **$ET_{gw}$:** (Groundwater ET computed as ET minus precipitation plus soil water storage change) divided by the number of years analyzed. **$ET_{gw}$ uncertainty:** uncertainty represents the square root of the sum of squared precipitation uncertainty, $ET_C$ uncertainty, and soil water storage measurement uncertainty (less than 0.001 feet). mm/dd/yyyy, month/day/year]

| Site number | Date range mm/dd/yyyy–mm/dd/yyyy | Precipitation (feet per year) | Precipitation uncertainty (feet per year) | $ET_C$ (feet per year) | $ET_C$ uncertainty (feet per year) | Soil-water storage change (feet per year) | $ET_{gw}$ (feet per year) | $ET_{gw}$ uncertainty (feet per year) |
|---|---|---|---|---|---|---|---|---|
| 1 | 08/25/2011–08/24/2012 | 0.50 | 0.04 | 0.65 | 0.05 | 0.00 | 0.15 | 0.06 |
| [1]2 | 08/28/2010–08/27/2012 | 0.77 | 0.01 | 1.21 | 0.06 | 0.00 | 0.44 | 0.06 |
| [1]3 | 08/05/2010–08/04/2012 | 0.66 | 0.04 | 1.45 | 0.08 | 0.01 | 0.80 | 0.09 |
| 4 | 11/03/2011–11/02/2012 | 0.65 | 0.01 | 1.78 | 0.09 | 0.00 | 1.13 | 0.09 |

[1]Values represent the average of 2 years.

upwind land-surface area contributing to measured water vapor and heat fluxes, whereas that for the available energy measurements (difference between $R_n$ and G) is constant and depends mostly on the net-radiometer height. Turbulent-flux source areas were derived from a dispersion model (Scheupp and others, 1990) and assuming mildly unstable atmospheric conditions. Sensors were mounted at least 5 ft above the average plant canopy to capture the well-mixed and unstable surface layer. Model parameters were determined from vegetative canopy measurements collected during this study and those obtained from Stull (1988). Computed source areas indicated up to 90-percent of the turbulent flux originated from upwind distances of 550 ft at site 1, 440 ft at site 2 (fig. 14), 450 ft at site 3, and 450 ft at site 4. The relative flux contribution peaked within 30 ft upwind of the sensors and decreased asymptotically thereafter. Source areas for available-energy measurements were small relative to turbulent-flux measurements. The 99-percent net-radiometer source area for downward-facing sensors is a circular area with a radius of 10 times the instrument height (Campbell Scientific, Inc., 2010). Net-radiometer source areas extended radially from nearly 80 ft at site 2 to about 100 ft at site 4, but measurements taken directly beneath or perpendicular to the sensors contributed the bulk of the total measured value. Source areas for ground-heat-flux measurements were very small, less than a 1-ft diameter circle around the sensor.

### Site-Level Groundwater Evapotranspiration

Site-scale $ET_{gw}$ was computed by subtracting the sum of annual precipitation and change in soil-water storage from total ET at each of the four ET sites. Total ET sources can include a combination of precipitation, groundwater, and surface water. Surface-water drainages in and local surface-water run-on were not observed in the ET measurement areas during the study period. Therefore, site-scale ET measurements were

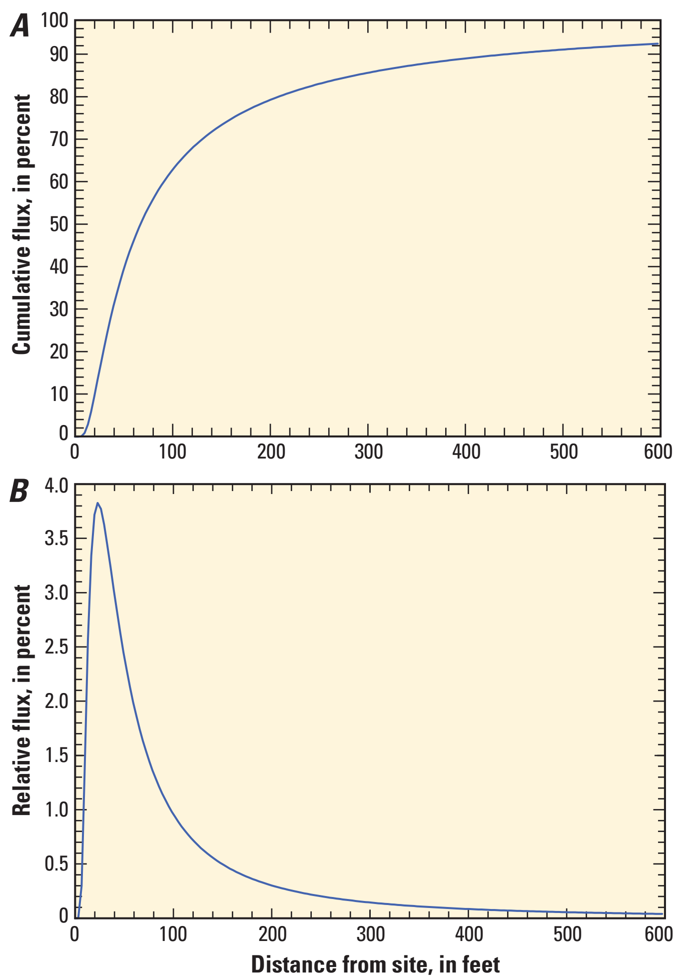


**Figure 14.** Source-area contributions to turbulent fluxes with distance from site 2, Kobeh Valley, Nevada: ***A,*** cumulative and ***B,*** relative measured.

assumed to represent precipitation and groundwater sources only. Local precipitation at each site was assumed to be removed by ET.

Groundwater ET was estimated for periods when differences in shallow, volumetric soil-water content and storage were small to negligible. Water-content differences between the beginning and end of the water year averaged 0.05 $in^3/in^3$ for sites 1–4 and ranged from a minimum of 0 for site 2 in water year 2011 to a maximum of 0.1 $in^3/in^3$ for site 3 in water year 2012 (fig. 12). These differences indicated that a small amount of soil moisture from precipitation that fell during the previous water year was not completely removed by ET in the same water year. Late-summer precipitation during water year 2012 largely led to this difference. At sites 2 and 3, $ET_{gw}$ was evaluated over a 2-year measurement period, whereas sites 1 and 4 were evaluated over a single year.

Wind-undercatch corrected precipitation measurements totaled 12.3 in. at site 2 and 10.7 in. at site 3 during water year 2011 (table 11). During water year 2012, corrected precipitation at the four sites ranged from 6.6 in. at site 3 to 8.0 in. at sites 2 and 4.

Daily $ET_c$ totals generally followed a seasonal pattern, such that ET typically was greatest during the summer and least during the winter (fig. 15). Energy-balance corrections increased ET measurements by about 8 percent at site 1, 6 percent at site 3, and 5 percent at sites 2 and 4. At the moderate-to-dense shrubland sites (sites 2 and 3), $ET_c$ exhibited a minor peak in early spring in addition to the major peak in summer. Early-spring peaks were driven by increasing temperatures and predominantly reflect evaporation of soil moisture from cool-season precipitation. The summer peak, which corresponded with plant growth during the summer months at all ET sites, steadily increased until plants reached full growth during mid-summer and declined thereafter. Summertime $ET_c$ also corresponded with declining groundwater levels (fig. 13). At the sparse shrubland site, site 1, these seasonal patterns were muted because most ET resulted from evaporation of intermittent precipitation.

Potential evapotranspiration (PET) was computed for comparison with $ET_c$ measurements from the grassland site (site 4; fig. 2; table 2). Potential ET was computed using the Priestley-Taylor model, with an alpha value of 1.26 (Priestley and Taylor, 1972), which assumes that all energy available for evaporation is accessible to the plant canopy (Shuttleworth, 1993). Daily $ET_c$ rates measured at site 4 during summer 2011 (June–September) averaged about 8 percent less than PET rates, whereas $ET_c$ rates during summer 2012 averaged about 16 percent less than potential rates (fig. 15). Differences in the ratio of actual to potential ET at site 4 between water years reflect a reduction in water availability, chiefly of water derived from precipitation; annual precipitation was less in water year 2012 than in 2011 (fig. 3; table 2).

Mean annual $ET_{gw}$ estimates increased from 0.15 ft at site 1 to 1.13 ft at site 4 (table 12) consistent with increasing vegetation density. At the moderate-to-dense shrubland sites, taller shrub heights at site 3 than site 2 and the presence of bunch grass at site 3 (table 8) corresponded to a greater $ET_{gw}$ rate (0.80 ft at site 3 and 0.45 ft at site 2, table 12). These estimates corresponded with ET measurement-based values from previous studies at shrubland sites, but appeared low with respect to the grassland site. Previous estimates from sparse to dense phreatophytic shrubland areas at similar latitudes and altitudes in Nevada range from less than 0.08 to about 0.76 feet per year (ft/yr), whereas estimates from grassland areas range from about 1.6 to 2.6 ft/yr (Berger and others, 2001; Moreo and others, 2007). Errors associated with $ET_{gw}$ estimates represent a combination of precipitation and $ET_c$ correction errors (table 12).

## Scaling Groundwater Evapotranspiration from Site to Basin Level

A variety of remote-sensing techniques have been used in groundwater discharge areas to scale point measurements to the basin level (Nichols, 2000; Berger and others, 2001; Moreo and others, 2007; Smith and others, 2007; Laczniak and others, 2008, Allander and others, 2009, Garcia and others, 2014). The amount and rate of water lost to the atmosphere by ET from groundwater discharge areas varies with vegetation type, cover, and structure; precipitation; depth to water; and soil characteristics (Laczniak and others, 1999, 2001, 2008; Nichols, 2000). Satellite imagery, in combination with field mapping, is often used to identify and group areas of similar vegetation and soil characteristics (Laczniak and others, 2001; Moreo and others, 2007; Smith and others, 2007; Garcia and others, 2014). Because ET generally increases with increasing vegetation density and soil moisture, these areal groupings are referred to as ET units because they are assumed to consist of areas with similar ET rates.

Site estimates of groundwater discharge in Kobeh Valley were combined with satellite imagery and PRISM data to scale groundwater discharge from the site to the basin level. Groundwater discharge in the DVFS was estimated by (1) identifying and delineating the GDA; (2) relating a vegetation index calculated from satellite imagery to $ET_{gw}$ rates at sites 1–4 in Kobeh Valley and to precipitation-adjusted $ET_{gw}$ rates (see the “Estimation of Pre-development Groundwater Evapotranspiration” section) at the sites for all other basins; (3) applying this relation to the spatially continuous vegetation index for vegetated areas in basin-specific GDAs; and (4) applying playa $ET_{gw}$ estimates from a previous study to playas in this study. Long-term average annual PRISM precipitation varied among basins in the DVFS.

### Satellite Imagery and Vegetation Indexes

Landsat satellite imagery was used to characterize vegetation cover in the GDA for this study. Landsat is a group of seven Earth-observing satellites, the first of which was launched in 1972, and the most recent in 2013. Each of the Landsat satellites was equipped with one or more sensor instruments designed to collect imagery in several distinct spectral bands in reflective visible and infrared, and emitted

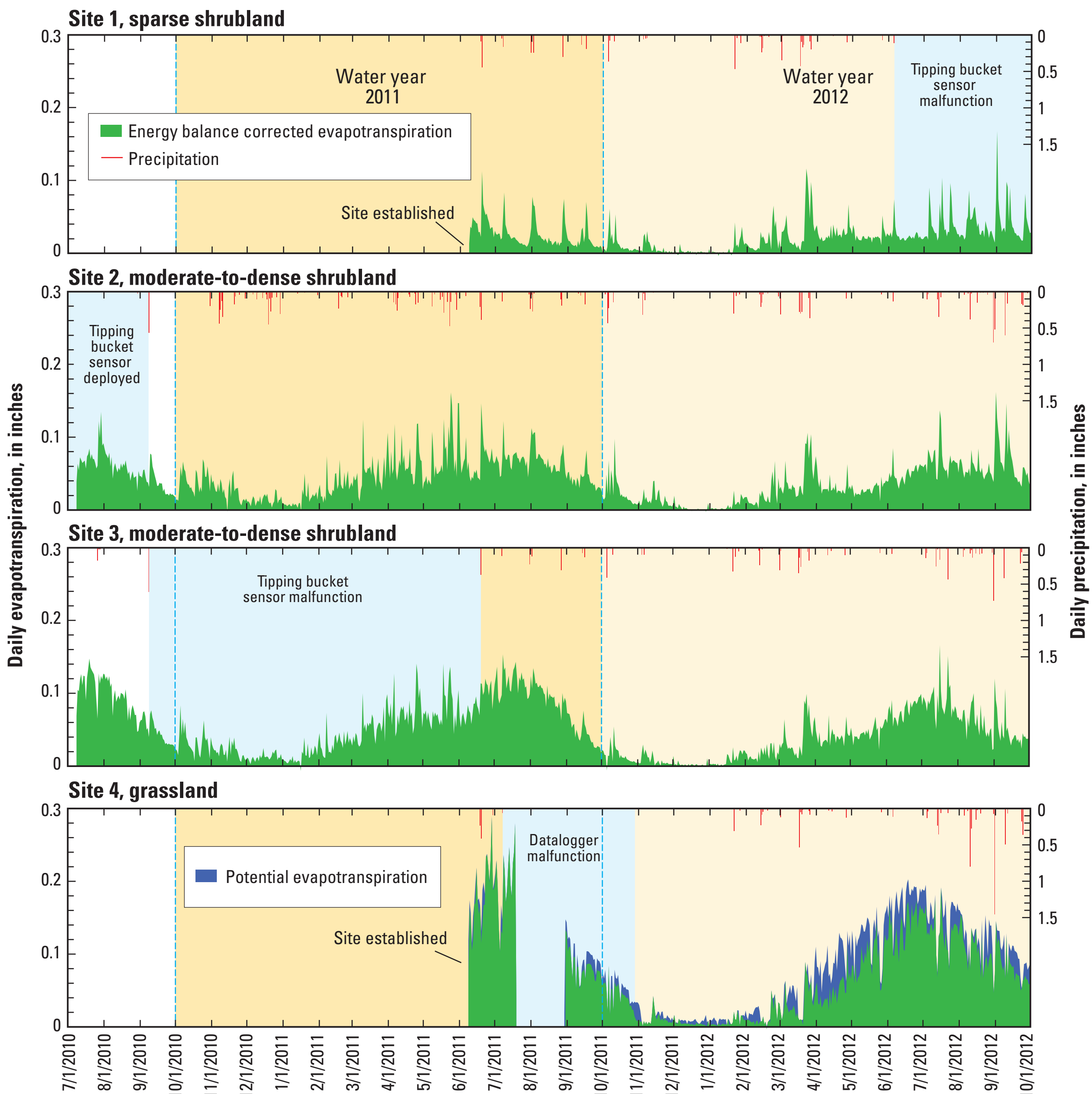


**Figure 15.** Daily energy-balance corrected evapotranspiration ($ET_c$) and precipitation at four evapotranspiration (ET) sites and the computed potential ET at site 4, October 2010 through September 2012, Kobeh Valley, central Nevada.

thermal wavelengths (U.S. Geological Survey, 2012a). Imagery acquired by the Thematic Mapper (TM) instrument aboard Landsat 5 was used for this study. The TM instrument collects information in six spectral bands, with wavelengths ranging from the visible blue (0.45 micrometers, or µm) to the shortwave infrared (2.35 µm), and in an additional seventh band with thermal infrared wavelengths between 10.4 and 12.5 µm. Continuous 112-mile-wide swaths of TM imagery are broken into overlapping "scenes" approximately 105 miles in length. Each scene is imaged by the sensor every 16 days at approximately 100-foot (30-meter) spatial resolution (394-feet, or 120-meters, for the thermal channel) and covers approximately 11,800 $mi^2$. Landsat 5 TM scene locations are identified using a world reference system 2 (WRS2) path and row number. The study area is in WRS2 path 41 rows 32 and 33.

Eight scene dates were selected for evaluation against vegetation conditions and measured ET at the four ET sites in Kobeh Valley. Two scenes for each date were required to cover the study area (table 13). The selected scenes represented a subset of available images, where skies were cloud-free, vegetation canopies were green and active, and little to no antecedent precipitation was observed at nearby weather stations. All of the scenes were acquired by the Landsat 5 TM sensor during the summer months to represent “growing-season” conditions, when phreatophytes in the GDA are actively transpiring, shrubs have reached maximum growth, but the vigor of early summer annual plants is presumed to be at a minimum. Two scene dates from 2011 were collected to coincide with site-scale ET measurements in the study area. No Landsat scenes were available in 2012 as a result of the failure of the TM sensor aboard Landsat 5 during the late winter of 2012. Six additional scene dates were selected from 2007 through 2010 to provide a larger group of data for evaluation against the site-scale ET data. Each scene was atmospherically corrected by the U.S. Geological Survey Center for Earth Resources Observation and Science (EROS) data center using Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) software. The LEDAPS software applies atmospheric corrections to Landsat data to generate a surface-reflectance product. The corrections are based on the Second Simulation of a Satellite Signal in the Solar Spectrum (6S) radiative transfer model used by the Moderate Resolution Imaging Spectroradiometer (MODIS) Land Science Team (U.S. Geological Survey, 2012b). The atmospherically corrected visible, near infrared, and short wave infrared bands for the two scenes for each scene date were mosaicked together to form a single 6-band image covering the study area for each scene date.

Information from multispectral satellite imagery, such as that collected by Landsat 5 TM, can be used to characterize vegetation on the basis of light absorption and reflection characteristics unique to vegetated surfaces. Healthy vegetation absorbs light for use in photosynthesis in the red wavelengths collected in TM band 3 (0.63–0.69 µm) and strongly reflects light in the near infrared wavelengths collected in TM band 4 (0.76–0.90 µm). Vegetation indices, such as the Normalized Difference Vegetation Index (NDVI; Rouse and others, 1974), the Modified Soil-Adjusted Vegetation Index (MSAVI; Qi and others, 1994), and the Enhanced Vegetation Index (EVI; Huete and others, 1999), use the contrast between these distinct absorption and reflectance features to help identify vegetated areas and to characterize the health and spatial extent of vegetation communities.

**Table 13.** Landsat 5 Thematic Mapper scenes evaluated for use in basin-scale estimation of groundwater evapotranspiration, Diamond Valley flow system, central Nevada.

[mm/dd/yyyy, month/day/year; WRS, World Reference System]

| Image date mm/dd/yyyy | Landsat image entity identification | |
|---|---|---|
| | WRS path 41 row 32 | WRS path 41 row 33 |
| 06/30/2007 | LT50410322007181PAC01 | LT50410332007181PAC01 |
| 04/02/2008 | LT50410322008184PAC01 | LT50410332008184PAC01 |
| 04/05/2009 | LT50410322009186PAC01 | LT50410332009186PAC01 |
| 07/22/2010 | LT50410322010173PAC01 | LT50410332010173PAC01 |
| 07/24/2010 | LT50410322010205EDC00 | LT50410332010205EDC00 |
| 08/25/2010 | LT50410322010237PAC01 | LT50410332010237PAC01 |
| 06/25/2011 | LT50410322011176PAC01 | LT50410332011176PAC01 |
| 07/12/2011 | LT50410322011224PAC01 | LT50410332011224PAC01 |

A vegetation index is a unitless single-band image with valid values ranging between −1 and 1. Index values in vegetated areas are nearly always greater than 0, and, in general, the healthier and denser the vegetation, the closer the vegetation index value is to 1. Different vegetation species at 100-percent cover can have different vegetation-index values due to differences in chlorophyll content, internal leaf structure, and canopy structure (Glenn and others, 2008). In combination, these variations can reduce the strength of relationships between the vegetation index and vegetation cover. Vegetation indices that are based on a simple combination of the near infrared and red wavelengths, such as the NDVI, are sensitive to the quantity of green-leaf vegetation in a scene, but also are influenced by the composite background reflectance of the soil surface, plant litter, and woody plant material, particularly in areas of moderate to sparse vegetation cover. The MSAVI and EVI are in a group of vegetation indices that use a canopy background-adjustment factor to reduce the influence of soil and background reflectance on the index and increase the signal from healthy vegetation in the image. The EVI includes an additional correction in the calculation to reduce the effect of atmospheric aerosols on the index.

Multiple vegetation indices were evaluated for their effectiveness at predicting $ET_{gw}$, which was assumed to be directly proportional to phreatophytic shrub density. The EVI, MSAVI, and NDVI were calculated from the atmospherically corrected 2007–11 mosaicked summer Landsat 5 Thematic Mapper (TM) scenes (table 13). The area-weighted average vegetation-index values in the source area for each ET site was compared with the estimated groundwater discharge computed from each site (table 14) using ordinary least-squares regression. Area-weighted vegetation-index values for the ET site source areas were determined by computing the pixel mean of the 45-percent and 90-percent contributing areas at each site. The calculation was done by creating two circular buffers around the ET site in a GIS, so each buffer was mapped as a circular area comparable to the computed 45-percent and 90-percent contributing area. The overlap between the two buffers was removed from the 90-percent contributing-area buffer to avoid double accounting of those pixels when calculating the mean vegetation index for each area. Coefficients of determination ($r^2$) for all the vegetation indices evaluated were consistently greater than 0.6, with the exception of two NDVI images (table 14). The EVI regularly exhibited the best coefficients of determination for all images evaluated; therefore, the EVI was selected for the relation-based $ET_{gw}$ estimation.

The best coefficients of determination for the EVI data were for the June 2007, August 2010, and August 2011 images. Precipitation records at the Combs Canyon, Coils Creek, and Smoky Valley Carvers weather stations (sites 5, 6, and 9; fig. 2; table 2) show that water years 2007, 2008, and 2010 were the driest water years in the 5-year period. Dry years are desirable for evaluation of $ET_{gw}$ from phreatophytes using satellite imagery because the remotely sensed signal from active xeric and annual plants and biological soil crusts should be minimized in years when water from precipitation is limited. Water year 2011 was wetter than the 30-year average annual at all stations where data were available. Although coefficients of determination values for the August 12, 2011, image were good, winter and spring of 2011 were wetter than normal, and early summer images showed pooled water on the Diamond and southern Monitor Valley playas; therefore, summer 2011 images were excluded from further analysis. The July and August 2010 images showed good correlation between measured $ET_{gw}$ and EVI and were the most recent dry scenes available relative to the period of measurement; therefore, these two summer 2010 images were assumed to be adequate to extrapolate $ET_{gw}$ across the basin and were selected for all subsequent calculations. The two 2010 scenes were averaged to create a single, summer-mean EVI image for 2010. The EVI images used in subsequent analyses were multiplied by 1000, and the values converted to integers. These data are referred to as "scaled EVI."

### Groundwater Discharge Area

Groundwater discharge areas typically are characterized by a mix of phreatophytic and xerophytic shrubs, bare soil, and playa. The GDA boundaries represent the margin between xerophytic shrubs that occur outside the boundaries and a mix of xerophytic and phreatophytic shrubs that occur inside the boundaries. In this study, the GDA represents discrete areas in five of the six study area basins (fig. 16). Vegetated areas in the GDA are composed of phreatophytic shrubs with smaller areas of grassland, marshland, xerophytic vegetation, bare soil, and agricultural lands, where phreatophytic shrubs were present historically. The GDA was mapped using techniques similar to those used in studies throughout Nevada and eastern Utah (Nichols, 2000; Laczniak and others, 2001; Smith and others, 2007; Allander and others, 2009; Garcia and others, 2014). National Agriculture Imagery Program (NAIP) imagery from 2010, a digital elevation model (DEM), and water-level data were used in conjunction with field visits to map the GDA at approximately a 1:24,000-scale. During field visits, accessible roads were followed, and the point of transition from predominantly xerophytes to phreatophytes was marked on a digital map using a Global Positioning System (GPS) unit connected to a computer running GIS software. Photographs and notes were taken to document plant and soil conditions present at the marked location. Points, photographs, and notes also were used to document changes in plant communities

**Table 14.** Coefficients of determination describing relations between vegetation indices and site-scale groundwater evapotranspiration ($ET_g$), Kobeh Valley, Nevada.

[EVI, enhanced vegetation index; ft/yr, feet per year; mm/dd/yyyy, month/day/year; MSAVI, modified soil adjusted vegetation index; NDVI, normalized difference vegetation index]

| Site number | $ET_g$ (ft/yr) | Mean scaled source area EVI[1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 06/30/07 | 07/02/08 | 07/05/09 | 06/22/10 | 07/24/10 | 08/25/10 | 06/25/11 | 08/12/11 |
| 1 | 0.15 | 86 | 102 | 108 | 117 | 97 | 95 | 115 | 85 |
| 2 | 0.45 | 114 | 111 | 126 | 113 | 121 | 114 | 124 | 122 |
| 3 | 0.8 | 138 | 150 | 143 | 127 | 163 | 150 | 126 | 155 |
| 4 | 1.13 | 236 | 253 | 371 | 302 | 294 | 228 | 381 | 291 |
| | Coefficient of determination ($r^2$) | 0.89 | 0.85 | 0.72 | 0.65 | 0.87 | 0.92 | 0.64 | 0.88 |
| **Site number** | **$ET_g$ (ft/yr)** | **Mean scaled source area MSAVI[1]** | | | | | | | |
| 1 | 0.15 | 73 | 84 | 93 | 99 | 83 | 81 | 98 | 73 |
| 2 | 0.45 | 96 | 94 | 109 | 96 | 102 | 96 | 103 | 101 |
| 3 | 0.8 | 113 | 124 | 120 | 100 | 133 | 124 | 103 | 129 |
| 4 | 1.13 | 207 | 212 | 320 | 253 | 257 | 202 | 328 | 255 |
| | Coefficient of determination ($r^2$) | 0.85 | 0.85 | 0.71 | 0.62 | 0.84 | 0.88 | 0.62 | 0.86 |
| **Site number** | **$ET_g$ (ft/yr)** | **Mean scaled source area NDVI[1]** | | | | | | | |
| 1 | 0.15 | 114 | 134 | 152 | 159 | 135 | 131 | 161 | 122 |
| 2 | 0.45 | 130 | 132 | 170 | 133 | 142 | 137 | 144 | 146 |
| 3 | 0.8 | 146 | 171 | 189 | 130 | 180 | 178 | 144 | 191 |
| 4 | 1.13 | 306 | 330 | 521 | 409 | 397 | 319 | 513 | 426 |
| | Coefficient of determination ($r^2$) | 0.75 | 0.76 | 0.69 | 0.52 | 0.75 | 0.80 | 0.57 | 0.79 |

[1]Scaled EVI, MSAVI, and NDVI are the result of multiplying the calculated vegetation index by 1,000 and then rounding to the nearest integer.

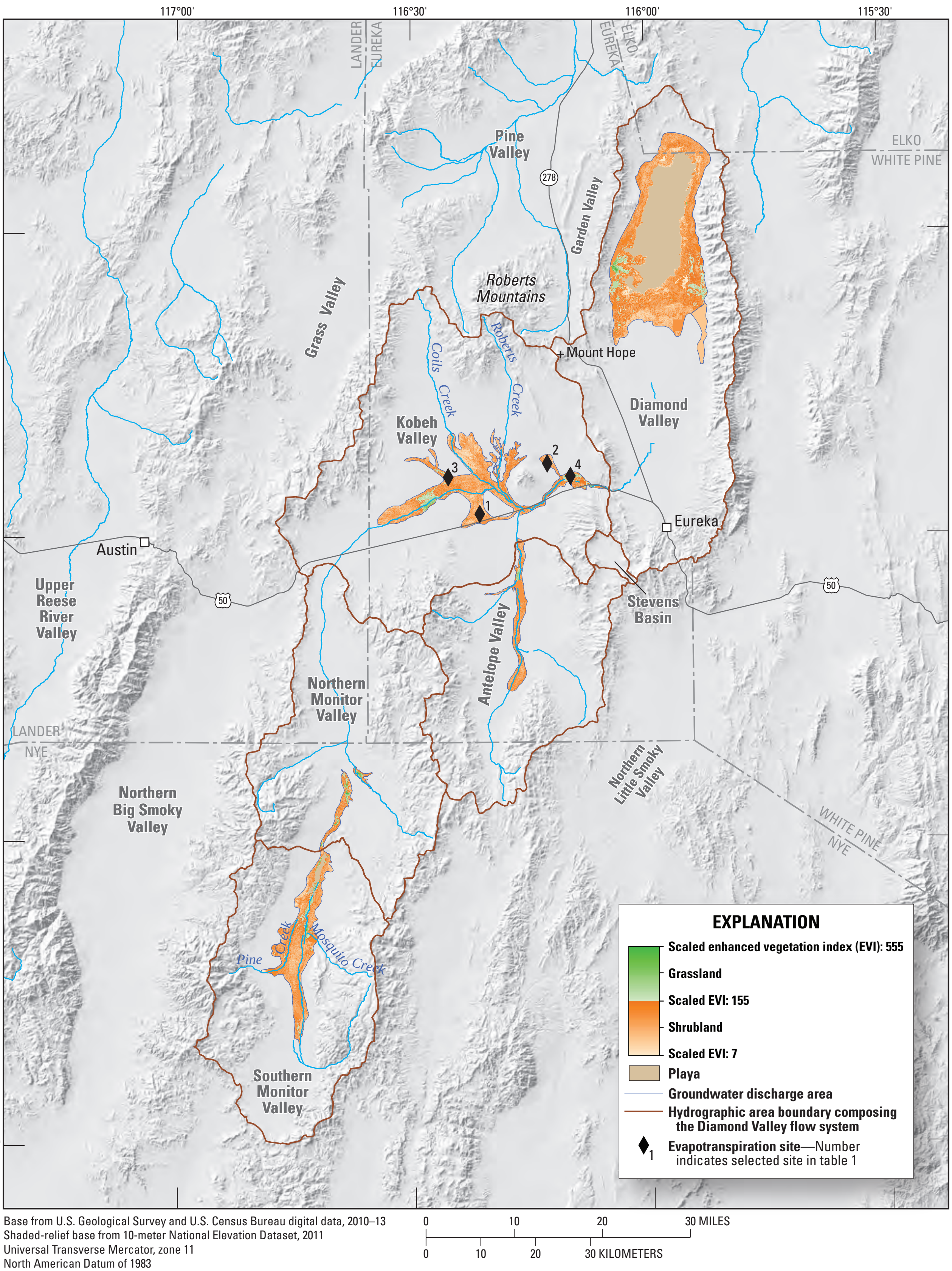


**Figure 16.** Groundwater discharge area, evapotranspiration units, and variation in the scaled summer-mean 2010 Enhanced Vegetation Index (EVI), Diamond Valley flow System, central Nevada.

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inside the mapped GDA boundary. Each valley was visited and mapped in a similar manner, and the final GDA boundary in each valley was digitized into a GIS. The boundary was generalized and smoothed using ancillary datasets, including 2010 NAIP imagery and DEM data, in areas with limited physical access. The GDA boundary encompasses approximately 118,600 acres in Diamond Valley; 47,500 acres in Kobeh Valley; 10,300 acres in Antelope Valley; and 5,400 and 31,700, acres in northern and southern Monitor Valleys, respectively. Digital GIS data representing the GDA are described in appendix 1.

The GDAs and ET units were delineated by Harrill (1968) for Diamond Valley and by Rush and Everett (1964) for Kobeh, Antelope, and northern and southern Monitor Valleys (figs. 17***A***–***C***). The GDA delineations in Antelope and Monitor (north and south) Valleys compared well with the boundary mapped for this study (table 15; figs. 17***B***, ***C***); the GDA delineation in Diamond and Kobeh valleys differed more substantially from the boundary in this study. Some areal differences between the recent and historic boundaries are likely due to the scale of mapping and the more recent availability of high resolution aerial imagery, which aided mapping playa boundaries with greater precision in this study than previously.

This study mapped approximately 19,700 more acres of vegetated land and 7,200 fewer acres of playa in Diamond Valley. The GDA delineated for this study included an area of low-density phreatophytes on the southern border of the Diamond Valley GDA that was not included in Harrill's 1968 delineation (fig. 17***A***). Field observations during recent mapping (fig. 17***A***) showed low-density greasewood and rabbitbrush intermixed with sage south of the 1968 boundary. The sage predominated along small elevation rises throughout the area. Similar conditions existed in areas of Kobeh Valley not included in the Rush and Everett (1964) GDA delineation (fig. 17***B***). This study mapped approximately 19,100 more acres of vegetation than was mapped by Rush; including

**Table 15.** Groundwater discharge areas by vegetation type and groundwater-evapotranspiration (ET) rates from previous investigations and this study, Diamond Valley flow system, central Nevada.

[NA, not applicable]

| Basin | ET unit | Previous estimates | | Recent estimates (2011–12) | |
|---|---|---|---|---|---|
| | | Area (acres) | Annual groundwater ET (acre-feet per acre)[1] | Area (acres) | Area-weighted mean annual groundwater ET (acre-feet per acre) |
| Southern Monitor Valley | Shrubland | [2]30,000 | 0.3 | 27,580 | 0.29 |
| | Grassland | | | 2,752 | 0.89 |
| | Playa | 2,500 | 0.1 | 1,396 | 0.05 |
| | Total | 32,500 | NA | 31,728 | NA |
| Northern Monitor Valley | Shrubland | 5,100 | 0.2 | 4,017 | 0.37 |
| | Grassland | 800 | 1.25 | 1,340 | 0.98 |
| | Total | 5,900 | NA | 5,357 | NA |
| Antelope Valley | Shrubland | 11,000 | 0.2 | 9,869 | 0.40 |
| | Grassland | 1,600 | 1.25 | 439 | 1.03 |
| | Total | 12,600 | NA | 10,308 | NA |
| Kobeh Valley | Shrubland | [3]10,000 | 0.2 | 43,873 | 0.30 |
| | | [4]12,000 | 0.4 | | |
| | Grassland | 6,500 | 1.25 | 3,659 | 0.94 |
| | Total | 28,500 | NA | 47,532 | NA |
| Diamond Valley | Shrubland | 50,000 | 0.3 | 69,066 | 0.29 |
| | Grassland | [5]4,650 | 1.2 | 6,746 | 0.83 |
| | | [6]1,500 | 3 | | |
| | Playa | 50,000 | 0.1 | 42,766 | 0.05 |
| | Total | 106,150 | NA | 118,578 | NA |
| All basins | Total | 185,650 | NA | 213,503 | NA |

[1] Values in Southern Monitor Valley, Northern Monitor Valley, Antelope Valley and Kobeh Valley are from Rush and Everett (1964). Values in Diamond Valley are from Harrill (1968).

[2] Rush and Everett (1964) combines greasewood, rabbitbrush, and small areas of saltgrass, and meadow into one unit.

[3] Rush and Everett (1964) splits greasewood and rabbitbrush into two units. This unit represents greasewood, and rabbitbrush.

[4] Rush and Everett (1964) splits greasewood and rabbitbrush into two units. This unit represents greasewood, rabbitbrush, and saltgrass.

[5] Harrill (1968) splits evapotranspiration in areas supported by spring discharge into two units. This unit represents meadowgrass, hay, and some saltgrass.

[6] Harrill (1968) splits evapotranspiration in areas supported by spring discharge into two units. This unit represents wet meadow, marsh, and is normallly flooded; it includes some acreage of alfalfa.

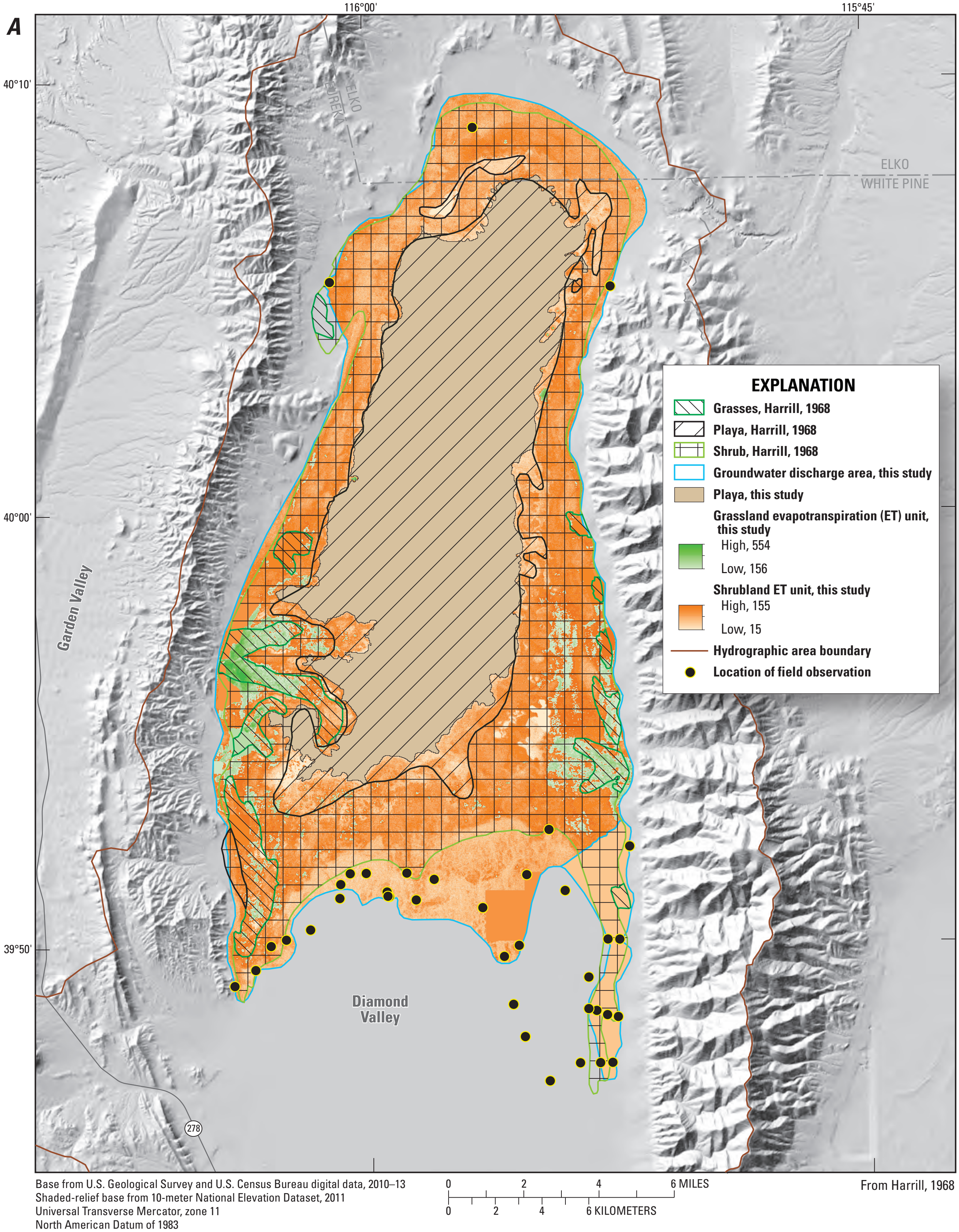


**Figure 17.** Previous groundwater discharge-area delineations compared with 2011 delineations, Diamond Valley flow system, central Nevada, for ***A***, Diamond Valley; ***B***, Kobeh and Antelope Valleys; and ***C***, northern and southern Monitor Valleys.

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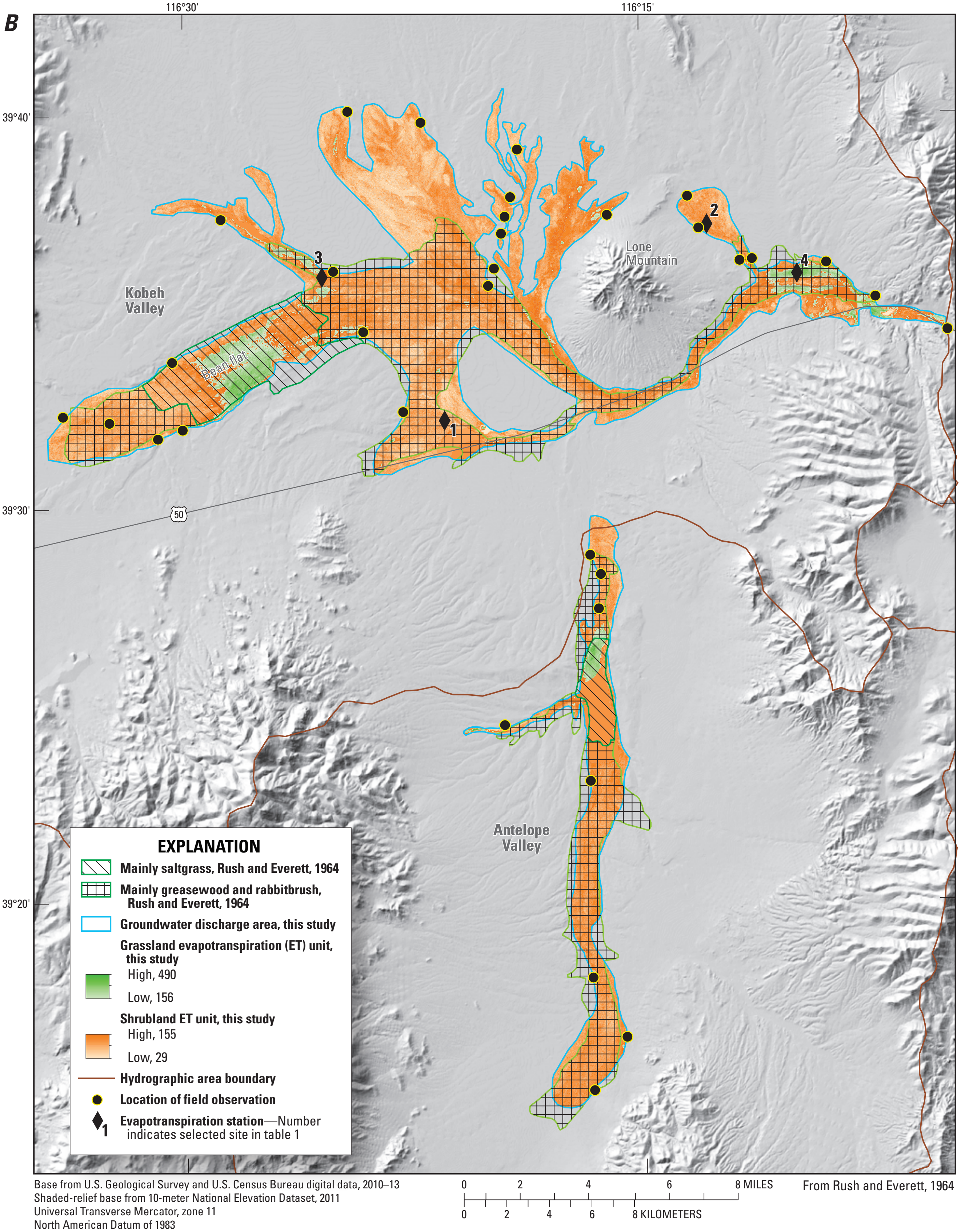


**Figure 17.** Maps showing previous groundwater discharge-area delineations compared with 2011 delineations, Diamond Valley flow system, central Nevada, for ***A***, Diamond Valley; ***B***, Kobeh and Antelope Valleys; and ***C***, northern and southern Monitor Valleys.—Continued

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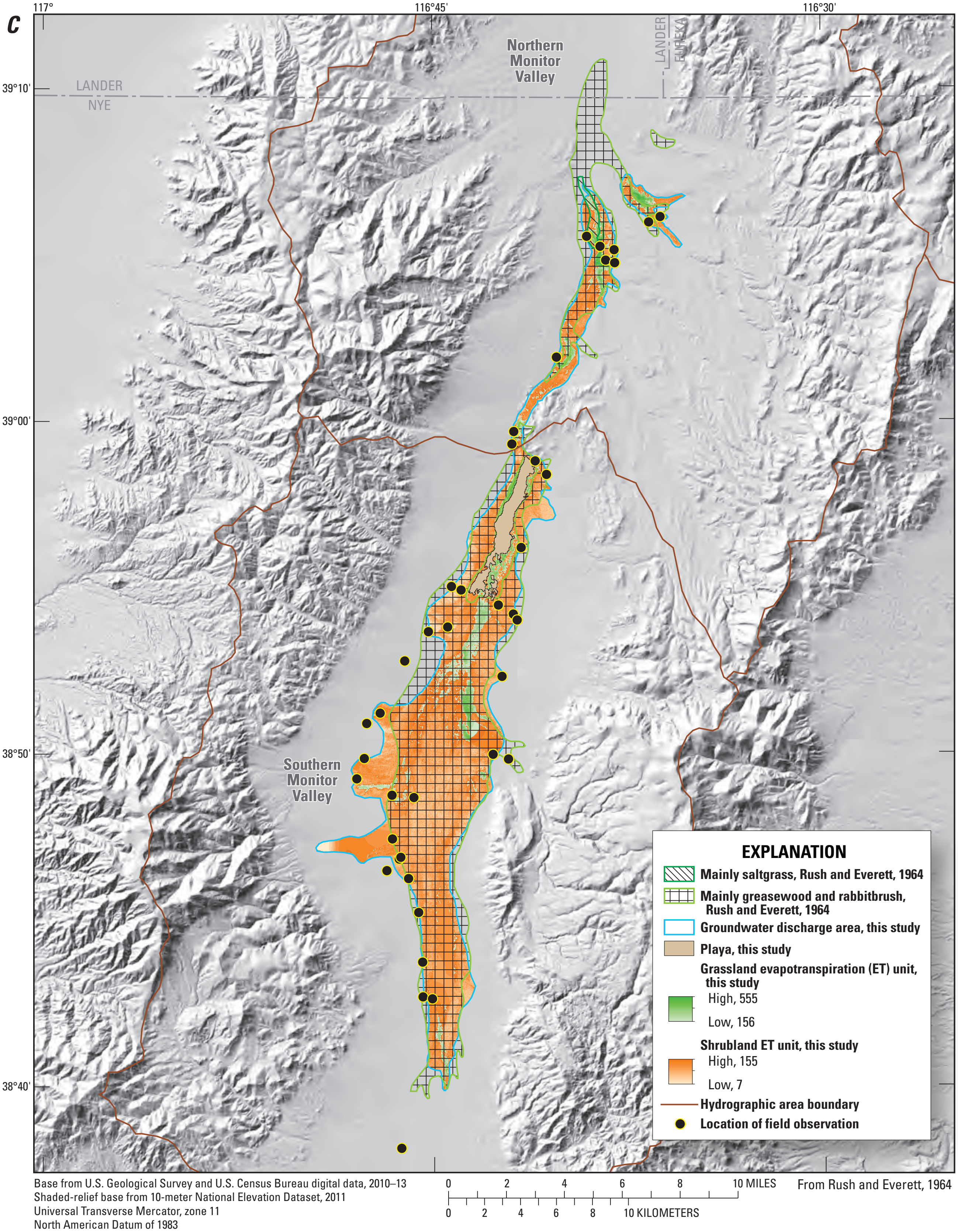


**Figure 17.** Maps showing previous groundwater-discharge-area delineations compared with 2011 delineations, Diamond Valley flow system, central Nevada, for ***A***, Diamond Valley; ***B***, Kobeh and Antelope Valleys; and ***C***, northern and southern Monitor Valleys.—Continued

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about 2,800 fewer acres of grassland and 21,900 more acres of shrubland than previously (table 15). The primary area of mapped grassland in the Rush delineation was around Bean Flat, although 12,000 acres of the total 22,000 acres of shrubland noted by Rush included "greasewood, rabbitbrush, and saltgrass." The greatest difference between the recent and previous delineation was northwest and northeast of Lone Mountain (fig. 17***B***). The area of GDA northeast of Lone Mountain not mapped by the earlier investigation included ET site 2 in a moderately dense greasewood and rabbitbrush community. The area of GDA northwest of Lone Mountain not mapped in the earlier study was composed of mixed greasewood and rabbitbrush interspersed with sage growing on slightly elevated ridges. The interior of the westernmost lobe of the mapped area was not accessible during field mapping, so it was delineated with less detail than the area nearer to Lone Mountain. Scaled EVI values and field observations in accessible areas indicated that the westernmost lobe was similar to the area in the more detailed delineation to the east. This investigation mapped about 2,300 fewer acres of phreatophytes than the delineation presented in Rush and Everett (1964) for Antelope Valley (fig. 17***B***). The areal difference comprised nearly equal areas of grassland and shrubland. Rush included an area influenced by a flowing well as grassland that was removed for the estimate of predevelopment-discharge presented in this report. Other differences can be attributed to scale and small differences in the boundary extents. This study mapped 540 fewer acres of vegetated area in northern Monitor Valley, where the GDA boundary for this investigation was mapped to the south of the boundary presented in Rush and Everett (1964; fig. 17***C***). The greatest boundary difference in southern Monitor valley was between the playa boundary mapped in 1964 and in the recent delineation. This study mapped 332 acres more total vegetated area (grassland and shrubland) in southern Monitor Valley than was mapped previously.

### Characterization of the Pre-development Landscape

Water-resources management in Nevada typically relies on pre-development groundwater budgets that are representative of hydrologic conditions prior to substantial groundwater development. Estimation of pre-development groundwater discharge in the DVFS required that vegetated areas disturbed by recent or historic agriculture and other human activities in the GDA and EVI image be delineated and replaced with historic EVI values. Vegetation index values in disturbed areas were replaced with values from surrounding, undisturbed areas. This was done either by passing a sequence of averaging filters to move smoothed undisturbed data from the perimeter of the disturbed area to the interior or by replacing disturbed area pixels with the mean undisturbed shrubland or grassland value for a particular basin. Disturbed areas were delineated using a combination of NAIP and Landsat 5 TM imagery. Irrigated agriculture and meadows surrounding flowing wells were identified and delineated from Landsat scenes and 2010 NAIP imagery. Areas where natural springs had been diverted for agricultural use were evaluated in different ways. An irrigated, center-pivot field at Bailey Spring (site 54; fig. 2; table 4) in Diamond Valley was delineated, and the mean grassland EVI value was applied to the area. Agricultural areas to the north and south of Shipley Hot Spring (site 56; fig. 2; table 4) were delineated, and the mean shrubland EVI value was applied to the disturbed area. Areas of healthy vegetation from spring or spring irrigation runoff west of Bailey and Shipley Hot Spring were not delineated because it was assumed that healthy, native vegetation would grow around natural spring-discharge areas. Areas in the southern Monitor Valley GDA, where Mosquito Creek and Pine Creek were diverted for irrigation, were delineated, and filtered, historic EVI values from the surrounding area replaced ones used previously. The Mosquito Creek disturbed area covered 483 acres, and the Pine Creek area covered 1,143 acres. In Antelope Valley, an area influenced by a flowing well was delineated, and the mean shrubland EVI value for Antelope Valley was applied to that area. Other areas in the GDA exhibiting anthropogenic disturbance, such as grazing, were delineated and EVI values were replaced with filtered values from neighboring, undisturbed areas.

Since the mid-1960s, numerous springs, mostly along the western margin of the playa in the northern part of Diamond Valley, have declined in flow or have stopped flowing entirely. Exact timing of the spring-flow decline is mostly unknown. Limited flow measurements at Taft-Thompson Spring (site 53; fig. 2; table 4), along the eastern margin, and Shipley Hot Spring (site 56; fig. 2; table 4), along the western margin, indicated notable flow declines from the mid-1980s to early 1990s. Spring-flow measurements collected in 1965–68 at five major springs (sites 53–57; fig. 2; table 4) in northern Diamond Valley ranged from 0.6 to 6.8 cfs. In 2011–12, only Shipley Hot Springs continued to flow, but at nearly half of the flow rate measured in 1990.

Active agriculture accounted for 7,034 acres of the total, and the residual 746 acres represented rectangular or oddly shaped disruptions in the natural vegetation visible in the NAIP imagery. All disturbances unrelated to active agriculture were in Diamond Valley and likely reflected abandoned agricultural lands, abandoned dwellings, or livestock enclosures. Of the recent disturbance, 2,854 acres were in Diamond Valley, 1,049 acres in Kobeh Valley, 1,305 acres in Antelope Valley, and the remaining 1,826 acres were in southern and northern Monitor valleys.

The southeastern lobe of the GDA in Diamond Valley exhibited elevated EVI, owing to cheat grass and other annuals; therefore, EVI values in this area were replaced. Comparisons between field observations and EVI values indicated that the very sparsely distributed shrubs did not reflect observed EVI values, which were greater than the mean value for the shrubland ET unit. Considering that vegetation in this area was very sparse and that neighboring vegetation was composed of xerophytes, approaches for EVI substitution used for other anthropogenically disturbed areas were unsuitable. In order to accurately characterize the very sparse density of the vegetation canopy and compute a representative $ET_{gw}$ rate, EVI values in this area were replaced with the mean EVI of very sparse areas in the Diamond Valley shrubland ET unit (89). Very sparse areas were delineated as pixels falling in the lower 25th percentile of the shrubland ET unit, or pixels with a scaled EVI value below 99.

Reductions in spring discharge and $ET_{gw}$ due to groundwater withdrawals could not be evaluated with satellite imagery. Greater spring discharge prior to groundwater development likely supported larger areas of healthy vegetation. Landsat imagery used to characterize vegetation density in this study was available only from 1984 to 2011, whereas groundwater development and spring diversions began in the early 1960s. Although historic aerial photographs could provide estimates of the pre-development area supported by springs, comparable vegetation index values and $ET_{gw}$ rates were unknown; therefore, changes in spring flow between pre-development measurements in the 1960s and measurements or observations from this study were accumulated and incorporated into pre-development $ET_{gw}$ estimates.

The spring-flow decline was determined by comparing a simple average of measurements taken in the mid-1960s with winter measurements taken from 2010–12. Negligible spring discharge decline between the mid-1960s and early 1990s indicated either that the springs were not yet affected by groundwater withdrawals or that spring discharge was composed of local precipitation and regional groundwater flow, such that a decline in spring discharge from groundwater withdrawals was equally compensated for by an increase in precipitation rates during the 1980s. Precipitation rates in the late 1960s were 19 percent (fig. 4) above the long-term mean, whereas rates in the early 1980s were 37 percent above long-term rates. During this study, precipitation rates were below the long-term mean; therefore, if springs are partially influenced by recent precipitation, then discharge rates measured during this study likely reflected a decline in precipitation in addition to declining water levels due to groundwater withdrawals.

### Evapotranspiration Unit Delineation

The GDA was partitioned into three ET units on the basis of field observations, satellite imagery, and mean-scaled EVI values at each of the four ET stations in Kobeh Valley (fig. 16 and 18***A***): playa, shrubland, and grassland. The playa ET unit in northern Diamond and southern Monitor Valleys (fig. 16) covered 20 percent (about 44,200 acres, table 15) of the study area GDA. The playa ET-unit boundary represents the transition from vegetation to very sparsely vegetated or unvegetated playa and was delineated initially by digitizing the boundary in a GIS using multiple years of EVI data as a guide. The 2010 NAIP and DEM data were then used to evaluate and refine the initial boundary location. The Diamond Valley and southern Monitor Valley playa boundaries encompassed about 42,800 and 1,400 acres, respectively (fig. 19; table 16). Evaluation of summer and winter Landsat images from 2001 to 2011 and precipitation records indicated that the source of intermittent standing water on the playa surface in both valleys was predominantly runoff of direct precipitation on the playa and precipitation-derived surface water run-on. Digital GIS data representing the ET units are described in appendix 1.

Shrubland and grassland ET units were defined between the playa and GDA boundaries in Diamond and southern Monitor Valleys and for the entire GDA in all other basins. The shrubland ET unit was defined as the 2010 summer mean-scaled EVI values greater than zero and less than or equal to the value in the contributing area of site 3 (153; fig. 18***A***). Scaled EVI values greater than 156 were classified as grassland. Scaled EVI values at site 3 were assumed to represent the upper extent of shrubland density and to define the transition between shrubland and grassland ET units. The mean-scaled EVI value at site 3 corresponded well with field observations of the shrubland-to-grassland transition zone for all the HAs evaluated. Vegetated areas, based on ET unit delineations, covered 79 percent (about 169,000 acres) of the GDA (fig. 16). The shrubland ET unit covered 91 percent (about 154,000 acres) of the vegetated areas, and the grassland ET unit, which was composed both of grass and marsh areas, covered 9 percent (about 14,900 acres) of the vegetated areas. The ET unit delineations were assessed using visual inspection of a combination of Landsat TM images, NAIP imagery, and field-reconnaissance notes and photographs. These delineations reflect general spatial changes on the landscape and were not intended to be exact delineations of plant communities or soil conditions.

### Estimation of Pre-development Groundwater Evapotranspiration

Pre-development $ET_{gw}$ was extrapolated across the flow system using relations between $ET_{gw}$ rates from this study and the pre-development mean-scaled EVI in vegetated areas and between playa $ET_{gw}$ rates from Garcia and others (2014) and ET unit acreages in playa areas. Groundwater ET from native, undisturbed vegetation was assumed to vary minimally from year to year; therefore, $ET_{gw}$ estimates from undisturbed sites in Kobeh Valley were considered to be representative of regional long-term rates.

Relations developed between scaled EVI and site-scale $ET_{gw}$ estimates were guided by water and energy limitations. The relation for the water-limited shrubland ET unit, where annual ET is mostly derived from precipitation, was assumed to follow a steep linear trend relative to the water- and energy-limited grassland ET unit, where ET is mostly derived from shallow groundwater (Garcia and others, 2014). Two separate relations were developed for shrubland and grassland ET units using scaled EVI data from the 2010 summer-mean image. Shrubland areas were characterized by the ordinary least-squares regression between $ET_{gw}$ and EVI at shrubland sites (sites 1–3). Grassland areas were characterized by linear interpolation between $ET_{gw}$ and EVI at sites 3 and 4 and extrapolating this line beyond site 4 (fig. 18). In Kobeh Valley, the relations were applied to spatially continuous pre-development distributions of scaled EVI to estimate $ET_{gw}$

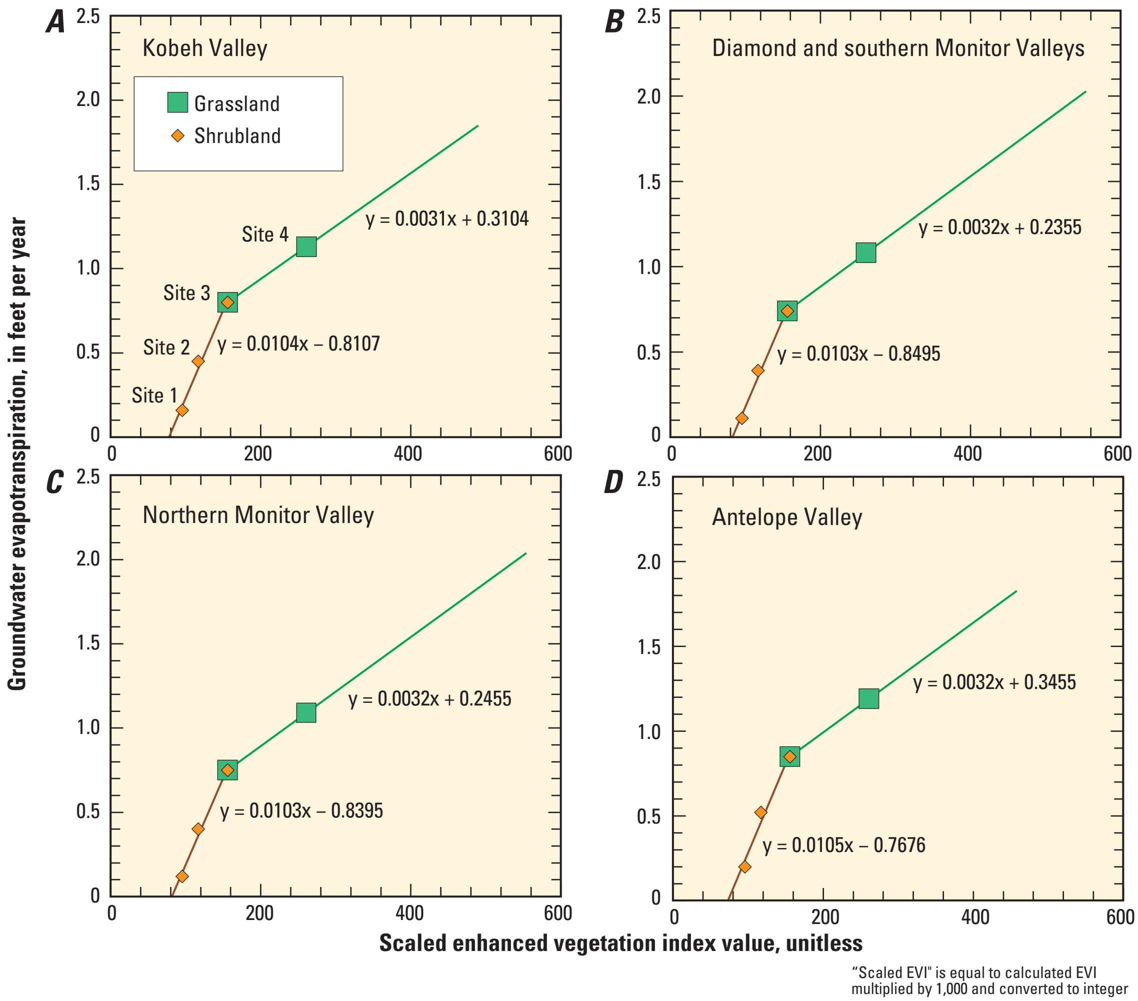


**Figure 18.** Relations between 2011–12 groundwater evapotranspiration and the scaled Enhanced Vegetation Index (EVI) for shrubland and grassland evapotranspiration units for the summer-mean 2010 image, Kobeh Valley, central Nevada. In Kobeh Valley, groundwater evapotranspiration rates were estimated directly; in all other valleys, rates were adjusted for precipitation differences.

on a pixel-by-pixel basis. Groundwater ET from shrubland pixels that have EVI values less than those at site 1 (average-scaled EVI of 96) and from grassland pixels that have EVI values greater than those at site 4 (average-scaled EVI of 261) were extrapolated from the shrubland and grassland relations, respectively. The total area extrapolated beyond the shrubland and grassland relations totaled 31,000 and 1440 acres, respectively, or 15 and less than 1 percent of the total GDA for the DVFS, respectively.

Basin-scale $ET_{gw}$ in Diamond, Monitor Valley (northern and southern part), and Antelope Valley was estimated using relations between precipitation-adjusted $ET_{gw}$ rates at sites 1–4 in Kobeh Valley and EVI. Groundwater ET in a basin generally decreases as phreatophyte density decreases or as precipitation increases. For example, Moreo and others (2007) determined that annual $ET_{gw}$ differed among three sites in three separate basins in eastern Nevada, where vegetation type and density were similar. Differences in annual $ET_{gw}$ corresponded to differences in annual precipitation, where $ET_{gw}$ decreased from site-to-site as precipitation increased. Long-term, average annual-precipitation rates varied among basins in the Diamond Valley flow system; therefore, $ET_{gw}$ rates were assumed to vary with precipitation among basins for a given phreatophyte density. The 30-year (1981–2010) average annual PRISM precipitation rates in Diamond, northern Monitor, and southern Monitor Valleys were 8, 6, and 8 percent greater, respectively, than rates in Kobeh Valley, whereas the 30-year average annual-precipitation rate in Antelope Valley was 9 percent less than in Kobeh Valley (fig. 20).

Groundwater-ET rates were adjusted for each basin by increasing or decreasing precipitation totals reported in table 12 by the relative percentage differences in long-term PRISM precipitation and, then, recalculating $ET_{gw}$ from scaled precipitation rates (see the "Site-Level Groundwater

**Table 16.** Mean annual basin-scale groundwater evapotranspiration (ET) and ET unit area, Diamond Valley flow system, central Nevada.

[**Mean-scaled enhanced vegetation index:** is the result of multiplying the calculated vegetation index by 1,000 and then rounding to the nearest integer. This value represents the mean of pre-development pixels where areas identified as anthropogenically disturbed were replaced with values representing the native landscape. **Mean Annual Groundwater Evapotranspiration:** Values determined using relations shown in figure 18 and the summer mean enhanced vegetation index (EVI) scene shown in figure 16. Values over 1,000 acre-feet are rounded to the nearest 100 acre-feet. **Probable uncertainty:** Determined in Kobeh Valley for vegetated ET units as the sum of up-scaling and site-based estimation uncertainties. Upscaling uncertainty was determined as the standard deviation between estimates determined from July and August 2010 scenes, whereas site-based estimation uncertainty was estimated by adding and subtracting the groundwater ET uncertainty from site-scale groundwater ET rates (table 12) used to scale measurements to the basin level. In addition to uncertainty accumulated for Kobeh Valley, maximum probable uncertainty in other basins incorporated an assumed 10 percent uncertainty for applying rates measured in Kobeh Valley. NA, not applicable]

| Basin | ET unit | Area (acres) | Mean-scaled enhanced vegetation index | Area-weighted mean annual groundwater evapotranspiration (acre-feet per acre) | Mean annual groundwater evapotranspiration (acre-feet) | |
|---|---|---|---|---|---|---|
| | | | | | 2010 summer value | Probable uncertainty |
| Southern Monitor Valley | Shrubland | 27,580 | 112 | 0.30 | 8,300 | 2,000 |
| | Grassland | 2,752 | 205 | 0.89 | 2,400 | 350 |
| | Playa | 1,396 | NA | 0.05 | 70 | 100 |
| | Total | 31,728 | NA | NA | 11,000 | 2,000 |
| Northern Monitor Valley | Shrubland | 4,017 | 117 | 0.37 | 1,500 | 310 |
| | Grassland | 1,340 | 242 | 1.02 | 1,400 | 210 |
| | Total | 5,357 | NA | NA | 2,900 | 370 |
| Antelope Valley | Shrubland | 9,869 | 111 | 0.40 | 3,900 | 780 |
| | Grassland | 439 | 211 | 1.02 | 450 | 63 |
| | Total | 10,308 | NA | NA | 4,400 | 780 |
| Kobeh Valley | Shrubland | 43,873 | 109 | 0.32 | 14,000 | 2,700 |
| | Grassland | 3,659 | 200 | 0.93 | 3,400 | 350 |
| | Total | 47,532 | NA | NA | 17,000 | 2,700 |
| Diamond Valley[1] | Shrubland | 69,066 | [2]112 | 0.30 | 21,000 | 6,000 |
| | Grassland | 6,746 | 186 | 0.83 | 5,600 | 850 |
| | Playa | 42,766 | NA | 0.05 | 2,100 | 2100 |
| | Total | 118,578 | NA | NA | 29,000 | 6,400 |
| All Basins | Total | 213,503 | NA | NA | 64,000 | 7,300 |

[1]Groundwater-evapotranspiration estimates do not compensate for a reduction in pre-development spring flow and pre-development evapotranspiration of that water by native vegetation.

[2]Mean value determined from the pre-development scene, where pixels with erroneously high values along southeastern lobe of the groundwater discharge area were replaced with values representing very sparse shrubland.

Evapotranspiration” section for $ET_{gw}$ computation methodology). For example, in order to develop $ET_{gw}$ -EVI relations in Diamond Valley, annual precipitation at sites 1–4 (table 12) was increased by 8 percent, and adjusted $ET_{gw}$ was computed as annual $ET_c$ minus adjusted precipitation and the change in soil-water storage. Basin-specific relations between precipitation-adjusted $ET_{gw}$ rates at sites 1–4 and EVI (fig. 18) were applied to spatially continuous pre-development EVI values across vegetated ET units in each basin. Reasonable comparisons between measured and PRISM-estimated precipitation rates (30-year, 2011, 2012; table 2; see the “Climate” section) provided confidence in the use of PRISM data to adjust $ET_{gw}$.

Groundwater ET from the playa ET unit was computed by multiplying the ET unit area by playa $ET_{gw}$ rates from Dixie Valley, NV (Garcia and others, 2014). Playa $ET_{gw}$ rates in Dixie Valley were determined from continuous eddy-covariance ET and precipitation measurements collected over 2 years (October 2010–September 2011) at dry and moist playa sites (mean volumetric water contents of 30 and 45 percent, respectively; Garcia and others, 2014). In Diamond and southern Monitor Valleys, physical properties of the playa material and depth to water are largely unknown, but similar to the Dixie Valley playa, phreatophytes, springs, and seeps along the margin indicate that playa material likely is impermeable with respect to the basin-fill alluvial aquifer and restricts regional groundwater movement and discharge. Therefore, the average $ET_{gw}$ rate determined for the Dixie Valley playa (0.05 ft/yr) was applied.

### Groundwater Evapotranspiration Uncertainty

Uncertainty in basin-scale $ET_{gw}$ estimates includes upscaling (from site-to-basin scale) uncertainty, site-based $ET_{gw}$ estimate uncertainty, and uncertainty associated with applying $ET_{gw}$ rates measured in other basins. Upscaling uncertainty was the standard deviation between estimates determined from July and August 2010 scenes. Site-based estimation uncertainty (or average annual groundwater ET uncertainty; table 12) included precipitation uncertainty, ET estimation uncertainty, and soil-water storage uncertainty. Precipitation

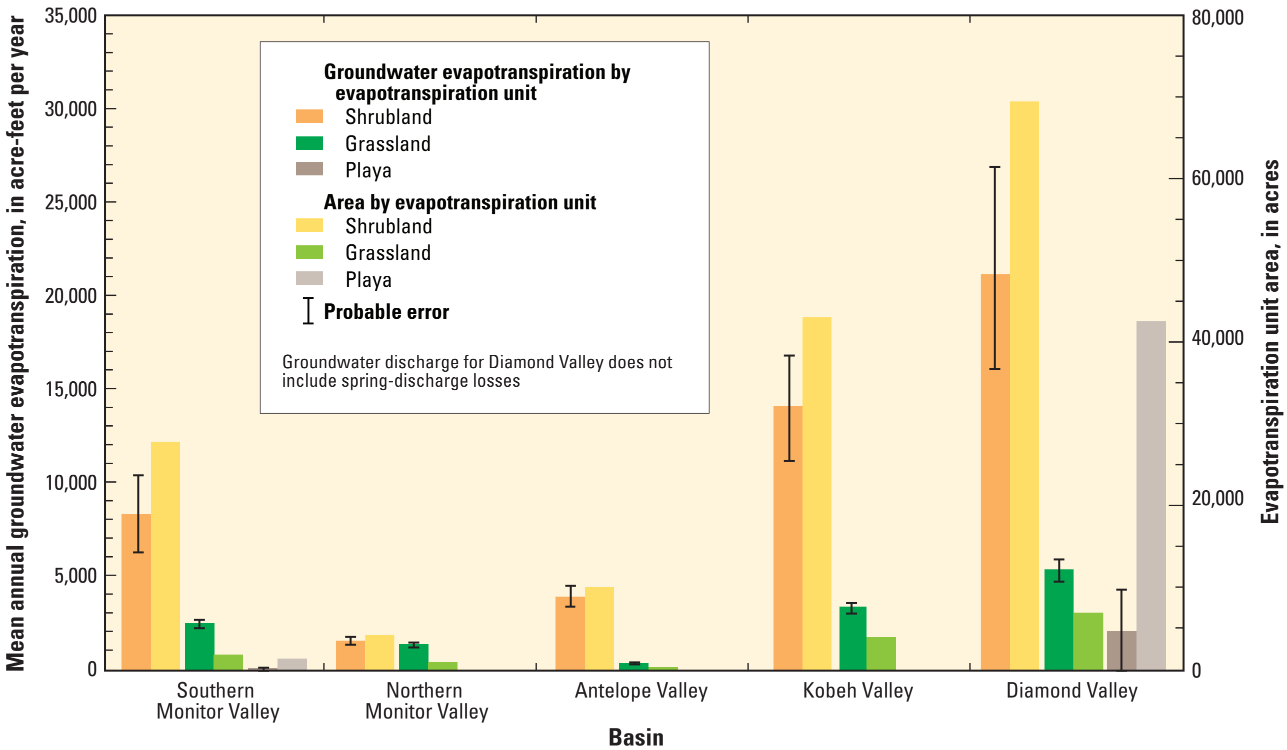


**Figure 19.** Mean annual basin-scale groundwater discharge from and total area of shrubland, grassland, and playa evapotranspiration (ET) units, Diamond Valley flow System, central Nevada.

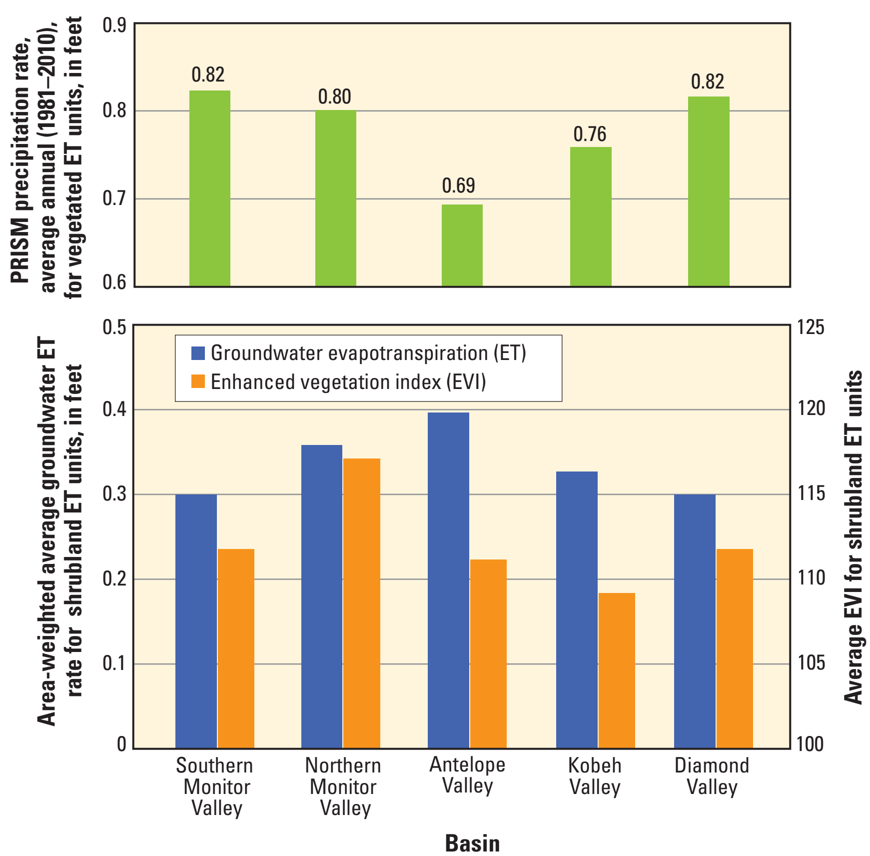


**Figure 20.** Basin-specific comparisons of average annual PRISM (Parameter-elevation Relationships on Independent Slopes Model) precipitation for 1981–2010 in vegetated ET units, area-weighted average groundwater evapotranspiration (ET) for shrubland ET units, and average scaled enhanced vegetation index (EVI) for shrubland ET units for the 2010 summer-mean image, Diamond Valley flow system, central Nevada.

uncertainty included measurement uncertainty, additional root mean squared error when wind was not measured at the height of the precipitation collector (2011 data only), and uncertainty associated with using the geometric mean of the undercatch uncertainty when the tipping bucket was offline. Evapotranspiration estimation uncertainty included gap-filling and systematic uncertainty associated with energy-balance closure. Site-based estimation uncertainty was applied by adding and subtracting the total uncertainty from site-scale groundwater ET rates (table 12) used to scale measurements to the basin level.

Uncertainty related to Kobeh Valley site measurements was applied to the entire DVFS and was not modified on the basis of precipitation-adjusted $ET_{gw}$ rates. Evapotranspiration from phreatophyte areas in southern and northern Monitor, Antelope, and Diamond Valleys was generally assumed to be similar to measured values in Kobeh Valley on the basis of species combinations and growth patterns observed during field reconnaissance.

The proportion of ET attributed to groundwater often varies with differences in hydrologic conditions, including the precipitation amount, soil texture, aquifer properties, surface morphology, and discharge-area characteristics. For example, $ET_{gw}$ estimates could be affected by surface-water contributions in Diamond Valley, elevated vegetation-index values in northern Monitor Valley due to soil background effects, or PRISM-based precipitation adjustments in Antelope Valley. In discharge areas where precipitation is relatively high and the surrounding drainage area is dominated by a steep mountain block, such as the Diamond Range along eastern Diamond Valley, surface-water inflow could be a sizeable component of the ET rate. In northern Monitor Valley, the mean vegetation index for the shrubland ET unit was the greatest of the five discharging basins (by an average of about 6 percent), whereas the surface albedo was the least (by an average of about 5 percent, data not shown). The elevated EVI in northern Monitor Valley could reflect dense phreatophytes or could be influenced by soil background effects from dark, pebble-covered soils unique in the study area to northern Monitor Valley. In Antelope Valley, the mean shrubland $ET_{gw}$ rate was greater than all other DVFS basins and was attributed to a lower (9 percent) long-term average PRISM precipitation rate than was estimated for Kobeh Valley. Although long-term precipitation measurement sites on the valley floor of these two basins were not available, similar altitudes for basin GDAs and a decreasing precipitation trend from north to south (Harrill, 1968) supports a lower precipitation rate in Antelope Valley. The effects of these varying hydrologic conditions on $ET_{gw}$ rates are unknown. Therefore, differences in $ET_{gw}$ among basins were assumed to be primarily driven by estimated vegetation density and precipitation patterns, and the effects of other hydrologic conditions were not considered. A minimum uncertainty of 10 percent was added to $ET_{gw}$ estimates for southern and northern Monitor, Antelope, and Diamond Valleys to account for potential variations in basin-specific hydrologic conditions in Kobeh Valley and the effects of these conditions on $ET_{gw}$ rates.

Uncertainty related to extrapolation of $ET_{gw}$ -EVI relations beyond the range in EVI characterized by sites 1–4 was small and well within the probable $ET_{gw}$ uncertainty of more than 12 percent. Shrubland areas with EVI values less than those at site 1 totaled about 31,000 acres, or 15 percent of the total GDA, but $ET_{gw}$ from these areas was only 5 percent of the total from the GDA. Similarly, grassland areas with EVI values greater than those at site 4 totaled 1440 acres, or less than 1 percent of the GDA, and $ET_{gw}$ from these areas was about 3 percent of the total from the GDA. The maximum $ET_{gw}$ estimated from the grassland relation was 2.04 ft/yr in northern Monitor Valley (fig. 16*C*). This value was slightly less than the net irrigation-water requirements for managed irrigated agriculture in this basin (2.3–4 ft/yr; Huntington and Allen, 2010).

## Groundwater Withdrawals

Most groundwater withdrawals in the DVFS are used for irrigation of agricultural lands in Diamond Valley and Kobeh Valley. Crop inventories in Diamond Valley date back to 1950; the 1950–65 data were compiled by Harrill (1968), and the 1966–2012 data were compiled from NDWR records (fig. 21; Adam Sullivan, Nevada Division of Water Resources, written commun., March 3, 2014). Minor areas of likely irrigation in southern Monitor Valley and Antelope Valley were estimated by remote-sensing techniques (2005–11).

Most groundwater withdrawals in the DVFS were from the southern part of Diamond Valley and were used for growing alfalfa. Harrill (1968) assumed that net pumpage, or the volume of pumped groundwater consumed by ET following irrigation, was about 75 percent of gross pumpage. Residual groundwater, computed as the difference between gross and net pumping, either infiltrates the ground surface and recharges the shallow aquifer system or contributes to runoff (tail water) from irrigated areas that is later consumed by ET in down gradient areas. Since 1966, the NDWR has assumed gross pumpage was 3.0 acre-feet per acre (acre-ft/acre) throughout the DVFS and that about 10 percent of the gross pumpage potentially returned to the groundwater system (Rick Felling, Nevada Division of Water Resources, written commun., July 24, 2014). This yielded a net groundwater withdrawal rate of 2.7 acre-ft/acre, which is similar to the net irrigation water requirement for alfalfa developed by Huntington and Allen (2010). In areas where the depth to groundwater is about 50 to 100 ft, much of the infiltrated water probably is retained in the unsaturated zone and does not reach the water table or takes several decades to reach the saturated zone or water table. In this study, net groundwater withdrawals were estimated as the product of the irrigated acreage and a net pumpage rate of 2.7 acre-ft/acre per year for 1966–2012 in Diamond Valley and for 2006–12 in Kobeh Valley.

Estimates of net groundwater withdrawals in southern Monitor and Antelope Valleys for 2005–11 also were calculated as the product of irrigated acreage and the 2.7 acre-ft/acre net pumpage rate (Rick Felling, Nevada Division of Water Resources, written commun., July 24, 2014). Minor

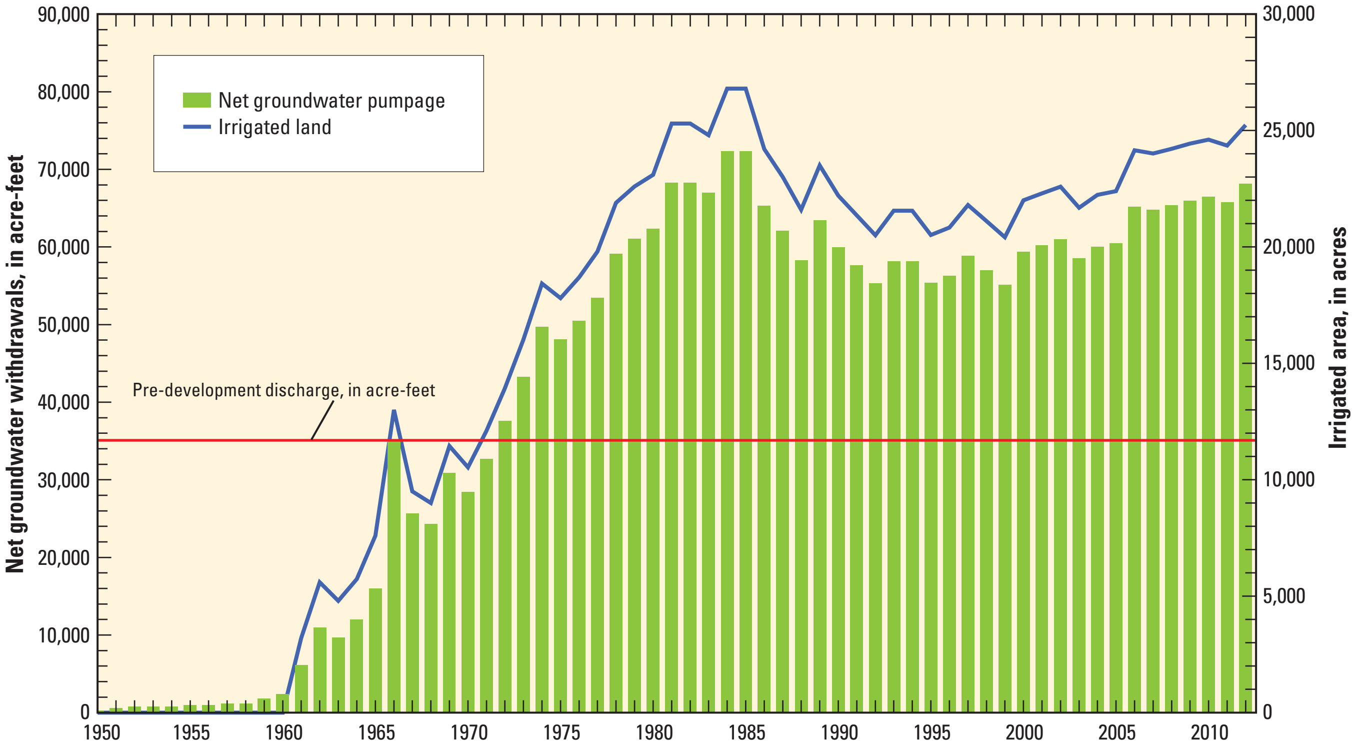


**Figure 21.** Estimated net groundwater withdrawals from pumping, pre-development natural discharge, and irrigated-acreage for 1950–2012 in Diamond Valley, central Nevada.

irrigated areas in these valleys were estimated from summertime satellite imagery and remote-sensing techniques. Reasonable agreement between remotely sensed irrigated areas estimated in Kobeh Valley and Diamond Valley and those areas reported by NDWR provided verification of the remote-sensing techniques applied in southern Monitor and Antelope Valleys.

## Groundwater Recharge

Groundwater recharge from precipitation is the largest component of inflow to DVFS, and, between 1949 and 2011, it was estimated using several methods, including the Maxey-Eakin method (Eakin and others, 1951), the Basin Characterization Model (BCM; Flint and Flint, 2007; Heilweil and Brooks, 2011), and a water-balance relation (this study). The Maxey-Eakin method consists of an empirically derived relation between precipitation and recharge at the basin scale (Maxey and Eakin, 1949). Recharge percentages for selected precipitation zones were developed by balancing recharge and estimated natural groundwater discharge for individual basins. The recharge percentages were mathematically coupled to precipitation distributions developed by Hardman (1936) and Hardman and Mason (1949). The Maxey-Eakin method was designed to estimate basin-scale recharge, which both includes in-place recharge from precipitation and infiltration from streamflow; however, the method does not include subsurface inflow from adjacent basins.

The BCM recharge model (Flint and Flint, 2007) was developed to provide regional consistency among annual estimates of potential recharge from precipitation (in place) and runoff. The BCM is a distributed-parameter water-balance accounting model that uses a compilation of regionally scaled and spatially distributed input data to determine the components and processes necessary to solve the water-balance equation on a grid with a 270-meter cell size. Details on the approach to solve the water-balance equation are presented in Flint and Flint (2007) and Masbruch and others (2011). In general, the BCM identifies areas, on the basis of favorable climatic and geologic conditions, where precipitation potentially becomes in-place recharge or runoff. The BCM defines in-place recharge as the volume of precipitation available after runoff that percolates past root zones and becomes net infiltration. The BCM provides estimates of runoff and the areas where runoff originates, but does not determine the volume of runoff that becomes recharge.

Heilweil and Brooks (2011) used the BCM (Flint and Flint, 2007) to estimate groundwater recharge from precipitation in the DVFS. This study was part of a regional assessment of groundwater availability, driven by a national water census, in which a conceptual model and numerical steady-state model of the Great Basin Carbonate and Alluvial Aquifer System (GBCAAS) were constructed (Heilweil and Brooks, 2011; Brooks and others, 2014). The GBCAAS is an update of the earlier RASA study (Harrill and others, 1983, 1988; Prudic and others, 1995), and as in the RASA no additional hydrologic data were collected. As an important element of the overall conceptual model, new groundwater budgets were developed that used recharge estimated from the BCM. Groundwater budgets based, in part, on the new recharge estimates were reported for 17 regional flow systems, including the DVFS (Masbruch and others, 2011). The GBCAAS assessment assumed that the fraction of runoff that became recharge ranged from 10 to 30 percent, depending on the amount of surface-water irrigation in a selected basin (Masbruch and others, 2011).

In the DVFS, recharge to the groundwater system from precipitation was minimally affected by groundwater development and was assumed to be relatively constant over time. Under steady-state conditions and limited groundwater development, inflow, derived from precipitation and subsurface inflow, equals outflow, derived from groundwater ET and subsurface outflow. For this study, recharge from precipitation is equivalent to the sum of $ET_{gw}$ and net subsurface outflow (subsurface outflow less subsurface inflow).

## Subsurface Flow

Water-level data indicated that net subsurface outflow or interbasin flow in the DVFS goes though the basin-fill aquifer from southern to northern Monitor Valley, from northern Monitor Valley to Kobeh Valley, from northern Antelope Valley to Kobeh Valley, and a minor amount of subsurface flow from Kobeh Valley to Diamond Valley beneath Devil's gate. Estimates of subsurface flow between basins that make up the DVFS were developed by previous investigators (Rush and Everett, 1964; Harrill, 1968) using Darcy's Law. Although these flow estimates were only for the basin-fill aquifer, additional subsurface flow could occur in underlying carbonate or volcanic rocks (Tumbusch and Plume, 2006). The hydrologic properties used to determine the quantity of flow were transmissivity, effective width of the flow section between the basins, and the hydraulic gradient across the flow section.

Subsurface flow through the basin-fill aquifer between hydrographic areas was re-evaluated in this study using previous transmissivity estimates, groundwater-flow sections derived from remotely sensed imagery, and hydraulic gradients determined from the 2012 water-level data. Transmissivity estimates from Rush and Everett (1964) and Harrill (1968) range from 6,700 square feet per day ($ft^2/d$) to 13,400 $ft^2/d$. The flow sections were revised using GIS analyses and recent water-level contours (plate 1). The revised flow cross section between southern and northern Monitor Valleys was 3.1 mi wide and was 3.4 mi wide between northern Monitor Valley and the western part of Kobeh Valley, whereas Rush and Everett (1964) estimated widths of 2 mi and 6 mi, respectively. Differences between previous and revised flow sections are likely due to use of more accurate maps, additional water-level data, and differences in flow-section locations for the revised flow sections. Water-level gradients from spring 2012 indicated the potential for groundwater flow from northern Antelope Valley to eastern Kobeh Valley, but the geologic structure and depositional history most likely restricts flow through most of the cross section (Rush and Everett, 1964; Tumbusch and Plume 2006). The revised flow section between Kobeh and Diamond Valleys at Devil's Gate (about 100 ft) is similar to Harrill (1968).

Revised hydraulic gradient estimates differed from previous estimates. The revised hydraulic gradient between southern and northern Monitor Valleys was about 8 feet per mile (ft/mi) and was about 9 ft/mi between northern Monitor Valley and the western part of Kobeh Valley, whereas Rush and Everett (1964) estimated 20 ft/mi and 10 ft/mi, respectively. The revised hydraulic gradient between Kobeh Valley and Diamond Valley through Devil's Gate was about 30 ft/mi, whereas Harrill (1968) estimated about 10 ft/mi. Hydraulic gradient differences probably resulted from the use of more detailed water-level data in this study and continued groundwater declines in southern Diamond Valley.

## Change in Groundwater Storage

Groundwater withdrawal alters the steady state, or predevelopment, flow system because the source of pumped water is either from an increase in inflow, a decrease in outflow, a decrease in groundwater storage, or some combination of these three. In the DVFS, the source of most pumped groundwater is storage, with lesser amounts from the capture of $ET_{gw}$ (which includes reduced spring discharge). This was inferred because, in Diamond Valley and the DVFS, groundwater was withdrawn primarily outside the GDA or along the sparse edge of the GDA, and the leading edge of the cone of depression in southern Diamond Valley was coincident with the southern extent of the GDA. The change in groundwater storage must be evaluated to adequately describe the groundwater budget under recent, post-development conditions in the DVFS. For this study, recent conditions were represented by the annual average water budget for 2011–12. The volume of groundwater removed from storage was estimated using two independent methods.

The first method assumed that the decrease in groundwater storage was equivalent to the estimate of net pumping less the decrease in $ET_{gw}$ , which was equivalent to the reduction in spring discharge. The second method, the water-level differencing approach, is based on changes in groundwater levels over time multiplied by the specific yield of the basin-fill aquifers. Storage-change estimates using groundwater levels were made only in the southern part of Diamond Valley, because all other areas lacked sufficient historic water-level data and were assumed to be relatively steady. Storage changes were evaluated from 1950 to 2012 and from 2005 to 2012 using water-level contours from Harrill (1968), Tumbusch and Plume (2006), and those developed for this study (plate 1). Water-level contours from previous studies were digitized, and contours from the three separate studies were interpolated to create continuous water-level surfaces. The pre-development (1950) water-level surface in the southern part of Diamond Valley created from Harrill (1968) was subtracted from the post-development spring 2012 surface and multiplied by the estimated distribution of specific yield (Harrill, 1968). The resultant product represented the volume of groundwater removed from storage between 1950 and spring 2012. The change in groundwater storage from 2005 (Tumbusch and Plume, 2006) to 2012 was computed using the same procedure.

# Groundwater Budgets

Pre-development (before 1950) and recent (2011–12) groundwater budgets were developed for each hydrographic area in the DVFS. A pre-development groundwater budget is representative of hydrologic conditions prior to notable groundwater withdrawals and when the groundwater system was in a state of dynamic equilibrium (Theis, 1940). Under pre-development conditions, the volume of inflow equaled the volume of outflow, and change in groundwater storage was assumed to be negligible. Early development in the DVFS consisted of diversion of natural streamflow or springs for direct irrigation of meadow grass and alfalfa or for storage in small reservoirs for later irrigation use (Rush and Everett, 1964; Harrill, 1968). Minor groundwater withdrawals probably began in the 1940s. Large groundwater withdrawals, mainly in the southern part of Diamond Valley, began in the early 1960s and steadily increased to a maximum by the mid-1980s (fig. 21). For the purposes of this study, the pre-development groundwater budget represents annual groundwater conditions prior to 1950. The recent, or "post-development," groundwater budget reflects groundwater conditions as an average annual for 2011–12.

Measured and precipitation-adjusted $ET_{gw}$ rates used to estimate basin-scale groundwater discharge were assumed representative of pre-development long-term rates in the study area. The site-based $ET_{gw}$ rates used to scale values to the basin level were measured in undisturbed areas representative of pre-development, steady-state conditions. Average annual precipitation during the $ET_{gw}$ measurement period reflected long-term rates and groundwater-levels within groundwater-discharge areas changed minimally from pre-development conditions to the study period, indicating that ET and $ET_{gw}$ source water availability reflected long-term conditions. Although precipitation rates measured at ET sites in Kobeh Valley varied from 2011 to 2012, the average precipitation during 2011 and 2012 was generally similar to the long-term average for the area (fig. 3). Relative precipitation differences between basins, which were used to up-scale site-based $ET_{gw}$ rates, were based on long-term average annual-precipitation rates from PRISM. Seasonal fluctuations in groundwater-level were similar during 2011 and 2012 (fig. 13), indicating that the removal of groundwater by ET was similar each year.

The EVI image used to up-scale site-based estimates was modified to reflect pre-development conditions by identifying anthropogenically disturbed areas in the GDA and replacing EVI values in these areas with those from adjacent undisturbed areas. Changes in spring-discharge rates and vegetation cover (with the exception of Diamond Valley) were assumed to be minimal outside of these disturbed areas. In Diamond Valley, spring diversions pre-dating the 1960s and the decline in spring flow that began in the early 1990s likely affected areas beyond those delineated. The effect of declining spring flow on vegetation and estimated pre-development $ET_{gw}$ was compensated for by adding the change in annual spring discharge to EVI-based groundwater $ET_{gw}$ estimates.

## Pre-development

Total pre-development groundwater outflow ranged from 200 acre-ft/yr for Stevens Basin to 35,000 acre-ft/yr for Diamond Valley (table 17). Pre-development $ET_{gw}$ estimates ranged from 0 acre-ft/yr in Stevens Basin to 29,000 acre-ft/yr in Diamond Valley (table 17). Total pre-development outflow estimated for Diamond Valley comprised 29,000 acre-ft/yr of $ET_{gw}$, based on the distribution and density of post-development phreatophytes, and 6,000 acre-ft/yr of $ET_{gw}$, based on observed spring-flow loss since the mid-1960s. Estimated $ET_{gw}$ from shrubland ET unit accounted for about 70 percent or more of the total $ET_{gw}$ in each basin, except for northern Monitor Valley, where shrubland $ET_{gw}$ accounted for about 52 percent, and grassland $ET_{gw}$ accounted for the remainder (table 16). Playa occupied nearly 35 percent of the GDA in Diamond Valley and about 4 percent of the GDA in southern Monitor Valley, but $ET_{gw}$ from the playa accounted for only about 7 percent and less than 1 percent of total $ET_{gw}$ from these basins, respectively.

Groundwater ET estimates for the hydrographic areas were generally greater than the upper range of previous estimates, but were of similar magnitude to them (table 17; Eakin, 1962; Rush and Everett, 1964; Harrill, 1968; Heilweil and Brooks, 2011). The estimated mean-annual $ET_{gw}$ in the DVFS under pre-development conditions was about 70,000 acre-ft. No $ET_{gw}$ was estimated for Stevens Basin, owing to the great depth to groundwater (greater than 450 ft). Differences in basin-scale $ET_{gw}$ were attributable to differences in the ET unit areas and the $ET_{gw}$ rates applied. The mapped GDAs in Antelope and northern and southern Monitor Valleys were comparable to previous studies; however, in Diamond and Kobeh Valleys, delineated GDAs were 1.1 and 1.8 times larger, respectively, than were mapped in previous studies (table 15). Area differences could be due to the use of aerial and satellite imagery and GPS mapping techniques for determination of the GDA. Earlier mapping might have excluded some areas of lower density phreatophytes included in the recent boundary to avoid overestimating discharge when using a single mean rate in the GDA.

Area-weighted mean $ET_{gw}$ rates in acre-ft/acre for shrubland (0.30–0.40 acre-ft/acre across all basins) were similar to previous studies (0.2–0.4 acre-ft/acre), whereas the area-weighted rates for grassland (0.83–1.02 acre-ft/acre across all basins) were generally less than those from previous studies (1.2–3 acre-ft/acre; Eakin, 1962; Rush and Everett, 1964;

**Table 17.** Estimated outflow components of the annual groundwater budget, in acre-feet, for pre-development and recent conditions (average annual 2011–12), Diamond Valley flow system, central Nevada.

[All values rounded to two significant figures. <, less than; —, no data]

| Hydrographic area | Groundwater discharge by evapotranspiration | | | Subsurface outflow to adjacent areas | | | Net groundwater withdrawals | Total outflow | |
|---|---|---|---|---|---|---|---|---|---|
| | Previous estimates[1] | Pre-development | Recent (2011–12)[2] | Previous estimates[3] | Pre-development | Recent (2011–12) | Annual average (2011–12)[4] | Pre-development[5] | Recent (2011–12)[6] |
| Southern Monitor Valley | 9,200 | 11,000 | 11,000 | 2,000 | 1,400 | 1,400 | 550 | 12,000 | 13,000 |
| Northern Monitor Valley | 2,000 | 2,900 | 2,900 | 6,000 | 3,400 | 3,400 | 0 | 6,300 | 6,300 |
| Antelope Valley | 4,200 | 4,400 | 4,400 | Trace | <800 | <800 | 420 | 5,200 | 5,600 |
| Kobeh Valley | 15,000 | 17,000 | 17,000 | 150 | 130 | 130 | 600 | 17,000 | 18,000 |
| Stevens Basin | 0 | 0 | 0 | 200 | 200 | 200 | 0 | 200 | 200 |
| Diamond Valley | 30,000[7] | 35,000[8] | 29,000 | 0 | 0 | 0 | 67,000 | 35,000 | 96,000 |
| Diamond Valley flow system | — | 70,000 | 64,000 | — | 0 | 0 | 69,000 | 70,000 | 133,000 |

[1]Rush and Everett (1964) for Southern and Northern Monitor Valleys, Antelope Valley, Kobeh Valley, and Stevens Basin, Harrill (1968) Diamond Valley. Heilweil and Brooks (2011) discharge values represent an average of previous estimates and are not included.

[2]Represents long-term average annual groundwater ET, excluding irrigated lands.

[3]Rush and Everett (1964) and Harrill (1968).

[4]Estimated from the product of annual average irrigated acreage and net irrigation water requirement (2.7 acre-feet/acre; Rick Felling, NDWR, July 24, 2014). Annual average irrigated acreage for Diamond Valley and Kobeh Valley (2011–12) obtained from Nevada Division of Water Resources (NDWR) (*http://water.nv.gov/mapping/inventories/cropinv.cfm*, accessed March 3, 2014). Southern Monitor Valley and Antelope Valley annual average acreage (2010) estimated from summer-time satellite imagery and remote-sensing techniques.

[5]Pre-development total outflow was calculated as the sum of pre-developmet groundwater discharge by evapotranspiration and pre-development subsurface outflow to adjacent areas.

[6]Annual average (2011–12) total outflow was calculated as the sum of average annual (2011–12) groundwater discharge by evapotranspiration, average annual (2011–12) subsurface outflow to adjacent areas, and average annual (2011–12) net groundwater withdrawals.

[7]Eakin (1962) estimated discharge in Diamond Valley for the native vegetation, meadow, and pasture grasses, and excluded a playa discharge estimate.

[8]Estimate includes 29,000 acre-feet per year groundwater evapotranspiration (ETg) and 6,000 acre-feet per year representing observed spring-flow declines since pre-development time.

Harrill, 1968; table 15). Lower estimates of $ET_{gw}$ in grassland areas were likely attributable to its measured rates at site 4, which were slightly less than grassland $ET_{gw}$ rates from other recent studies in northeastern Nevada (see the “Site-Level Groundwater Evapotranspiration” section). Although area-weighted mean $ET_{gw}$ rates were comparable among shrubland ET units overall, estimated $ET_{gw}$ rates in this study for Antelope and northern Monitor Valleys (0.40 and 0.37 ft/yr, respectively) were the highest among the five discharging basins, whereas rates applied in Rush and Everett (1964; 0.2 ft/yr) for these two basins were the lowest of the reconnaissance estimates among the five basins. These differences could be attributable to the low $ET_{gw}$ rates applied in the reconnaissance studies (and determined in distant basins) and to uncertainties in the recent $ET_{gw}$ estimates (table 16; see the “Groundwater Evapotranspiration Uncertainty” section).

The estimated mean-annual subsurface outflow to adjacent basins, where estimated, ranged from 0 acre-ft from Diamond Valley to 3,400 acre-ft from northern Monitor Valley to the western part of Kobeh Valley (table 17). Revised estimates of subsurface outflow for southern and northern Monitor Valley were 30 and 43 percent less, respectively, than previous estimates (600 and 2,600 acre-ft, respectively) as a result of the lower gradient estimated between southern and northern Monitor Valley and the shorter flow section delineated between northern Monitor and Kobeh Valleys in this study. A maximum mean-annual subsurface flow estimate of 800 acre-ft from Antelope to Kobeh Valley was determined on the basis of surface geology and recent groundwater data. Additional field mapping and aquifer testing is required to make a better estimate of subsurface outflow from Antelope Valley. No re-evaluation of subsurface outflow from Stevens Basin was made. The value of 200 acre-ft reported by Rush and Everett (1964) was used in the calculation for total outflow in this study. The hydrographic area receiving this outflow is unknown.

Groundwater recharge from precipitation was the greatest inflow component and was assumed to be minimally affected by groundwater withdrawals (table 18). For this study, estimates of recharge from precipitation were based on a water-balance relation where recharge from precipitation is equivalent to the sum of $ET_{gw}$ and net subsurface outflow (subsurface outflow minus subsurface inflow). Excluding Diamond Valley, recharge estimates from the water-balance method in this study were within 20 percent of Maxey-Eakin method recharge estimates. Values for southern and northern Monitor Valleys were less than Maxey-Eakin method estimates, whereas values for Antelope and Kobeh Valleys were greater (table 18; Eakin, 1962; Rush and Everett, 1964; Harrill, 1968). Recharge estimates from the BCM (Flint and others, 2004; Heilweil and Brooks, 2011) were generally greater than Maxey-Eakin estimates for all basins. In this study, there was insufficient data to differentiate groundwater recharge from subsurface inflow in Diamond Valley and Diamond Valley

**Table 18.** Estimated inflow components for annual groundwater budget, in acre-feet, representing pre-development and recent conditions (average annual 2011–12), Diamond Valley flow system, central Nevada.

[All values rounded to two significant figures. BCM, Basin Characterization Model; —, no data]

| Hydrographic area | Groundwater recharge from precipitation | | | Subsurface inflow from adjacent areas | | Total inflow |
|---|---|---|---|---|---|---|
| | Maxey-Eakin Method[1] | BCM[2] | Pre-development and recent (2011–12)[3] | Previous estimates[1] | Pre-development and recent (2011–12) | Pre-development and recent (2011–12)[4] |
| Southern Monitor Valley | 15,000 | 16,000–27,000 | 12,000 | 0 | 0 | 12,000 |
| Northern Monitor Valley | 6,300 | 10,000–34,000 | 4,900 | 2,000 | 1,400 | 6,300 |
| Antelope Valley | 4,100 | 5,000–5,900 | 5,200 | Trace | 0 | 5,200 |
| Kobeh Valley | 11,000 | 8,400–19,000 | 13,000 | 6,000 | 4,200 | 17,000 |
| Stevens Basin | 200 | 1,400 | 200 | 0 | 0 | 200 |
| Diamond Valley | 16,000–21,000 | 15,000–23,000 | [5]— | [6]9,200 | [5]— | 35,000 |
| Diamond Valley flow system | — | — | [5]— | — | [5]— | 70,000 |

[1] Rush and Everett (1964) for Southern and Northern Monitor Valleys, Kobeh Valley, Antelope Valley, and Stevens Basin; Eakin (1962) for Diamond Valley; Harrill (1968) for Diamond Valley.

[2] Flint and others (2004), Heilweil and Brooks (2010).

[3] Based on the sum of groundwater evapotranspiration (ET) and net subsurface flow and assumes hydrologic flow system is in dynamic equilibrium (inflow equals outflow). No groundwater ET takes place in Stevens Basin, the Maxey-Eakin estimate for groundwater recharge of Rush and Everett (1964) was used.

[4] Pre-development/average annual total inflow was calculated as the sum of pre-development/average annual groundwater recharge from precipitation and pre-development/average annual subsurface inflow from adjacent areas.

[5] Insufficient data to differentiate groundwater recharge from subsurface inflow.

[6] Includes 150 acre-feet inflow from eastern Kobeh Valley to southern Diamond Valley through Devil's gate (current estimate is 130 acre-feet) and 9,000 acre-feet from Garden Valley (Harrill, 1968). Subsurface flow from Garden Valley was not re-evaluated or included in current study.

recharge estimates, based on the water-balance method, were greater than the upper range of Maxey-Eakin and BCM estimates (by 19 and 9 percent, respectively). Groundwater recharge in Stevens Basin was not estimated in this study, therefore the Maxey-Eakin method based estimate of 200 acre-ft/yr from Rush and Everett (1964) was used (table 18). Total groundwater inflow from precipitation and subsurface inflow from adjacent basins in the DVFS is about 70,000 acre-ft/yr.

The estimated mean-annual subsurface inflow from adjacent basins ranged from 0 acre-ft/yr in southern Monitor Valley, Antelope Valley, and Stevens Basin to 1,400 acre-ft/yr in northern Monitor Valley and 4,200 acre-ft/yr in Kobeh Valley (table 18). Harrill's (1968) estimate of subsurface inflow to Diamond Valley was about 9,200 acre-ft/yr, of which 9,000 acre-ft/yr was assumed to originate from Garden Valley. This estimate was based on an imbalance in the estimated water budget for Garden Valley, where recharge from precipitation was about 9,000 acre-ft/yr greater than estimated discharge (Harrill, 1968). The potential for subsurface flow from Garden Valley was not re-evaluated during this study; consequently, there were insufficient data to differentiate between groundwater recharge and subsurface inflow to Diamond Valley.

## Recent (2011–12)

The 2011–12 groundwater budget for each hydrographic area incorporated estimates of $ET_{gw}$, recharge from precipitation, interbasin flow, spring-flow losses, and net groundwater withdrawals. Outflow estimates were greater than inflow for most areas, and the differences were generally accounted for by a decrease in groundwater-storage (table 19) due to groundwater withdrawal. Imbalances computed for all areas, except Diamond Valley, were within 10 percent of inflow and outflow estimates.

Diamond Valley had the greatest imbalance between groundwater inflow and outflow, about 61,000 acre-ft (table 19), because of groundwater withdrawals for irrigation in the southern part of the valley and the loss of an estimated 6,000 acre-ft/yr of spring flow along the margins of the playa in the northern part of the valley. Estimated annual net groundwater withdrawal was about 65,000 acre-ft in the southern part and about 1,900 acre-ft in the northern part of Diamond Valley. Water levels have shown large declines throughout a large portion of the southern part of Diamond Valley as groundwater has been removed from storage in the basin-fill aquifer (plate 1).

Using the water-level differencing approach, the average annual volume of groundwater removed from storage during the period 2005 to 2011 was estimated to be about 20,000–33,000 acre-ft in the southern part of Diamond Valley or about 33 to 54 percent of the calculated imbalance between inflow and outflow. Total storage loss based on water-level declines during the 7 water years was on the order of 140,000–231,000 acre-ft compared to about 412,000 acre-ft of storage loss estimated from net groundwater withdrawals and reduction in $ET_{gw}$ during the same period. Storage-loss estimates based on net groundwater withdrawals were used in the budget calculations because the water-level differencing approach only was applicable in Diamond Valley, and the specific yield distribution of basin-fill deposits in Diamond Valley was uncertain. The average annual (2011–12) decrease in storage in Diamond Valley was about 61,000 acre-ft/yr (table 19) based on net groundwater withdrawals and the reduction in $ET_{gw}$.

**Table 19.** Average annual groundwater budget, in acre-feet, representing current (2011–12) conditions, Diamond Valley flow system, central Nevada.

[All values rounded to two significant figures. Inflow values are from the Total inflow column in table 18. Outflow and Storage change values are from the Total outflow and Net groundwater withdrawals columns in table 17, respectively. BCM, Basin Characterization Model]

| Hydrographic area | Inflow | Outflow | Storage change | Imbalance[1] |
|---|---|---|---|---|
| Southern Monitor Valley | 12,000 | 13,000 | −550 | −450 |
| Northern Monitor Valley | 6,300 | 6,300 | 0 | 0 |
| Antelope Valley | 5,200 | 5,600 | −420 | 20 |
| Kobeh Valley | 17,000 | 18,000 | −600 | −400 |
| Stevens Basin | 200 | 200 | 0 | 0 |
| Diamond Valley | 35,000 | 96,000 | [2] −61,000 | 0 |
| Diamond Valley flow system | 70,000 | 133,000 | [2] −63,000 | 0 |

[1]Imbalance is equal to inflow minus outflow minus storage change.

[2]Reduction in spring discharge in Diamond Valley was estimated to be 6,000 acre-feet per year.

Groundwater is the source of nearly all the water supply in Diamond Valley, and it is derived from the depletion of groundwater storage; the capture of $ET_{gw}$ (which includes reduction in spring discharge); and, to a lesser extent, recycled irrigation water. Available groundwater supply typically is limited to the amount of $ET_{gw}$ that can be captured by pumping. Because agricultural development in the southern part of Diamond Valley was distant from the GDA (plate 1), most groundwater removed from the southern part of the valley came from storage. Whether the estimated 6,000 acre-ft/yr of spring-flow loss since pre-development in the northern part of Diamond Valley is entirely related to groundwater withdrawals or, is in part related to a decrease in precipitation is unknown. If the combination of net pumpage and $ET_{gw}$ continues to exceed pre-development $ET_{gw}$, water levels are likely to decline indefinitely, precluding establishment of a new equilibrium.

The overall groundwater budget for the DVFS under recent (2011–12) conditions was not in balance. Only if the volume of storage change, assumed to equal net groundwater withdrawals, was included, could the budget be considered in balance. Total annual inflow to the DVFS was about 70,000 acre-ft/yr, whereas outflow was nearly twice that (133,000 acre-ft/yr), resulting in an average imbalance between inflow and outflow of about 63,000 acre-ft/yr during 2011–12 (table 19). The calculated imbalance was only about 9 percent less than the estimated storage change and reflected the uncertainty inherent in estimated budget components.

## Limitations of Methodology

The accuracy of the groundwater budgets presented here is limited by the accuracy of the estimated inflow and outflow components. The largest independently derived water-budget components included groundwater discharge by ET, net groundwater withdrawals, and storage loss in Diamond Valley. Subsurface-flow estimates represented smaller, but noteworthy, components, especially in Diamond Valley.

Annual $ET_{gw}$ documented in this report has probable uncertainties averaging 16 percent for site-based estimates and more than 10 percent for the entire DVFS. Annual site-based ET estimates were considered to be of good quality, within the limits of the assumptions, because accepted data processing and correction methods were applied. The mean energy-balance ratio calculated for all sites and water years (0.9) was noticeably greater than the mean for other ET studies. The probable uncertainty in basin-scale estimates ranged from 13 percent for northern Monitor Valley to 23 percent for Diamond Valley. In Kobeh Valley, the probable uncertainty was 16 percent, and it incorporated EVI scene variability and site-based estimate uncertainties used to scale estimates to the basin level. In addition to uncertainties evaluated in Kobeh Valley, probable uncertainties in southern and northern Monitor, Antelope, and Diamond Valleys incorporated an additional 10 percent uncertainty to account for applying the rates measured in Kobeh Valley. The accuracy of site-based $ET_{gw}$ estimates was limited by site-based $ET_{gw}$ measurements, a lack of $ET_{gw}$ measurements in the DVFS basins other than Kobeh Valley, and any potential errors in differentiating ET units and assigning $ET_{gw}$ rates. Site-based $ET_{gw}$ was limited by the accuracy of the eddy-covariance method to estimate ET, the limited spatial extent of ET measurements, and the period during which ET and precipitation were measured.

The accuracy of basin-scale $ET_{gw}$ estimates was limited by the following assumptions: (1) $ET_{gw}$ was restricted to the GDA; (2) $ET_{gw}$ from vegetated ET units was adequately characterized by linear relations with vegetation indices; (3) $ET_{gw}$ rates from the playa ET unit in the DVFS were equivalent to playa $ET_{gw}$ rates in Dixie Valley, Nev.; (4) differences in $ET_{gw}$ among basins were primarily driven by vegetation density and precipitation magnitudes, and soil characteristics, depth to water, surface water, and effects related to confined or unconfined aquifers were negligible by comparison; (5) precipitation-adjusted $ET_{gw}$ estimates from Kobeh Valley were comparable to unmeasured rates in other DVFS basins, and relative differences in 30-year average annual PRISM precipitation model data for other DVFS basins were accurate;

and (6) basin-scale $ET_{gw}$ estimates were representative of pre-development conditions.

The accuracy of $ET_{gw}$ estimates can be improved and uncertainty reduced by establishing additional ET and precipitation sites in the GDA of each discharging basin and by measuring for longer periods than in this study. As was demonstrated by Moreo and others (2007), small changes in precipitation can affect $ET_{gw}$ rates in a basin. Similarly, application of $ET_{gw}$-vegetation index relations from measured to unmeasured basins can lead to errors in basin-scale discharge estimates. Establishing ET sites in each basin would decrease the amount of interpolation and extrapolation and provide a dataset that allows the effects of differences in precipitation, soil texture, background reflectance, depth to groundwater, and phreatophyte distributions to be evaluated.

The accuracy of groundwater withdrawals, storage loss, and subsurface-flow estimates were limited by the simplifying assumptions used to compute these components. Limiting assumptions for groundwater withdrawal estimates were (1) a net groundwater-pumping rate of 2.7 acre-ft/acre accurately represented the volume of water used by crops and pastureland, and (2) the irrigated acreage reported to the State of Nevada was accurate. Estimates of groundwater-irrigated acreage in Diamond Valley and other valleys made from remotely sensed imagery produced results similar to values reported by the State; therefore these estimates were considered relatively accurate. The assumption that storage loss was equivalent to groundwater withdrawals was considered adequate because, in Diamond Valley and the DVFS at large, most groundwater was withdrawn outside the GDA or along the sparse edge of the GDA, and the leading edge of the cone of depression in southern Diamond Valley was coincident with the southern extent of the GDA.

The accuracy of subsurface-flow estimates was limited by the hydraulic variables used, such as flow sections, hydraulic gradients, and transmissivity. Subsurface-flow estimates could be improved by having additional wells between basins to more accurately measure hydraulic gradients and by using transmissivity estimates derived from aquifer tests rather than specific-capacity data, as were used by others and applied in this study.

## Summary

The Diamond Valley flow system (DVFS), as defined by Harrill and others (1983), consists of six hydrographic areas in central Nevada that are hydrologically connected. Concerns relating to continued water-resources development in the DVFS resulted in a phased hydrologic investigation that began in 2005. The culmination of the phased approach, presented in this report, was designed to increase understanding of the groundwater resources in the DVFS by characterizing the groundwater quality and developing groundwater budgets representing pre-development (pre-1950) and recent conditions (average annual for 2011–12).

The large playa in the north part of Diamond Valley was the terminus of the groundwater-flow system before large scale groundwater withdrawals began in the south part of Diamond Valley. Sometime around the late 1960s, a groundwater divide developed between the area of natural discharge in the north part of Diamond Valley and the area of groundwater development in the south part. The estimated position of the groundwater divide appears to have migrated northward since 2005. This migration indicates that the cone of depression caused by groundwater pumping in the south is expanding radially, has not reached equilibrium, and, eventually, can lead to southward movement of poor-quality groundwater. In general, water-level altitudes and groundwater-flow directions have not changed since 2005 in the other hydrographic areas that make up the DVFS.

The majority of groundwater samples from Diamond, Antelope, northern Little Smoky, and southern and northern Monitor Valleys, and about half the samples from Kobeh Valley, were a calcium-bicarbonate water type. Groundwater samples throughout southern Kobeh Valley, central Diamond Valley, and southern Monitor Valley were a sodium-bicarbonate water type. As groundwater moved from the basin periphery in Diamond Valley from the south to the north, the cation chemistry changed from predominately a calcium-magnesium to a sodium type. Sulfate water types with various cation proportions were found in the northern part of southern Monitor Valley, the western part of Kobeh Valley, and west-central Diamond Valley. Groundwater quality in the DVFS generally was within acceptable drinking-water standards. Of the 100 well and spring sites sampled, only 10 exceed the secondary maximum contaminant level (MCL) for total dissolved solids (TDS) of 500 milligrams per liter.

Stable-isotope signatures of oxygen-18 and deuterium in groundwater and precipitation indicated recharge in the DVFS was relatively recent and was derived from cool-season precipitation. Precipitation samples collected at the four Kobeh Valley evapotranspiration (ET) sites exhibited a strong seasonal pattern with more evaporative enrichment in samples collected during warmer months (July, August, and September) compared to samples collected in cooler months (October, November, and February). Groundwater sampled from 34 well and spring sites was slightly enriched in oxygen-18 relative to the global meteoric water line. This enrichment could reflect groundwater interaction with warmer water along deep flow paths.

Groundwater budgets summarize groundwater inflows, outflows, and changes in groundwater storage. Groundwater conditions in the DVFS prior to about 1950 were considered to be in dynamic equilibrium and were assumed to be representative of pre-development conditions, where groundwater inflow was approximately equal to groundwater outflow, and changes in groundwater storage were negligible. Once pumping began, the equilibrium between inflow and outflow was disrupted, and the source of the pumped groundwater needed to be accounted for in a post-development budget. In the DVFS, most pumped water was accounted for by a decrease in groundwater storage and by the capture of natural groundwater discharge, $ET_{gw}$.

Pre-development (pre-1950) and recent (2011–12) groundwater budgets were developed for each hydrographic area in the DVFS. The pre-development budget included natural groundwater discharge by ET, whereas the recent budget (2011–12) included discharge by ET plus groundwater withdrawals and related decreases in groundwater storage change and declines in spring flow. Components of groundwater outflow included ET by phreatophytes and bare soil, and evaporation from playas (collectively called groundwater evapotranspiration; $ET_{gw}$), net groundwater withdrawals, and subsurface outflow. Components of groundwater inflow included recharge from mountain block (in place) precipitation, infiltration of streamflow and runoff, and subsurface inflow from adjacent basins. Subsurface (interbasin) flow between basins represented small, but important, components of individual hydrographic-area budgets.

Site estimates of groundwater discharge in Kobeh Valley and net irrigation-water requirements for alfalfa in Diamond Valley were combined with satellite imagery to scale groundwater discharge from the site to the basin level. Annual site-scale $ET_{gw}$ estimates increased with increasing vegetation density from 0.15 feet per year (ft/yr) at site 1 to 1.13 ft/yr at site 4. A vegetation index- $ET_{gw}$ relation was used to partition the groundwater discharge area (GDA) into shrubland and grassland ET units and to calculate basin-scale $ET_{gw}$ for each of those units, whereas playa ET units were delineated with satellite and aerial imagery, and discharge rates from a recent nearby study were used. Recent average annual basin-scale $ET_{gw}$ estimates ranged from 0 in Stevens Basin to 29,000 acre-ft/yr in Diamond Valley. An additional 6,000 acre-ft/yr of spring-flow loss since pre-development time was included in the total outflow from Diamond Valley (35,000 acre-ft/yr). This 6,000 acre-ft/yr most likely represented a maximum spring-flow loss, because seasonal variability in spring flow was not generally known. The estimated groundwater discharge from the shrubland ET unit accounted for 80 percent or more of total discharge for each valley, except for northern Monitor Valley, where shrubland accounted for only 57 percent of total discharge, and grassland accounted for the remainder. Playas covered about 35 percent of Diamond Valley and 4 percent of southern Monitor Valley, but the playa ET unit accounted for only about 6 percent and 1 percent of discharge in those valleys, respectively.

Groundwater withdrawals in the DVFS mostly supported agriculture in the southern part of Diamond Valley. Estimates of net groundwater withdrawals were determined by assuming 10 percent of the gross pumpage returns to the groundwater system. Net groundwater withdrawals were determined by the product of irrigated acres and 2.7 acre-ft/acre and were considered to be minimum values. The average annual estimates of groundwater pumping (2011–12) ranged from 0 in northern Monitor Valley and Stevens Basin to 67,000 acre-ft/yr in Diamond Valley. Estimates of net groundwater pumpage were assumed to be equivalent to the change in groundwater storage minus the decrease in $ET_{gw}$.

In the DVFS, recharge to the groundwater system from precipitation was minimally affected by groundwater development and was assumed to be relatively constant with time. Under steady-state conditions and limited groundwater development, inflow derived from precipitation and subsurface inflow equals outflow derived from groundwater ET and subsurface outflow. For this study, estimates of recharge from precipitation were based on a water-balance relation where recharge was equivalent to the sum of $ET_{gw}$ and net subsurface outflow. The average annual groundwater inflow ranged from 200 acre-ft/yr in Stevens Basin to 35,000 acre-ft/yr in Diamond Valley.

Subsurface flow through the basin-fill aquifer between basins was re-evaluated in this study using transmissivity estimates made previously, groundwater flow sections derived from remotely sensed imagery, and hydraulic gradients determined from 2012 water-level data. Subsurface outflow to adjacent basins in the DVFS ranged from 0 acre-ft from Diamond Valley to 3,400 acre-ft from northern Monitor Valley to the western part of Kobeh Valley. Recent subsurface-inflow estimates to adjacent basins in the DVFS ranged from 0 in southern Monitor Valley, Antelope Valley, and Stevens Basin to 4,200 acre-ft/yr to Kobeh Valley. Not enough information was available to estimate subsurface inflow to Diamond Valley.

Under pre-development conditions, inflows equaled outflows, and individual hydrographic areas were in balance. Inflow and outflow values ranged from 200 acre-ft/yr for Stevens Basin to 35,000 acre-ft/yr for Diamond Valley. The DVFS was also in balance at about 70,000 acre-ft/yr. Under recent conditions, estimates of outflow were greater than inflow for most areas; however, the imbalances were generally accounted for by estimates of net groundwater pumpage, which was assumed to be equivalent to groundwater-storage change. Imbalances computed for all areas, except Diamond Valley, generally were less than10 percent of inflow and outflow estimates.

The overall groundwater budget for the DVFS under recent (2011–12) conditions was generally in balance, if storage change was considered. Total annual inflow to the DVFS was about 70,000 acre-ft/yr, whereas outflow was nearly twice that, resulting in an imbalance of about 63,000 acre-ft/yr during 2011–12. The calculated imbalance was about 9 percent less than the estimated storage change and was a result of the uncertainty in estimated budget components.

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# Appendix 1: Description of Spatial Datasets

The U.S. Geological Survey (USGS) Water Resources Mission Area (WMA) maintains a clearinghouse for publicly available geographic information system (GIS) data on the USGS WMA National Spatial Data Infrastructure (NSDI) node. The NSDI is a physical, organizational, and virtual network designed to enable the development and sharing of digital geographic information resources (Federal Geographic Data Committee, accessed January 7, 2014, at *http://www.fgdc.gov/*). The GIS datasets created in conjunction with this study have been placed on the WMA NSDI node for public access. Brief descriptions of the datasets are included in this appendix. Complete dataset descriptions, including source documentation and processing steps, can be accessed in the metadata documents accompanying the datasets on the WMA NSDI node. The datasets are in GIS format and require specialized software to view.

## Water-Level Altitude Contours for the Diamond Valley Flow System, Central Nevada, 2012

This dataset represents 2012 water levels in the Diamond Valley Flow System (DVFS) depicted on plate 1 of the report associated with this appendix. Water-level contours were developed using data from wells primarily measured in 2012, although earlier water-level data in select wells were used in cases where no new data were available and water levels were not expected to have changed over time. Detailed information about the sites used to construct these contours is available in the main body of the associated report. The dataset can be downloaded from the WMA NSDI node at *http://dx.doi.org/10.5066/F71J97VZ*.

## Irrigated Agricultural Lands and Associated Land Disturbance in the Diamond Valley Flow System, Central Nevada, 2011

This dataset represents agricultural lands assumed to be irrigated in 2011 and associated land disturbances in the DVFS. The data are depicted on plate 1 of the report associated with this appendix. The locations of probable irrigated agricultural lands were interpreted using Landsat imagery from the summer of 2011, National Agricultural Imagery Program imagery from 2010, and well-water use information from the U.S. Geological Survey National Water Information System. Some areas classified as agricultural lands could be irrigated using diverted surface water or springs. Associated disturbances are areas surrounding agricultural lands that might not be irrigated, but have been disturbed as a result of agricultural or other anthropogenic activities. The dataset can be downloaded from the WMA NSDI node at *http://dx.doi.org/10.5066/F7JM27QV*.

## Groundwater Discharge Area for the Diamond Valley Flow System, Central Nevada

This dataset represents the groundwater discharge area (GDA) in the DVFS. The GDA depicts the general boundary of groundwater discharge by evapotranspiration (ET) from phreatophytic plants and moist bare soil. Vegetated areas in the GDA are composed of phreatophytic shrubs with smaller areas of grassland, marshland, xeric vegetation, bare soil, and agricultural lands, where phreatophytic shrubs were present historically. Vegetated areas outside the GDA primarily are composed of xeric vegetation and bare soil, although very sparse phreatophytic shrubs could be present on the outer margins of the boundary. The GDA was mapped in the summer of 2011 using field reconnaissance and supporting digital data. Additional supporting field data were gathered in the fall of 2014. The dataset can be downloaded from the WMA NSDI node at *http://dx.doi.org/10.5066/F75B00K7*.

## Summer Mean Enhanced Vegetation Index for the Diamond Valley Flow System Groundwater Discharge Area, 2010

This dataset represents the mean Enhanced Vegetation Index (EVI; Huete, 1999) of two Landsat 5 Thematic Mapper scenes from the summer of 2010 in the DVFS. The EVI is a type of vegetation index that uses a canopy background adjustment factor to reduce the influence of soil and background reflectance on the index to increase the signal from healthy vegetation in the image. The EVI includes an additional correction in the calculation to reduce the effect of atmospheric aerosols on the index. The data were used to evaluate and estimate groundwater discharge by ET by relating the mean of EVI calculated from July 24 and August 25, 2010, Landsat scenes to ET measured at four eddy-covariance sites in areas of phreatophytic vegetation of varying types and densities in Kobeh Valley, Nevada. Values of ET were extrapolated for all valleys in the study area using the relation developed for Kobeh valley. The dataset can be downloaded from the WMA NSDI node at *http://dx.doi.org/10.5066/F7930R9K*.

## Evapotranspiration Units for the Diamond Valley Flow System, Central Nevada, 2010

This dataset represents ET units derived from the mean EVI calculated from two Landsat 5 Thematic Mapper scenes from the summer of 2010 in the DVFS. The ET units were defined in the DVFS GDA to group areas characterized by similar phreatophytic vegetation type and cover and to extrapolate site-scale groundwater ET estimates across the study area. This dataset represents three ET units: shrubland, grassland, and playa. The grassland ET unit is composed of grassland, meadow, and marshland vegetation types. The ET units were developed using a combination of field reconnaissance, EVI and site-scale discharge measurements. The data were used to evaluate and estimate groundwater discharge by ET in the study area. The dataset can be downloaded from the WMA NSDI node at *http://dx.doi.org/10.5066/F7DV1H0J*.

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# Appendix 2: Water-Quality Data

## Quality Assurance

Water-chemistry sampling followed U.S. Geological Survey (USGS) National Field Manual methods (U.S. Geological Survey, variously dated). Samples analyzed for major ions and trace metals were sent to the USGS National Water Quality Laboratory in Denver, Colorado. Samples analyzed for stable isotopes were sent to the USGS Isotope Laboratory in Reston, Virginia.

A field blank was run during the 2012 sampling event for quality-assurance purposes. This quality-assurance sample was used to ensure that sampling equipment (pumps, sampling lines, and bottles) and actions used to collect, process, and analyze environmental samples did not contaminate environmental samples. Results indicated that concentrations of all constituents used in this study's water quality analyses were at or below laboratory detection limits. Internal components of the pump are made of stainless steel, which can corrode and release trace metals (Wilde, 2004), even after diligent decontamination. Although no corrosion was observed on the pump, concentrations of several major ions (calcium, sodium, chloride, magnesium, silica, and manganese) measured in the field blank were at concentrations above laboratory reporting limits. These major-ion concentrations were within 3 percent of those concentrations in environmental samples; therefore, this level of contamination relative to the environmental concentrations indicates no substantial effect was imparted on data interpretations.

A sequential replicate (U.S. Geological Survey, 2006) sample was collected from site 126 in 2012 to quantify variability associated with the collection and processing of a sample. Replicate and environmental-sample concentrations were generally similar (coefficient of variation less than 5 percent), with the exception of aluminum (coefficient of variation 27 percent), where the environmental and replicate concentrations were 4.5 and 6.6 micrograms per liter, respectively (table 6 in the report associated with this appendix).

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**Banking Storage Account** | **HSU4**

# DETERMINATION OF YEAR-TO-YEAR LOSSES TO BANKED WATER:
# NORTHERN DIAMOND VALLEY

| Annual Efficiency Estimate | Trial/Error Input: | 0.83 |
|---|---|---|
| * | Loss %: | 17.0% |

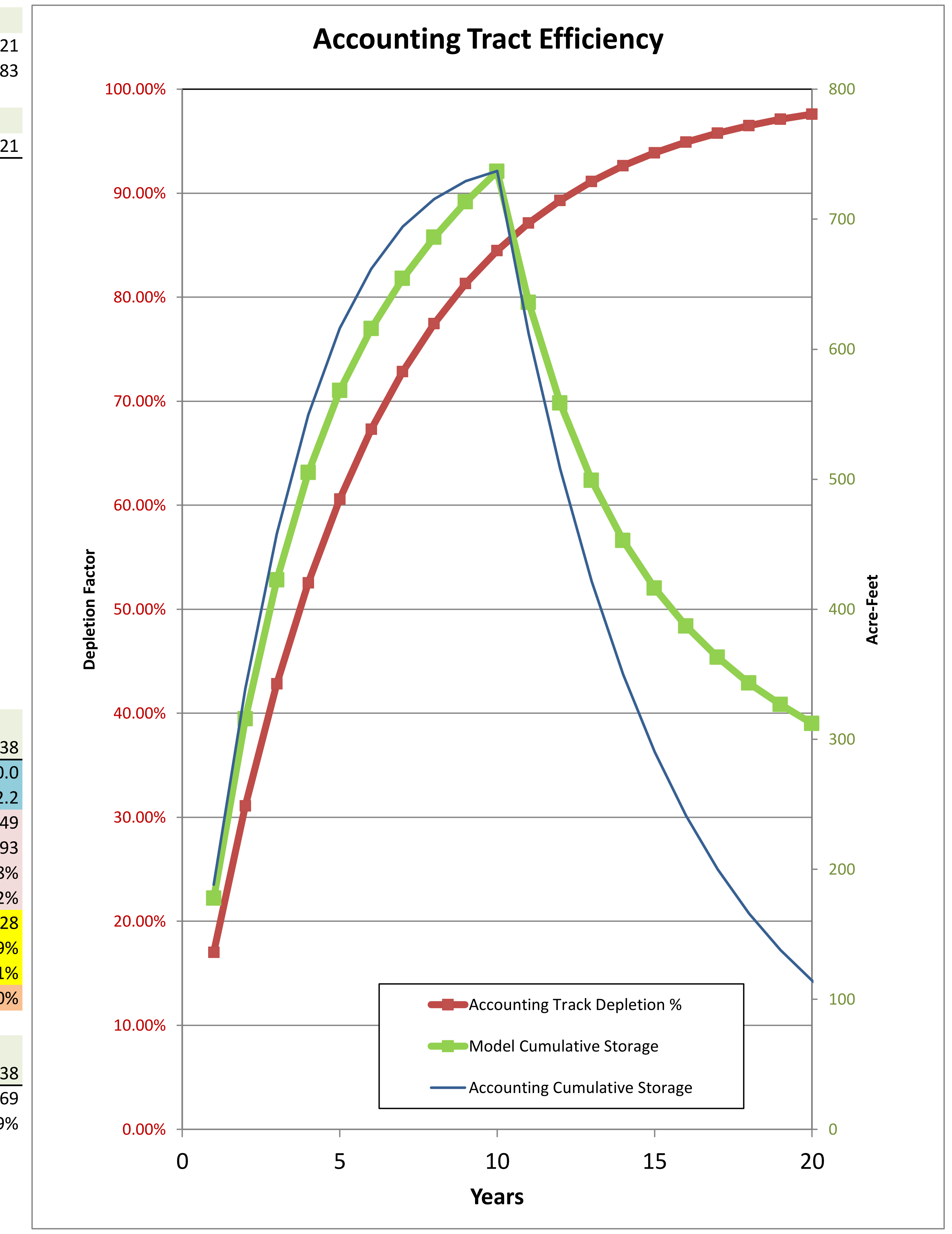
STORAGE ACCOUNT TRACT EFFICIENCY FACTORS

| Year #: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trial and Error Factor: | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 |

VALUES IN ACRE-FEET

TRACT STORAGE ACCOUNTING TABLE

| Year/Track | Banked INPUT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018 | 226.7 | 188.2 | 156.2 | 129.6 | 107.6 | 89.3 | 74.1 | 61.5 | 51.1 | 42.4 | 35.2 | 29.2 | 24.2 | 20.1 | 16.7 | 13.9 | 11.5 | 9.5 | 7.9 | 6.6 | 5.5 | 4.5 |
| 2019 | 219.9 | | 182.5 | 151.5 | 125.7 | 104.4 | 86.6 | 71.9 | 59.7 | 49.5 | 41.1 | 34.1 | 28.3 | 23.5 | 19.5 | 16.2 | 13.4 | 11.2 | 9.3 | 7.7 | 6.4 | 5.3 |
| 2020 | 213.1 | | | 176.9 | 146.8 | 121.9 | 101.1 | 83.9 | 69.7 | 57.8 | 48.0 | 39.8 | 33.1 | 27.4 | 22.8 | 18.9 | 15.7 | 13.0 | 10.8 | 9.0 | 7.4 | 6.2 |
| 2021 | 204.1 | | | | 169.4 | 140.6 | 116.7 | 96.8 | 80.4 | 66.7 | 55.4 | 46.0 | 38.1 | 31.7 | 26.3 | 21.8 | 18.1 | 15.0 | 12.5 | 10.4 | 8.6 | 7.1 |
| 2022 | 192.7 | | | | | 160.0 | 132.8 | 110.2 | 91.5 | 75.9 | 63.0 | 52.3 | 43.4 | 36.0 | 29.9 | 24.8 | 20.6 | 17.1 | 14.2 | 11.8 | 9.8 | 8.1 |
| 2023 | 181.4 | | | | | | 150.5 | 125.0 | 103.7 | 86.1 | 71.4 | 59.3 | 49.2 | 40.9 | 33.9 | 28.1 | 23.4 | 19.4 | 16.1 | 13.4 | 11.1 | 9.2 |
| 2024 | 174.6 | | | | | | | 144.9 | 120.3 | 99.8 | 82.9 | 68.8 | 57.1 | 47.4 | 39.3 | 32.6 | 27.1 | 22.5 | 18.7 | 15.5 | 12.9 | 10.7 |
| 2025 | 167.8 | | | | | | | | 139.3 | 115.6 | 95.9 | 79.6 | 66.1 | 54.9 | 45.5 | 37.8 | 31.4 | 26.0 | 21.6 | 17.9 | 14.9 | 12.4 |
| 2026 | 163.2 | | | | | | | | | 135.5 | 112.5 | 93.3 | 77.5 | 64.3 | 53.4 | 44.3 | 36.8 | 30.5 | 25.3 | 21.0 | 17.4 | 14.5 |
| 2027 | 158.7 | | | | | | | | | | 131.7 | 109.3 | 90.7 | 75.3 | 62.5 | 51.9 | 43.1 | 35.7 | 29.7 | 24.6 | 20.4 | 17.0 |
| 2028 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2029 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2030 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2031 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2032 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2033 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2034 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2035 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2036 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2037 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2038 | 0.0 | | | | | | | | | | | | | | | | | | | | | |




MODELED RESULTS VS STORAGE ACCOUNT

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model/Accounting Annual Banked | 226.7 | 219.9 | 213.1 | 204.1 | 192.7 | 181.4 | 174.6 | 167.8 | 163.2 | 158.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Model/Accounting Cumulative Banked | 226.7 | 446.6 | 659.8 | 863.8 | 1056.5 | 1237.9 | 1412.5 | 1580.3 | 1743.5 | 1902.2 | 1902.2 | 1902.2 | 1902.2 | 1902.2 | 1902.2 | 1902.2 | 1902.2 | 1902.2 | 1902.2 | 1902.2 | 1902.2 |
| Model Annual Storage | 177.5712 | 138.0695 | 106.9767 | 82.53766 | 63.01099 | 47.69855 | 38.45913 | 31.83217 | 27.09439 | 23.46228 | -100.793 | -77.485 | -59.2603 | -46.4072 | -36.4678 | -29.3548 | -23.8053 | -20.0618 | -16.4759 | -14.6333 | -11.8749 |
| Model Cumulative Storage | 177.5712 | 315.6407 | 422.6173 | 505.155 | 568.166 | 615.8645 | 654.3236 | 686.1558 | 713.2502 | 736.7125 | 635.9193 | 558.4343 | 499.174 | 452.7668 | 416.2989 | 386.9441 | 363.1388 | 343.077 | 326.6011 | 311.9679 | 300.093 |
| Model Cumulative Efficiency | 78.32% | 70.67% | 64.06% | 58.48% | 53.78% | 49.75% | 46.32% | 43.42% | 40.91% | 38.73% | 33.43% | 29.36% | 26.24% | 23.80% | 21.88% | 20.34% | 19.09% | 18.04% | 17.17% | 16.40% | 15.78% |
| Model Cumulative Depletion % | 21.68% | 29.33% | 35.94% | 41.52% | 46.22% | 50.25% | 53.68% | 56.58% | 59.09% | 61.27% | 66.57% | 70.64% | 73.76% | 76.20% | 78.12% | 79.66% | 80.91% | 81.96% | 82.83% | 83.60% | 84.22% |
| Accounting Cumulative Storage | 188.1818 | 338.7272 | 458.0344 | 549.5321 | 616.0661 | 661.8803 | 694.2605 | 715.4907 | 729.3482 | 737.0862 | 611.7815 | 507.7787 | 421.4563 | 349.8087 | 290.3412 | 240.9832 | 200.0161 | 166.0134 | 137.7911 | 114.3666 | 94.92428 |
| Accounting Cumulative Efficiency | 83.00% | 75.84% | 69.42% | 63.62% | 58.31% | 53.47% | 49.15% | 45.28% | 41.83% | 38.75% | 32.16% | 26.69% | 22.16% | 18.39% | 15.26% | 12.67% | 10.51% | 8.73% | 7.24% | 6.01% | 4.99% |
| Accounting Cumulative Depletion % | 17.00% | 24.16% | 30.58% | 36.38% | 41.69% | 46.53% | 50.85% | 54.72% | 58.17% | 61.25% | 67.84% | 73.31% | 77.84% | 81.61% | 84.74% | 87.33% | 89.49% | 91.27% | 92.76% | 93.99% | 95.01% |
| Accounting Track Depletion % | 17.00% | 31.11% | 42.82% | 52.54% | 60.61% | 67.31% | 72.86% | 77.48% | 81.31% | 84.48% | 87.12% | 89.31% | 91.13% | 92.64% | 93.89% | 94.93% | 95.79% | 96.51% | 97.10% | 97.59% | 98.00% |

STATISTICS

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Residual (Acct Sto - Mod Sto) | 10.6106 | 23.08652 | 35.41711 | 44.37711 | 47.90016 | 46.01573 | 39.93687 | 29.33491 | 16.09797 | 0.373709 | -24.1378 | -50.6557 | -77.7177 | -102.958 | -125.958 | -145.961 | -163.123 | -177.064 | -188.81 | -197.601 | -205.169 |
| % Error | 4.68% | 5.17% | 5.37% | 5.14% | 4.53% | 3.72% | 2.83% | 1.86% | 0.92% | 0.02% | -1.27% | -2.66% | -4.09% | -5.41% | -6.62% | -7.67% | -8.58% | -9.31% | -9.93% | -10.39% | -10.79% |
| Largest Overestimate | 47.90016 | | | | | | | | | | | | | | | | | | | | |
| Largest % Overestimate | 5.37% | | | | | | | | | | | | | | | | | | | | |
| Largest Underestimate | -205.169 | | | | | | | | | | | | | | | | | | | | |
| Largest % Underestimate | -10.79% | | | | | | | | | | | | | | | | | | | | |

NOTES: Mount Hope numerical model was used to simulate natural losses of banked water in Diamond Valley.
Baseline model was compared to model simulation that incorporated 10 years of banking where 10% of available water to pump is banked.
Comparing the models allowed for the determination of the amount of additional storage in the aquifer and natural losses from the aquifer.
Results from the model were then used to curve-match the modeled determination with a constant "efficiency rate".
The efficiency rate represents the proportion of annual amount of banked water that would remain in the aquifer.
The natural loss % is 1 minus the efficiency rate.

Banking Storage Account: **HSU3**

# DETERMINATION OF YEAR-TO-YEAR LOSSES TO BANKED WATER:
# **SOUTHERN DIAMOND VALLEY**

| Annual Efficiency Estimate | Trial/Error Input: | 0.9975 | |
|---|---|---|---|
| | Loss %: | 0.2% | Round to 1% |

STORAGE ACCOUNT TRACT EFFICIENCY FACTORS

| Year #: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trial and Error Factor: | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 | 0.9975 |

VALUES IN ACRE-FEET

TRACT STORAGE ACCOUNTING TABLE

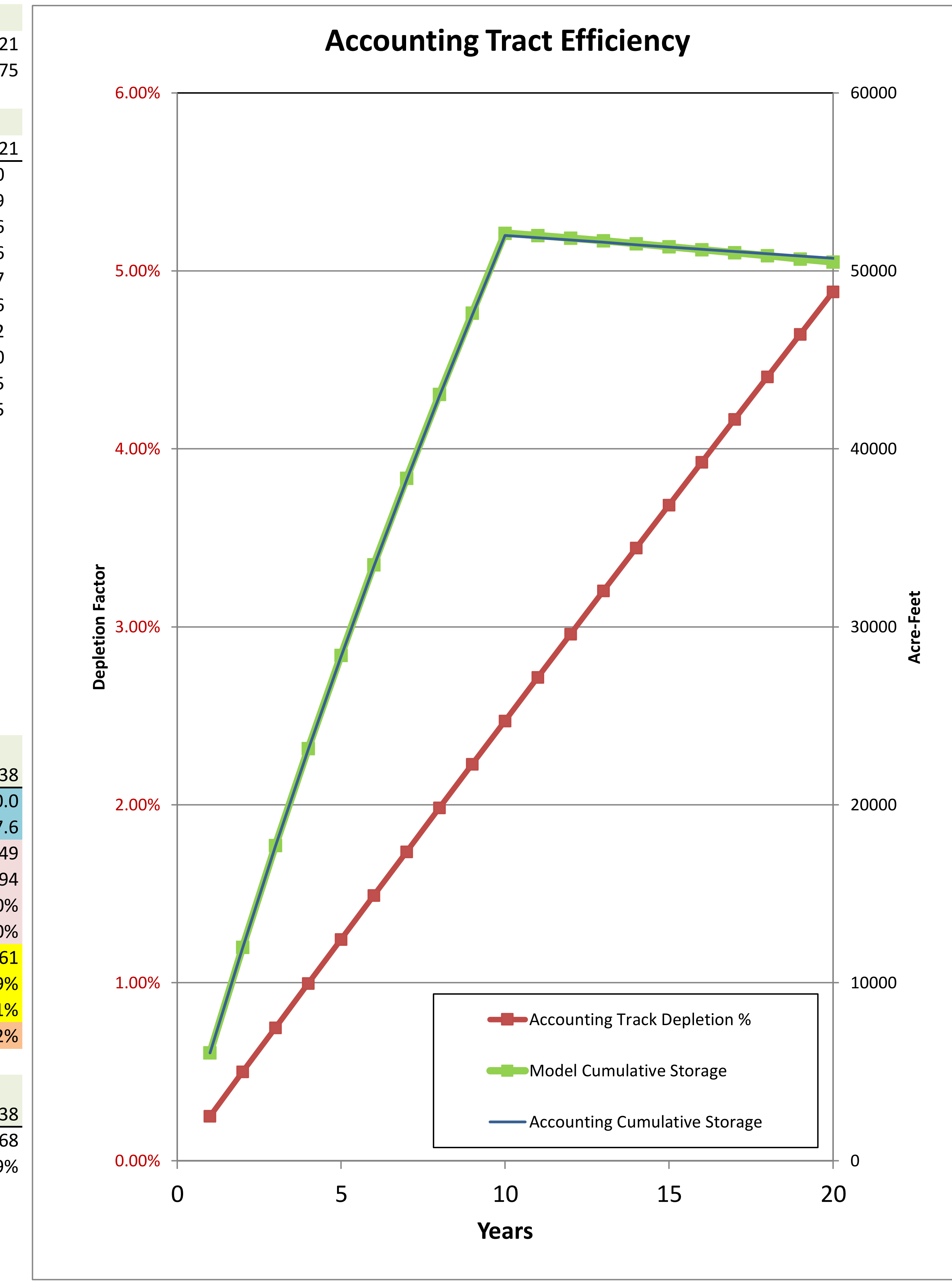
| Year/Track | Banked INPUT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018 | 6074.1 | 6058.9 | 6043.8 | 6028.6 | 6013.6 | 5998.5 | 5983.5 | 5968.6 | 5953.7 | 5938.8 | 5923.9 | 5909.1 | 5894.3 | 5879.6 | 5864.9 | 5850.3 | 5835.6 | 5821.0 | 5806.5 | 5792.0 | 5777.5 | 5763.0 |
| 2019 | 5936.8 | | 5921.9 | 5907.1 | 5892.4 | 5877.6 | 5862.9 | 5848.3 | 5833.7 | 5819.1 | 5804.5 | 5790.0 | 5775.6 | 5761.1 | 5746.7 | 5732.3 | 5718.0 | 5703.7 | 5689.5 | 5675.2 | 5661.0 | 5646.9 |
| 2020 | 5750.7 | | | 5736.3 | 5722.0 | 5707.7 | 5693.4 | 5679.2 | 5665.0 | 5650.8 | 5636.7 | 5622.6 | 5608.5 | 5594.5 | 5580.5 | 5566.6 | 5552.7 | 5538.8 | 5524.9 | 5511.1 | 5497.3 | 5483.6 |
| 2021 | 5494.6 | | | | 5480.9 | 5467.2 | 5453.5 | 5439.9 | 5426.3 | 5412.7 | 5399.2 | 5385.7 | 5372.2 | 5358.8 | 5345.4 | 5332.0 | 5318.7 | 5305.4 | 5292.1 | 5278.9 | 5265.7 | 5252.6 |
| 2022 | 5289.1 | | | | | 5275.8 | 5262.6 | 5249.5 | 5236.4 | 5223.3 | 5210.2 | 5197.2 | 5184.2 | 5171.2 | 5158.3 | 5145.4 | 5132.5 | 5119.7 | 5106.9 | 5094.1 | 5081.4 | 5068.7 |
| 2023 | 5147.7 | | | | | | 5134.8 | 5122.0 | 5109.2 | 5096.4 | 5083.7 | 5070.9 | 5058.3 | 5045.6 | 5033.0 | 5020.4 | 5007.9 | 4995.4 | 4982.9 | 4970.4 | 4958.0 | 4945.6 |
| 2024 | 4948.6 | | | | | | | 4936.2 | 4923.9 | 4911.6 | 4899.3 | 4887.0 | 4874.8 | 4862.6 | 4850.5 | 4838.4 | 4826.3 | 4814.2 | 4802.2 | 4790.2 | 4778.2 | 4766.2 |
| 2025 | 4815.9 | | | | | | | | 4803.8 | 4791.8 | 4779.8 | 4767.9 | 4756.0 | 4744.1 | 4732.2 | 4720.4 | 4708.6 | 4696.8 | 4685.1 | 4673.4 | 4661.7 | 4650.0 |
| 2026 | 4678.3 | | | | | | | | | 4666.6 | 4654.9 | 4643.3 | 4631.6 | 4620.1 | 4608.5 | 4597.0 | 4585.5 | 4574.0 | 4562.6 | 4551.2 | 4539.8 | 4528.5 |
| 2027 | 4612.0 | | | | | | | | | | 4600.4 | 4588.9 | 4577.5 | 4566.0 | 4554.6 | 4543.2 | 4531.9 | 4520.5 | 4509.2 | 4498.0 | 4486.7 | 4475.5 |
| 2028 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2029 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2030 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2031 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2032 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2033 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2034 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2035 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2036 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2037 | 0.0 | | | | | | | | | | | | | | | | | | | | | |
| 2038 | 0.0 | | | | | | | | | | | | | | | | | | | | | |

MODELED RESULTS VS STORAGE ACCOUNT

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model/Accounting Annual Banked | 6074.1 | 5936.8 | 5750.7 | 5494.6 | 5289.1 | 5147.7 | 4948.6 | 4815.9 | 4678.3 | 4612.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Model/Accounting Cumulative Banked | 6074.1 | 12010.9 | 17761.6 | 23256.2 | 28545.2 | 33692.9 | 38641.5 | 43457.4 | 48135.7 | 52747.6 | 52747.6 | 52747.6 | 52747.6 | 52747.6 | 52747.6 | 52747.6 | 52747.6 | 52747.6 | 52747.6 | 52747.6 | 52747.6 |
| Model Annual Storage | 6067.439 | 5922.029 | 5725.313 | 5455.508 | 5236.351 | 5078.052 | 4867.7 | 4719.68 | 4567.625 | 4486.228 | -138.113 | -146.361 | -153.876 | -158.473 | -163.53 | -167.577 | -171.868 | -174.638 | -177.018 | -175.086 | -179.449 |
| Model Cumulative Storage | 6067.439 | 11989.47 | 17714.78 | 23170.29 | 28406.64 | 33484.69 | 38352.39 | 43072.07 | 47639.7 | 52125.92 | 51987.81 | 51841.45 | 51687.58 | 51529.1 | 51365.57 | 51197.99 | 51026.13 | 50851.49 | 50674.47 | 50499.38 | 50319.94 |
| Model Cumulative Efficiency | 99.89% | 99.82% | 99.74% | 99.63% | 99.51% | 99.38% | 99.25% | 99.11% | 98.97% | 98.82% | 98.56% | 98.28% | 97.99% | 97.69% | 97.38% | 97.06% | 96.74% | 96.41% | 96.07% | 95.74% | 95.40% |
| Model Cumulative Depletion % | 0.11% | 0.18% | 0.26% | 0.37% | 0.49% | 0.62% | 0.75% | 0.89% | 1.03% | 1.18% | 1.44% | 1.72% | 2.01% | 2.31% | 2.62% | 2.94% | 3.26% | 3.59% | 3.93% | 4.26% | 4.60% |
| Accounting Cumulative Storage | 6058.9 | 11965.7 | 17672.1 | 23108.81 | 28326.87 | 33390.86 | 38243.61 | 42951.83 | 47511.01 | 51992.67 | 51862.69 | 51733.03 | 51603.7 | 51474.69 | 51346 | 51217.64 | 51089.6 | 50961.87 | 50834.47 | 50707.38 | 50580.61 |
| Accounting Cumulative Efficiency | 99.75% | 99.62% | 99.50% | 99.37% | 99.23% | 99.10% | 98.97% | 98.84% | 98.70% | 98.57% | 98.32% | 98.08% | 97.83% | 97.59% | 97.34% | 97.10% | 96.86% | 96.61% | 96.37% | 96.13% | 95.89% |
| Accounting Cumulative Depletion % | 0.25% | 0.38% | 0.50% | 0.63% | 0.77% | 0.90% | 1.03% | 1.16% | 1.30% | 1.43% | 1.68% | 1.92% | 2.17% | 2.41% | 2.66% | 2.90% | 3.14% | 3.39% | 3.63% | 3.87% | 4.11% |
| Accounting Track Depletion % | 0.25% | 0.50% | 0.75% | 1.00% | 1.24% | 1.49% | 1.74% | 1.98% | 2.23% | 2.47% | 2.72% | 2.96% | 3.20% | 3.44% | 3.69% | 3.93% | 4.17% | 4.41% | 4.64% | 4.88% | 5.12% |

STATISTICS

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Residual (Acct Sto - Mod Sto) | -8.53916 | -23.7681 | -42.681 | -61.4787 | -79.7707 | -93.8317 | -108.784 | -120.238 | -128.682 | -133.253 | -125.122 | -108.418 | -83.8745 | -54.4103 | -19.5666 | 19.64523 | 63.46879 | 110.3831 | 159.996 | 207.9961 | 260.6768 |
| % Error | -0.14% | -0.20% | -0.24% | -0.26% | -0.28% | -0.28% | -0.28% | -0.28% | -0.27% | -0.25% | -0.24% | -0.21% | -0.16% | -0.10% | -0.04% | 0.04% | 0.12% | 0.21% | 0.30% | 0.39% | 0.49% |
| Largest Overestimate | 260.6768 | | | | | | | | | | | | | | | | | | | | |
| Largest % Overestimate | 0.49% | | | | | | | | | | | | | | | | | | | | |
| Largest Underestimate | -133.253 | | | | | | | | | | | | | | | | | | | | |
| Largest % Underestimate | -0.28% | | | | | | | | | | | | | | | | | | | | |




NOTES: Mount Hope numerical model was used to simulate natural losses of banked water in Diamond Valley.
Baseline model was compared to model simulation that incorporated 10 years of banking where 10% of available water to pump is banked.
Comparing the models allowed for the determination of the amount of additional storage in the aquifer and natural losses from the aquifer.
Results from the model were then used to curve-match the modeled determination with a constant "efficiency rate".
The efficiency rate represents the proportion of annual amount of banked water that would remain in the aquifer.
The natural loss % is 1 minus the efficiency rate.

**STATE OF NEVADA**

**DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES**

**DIVISION OF WATER RESOURCES**

**JASON KING, P.E.**
**STATE ENGINEER**

# DIAMOND VALLEY
# HYDROGRAPHIC BASIN 10-153

## CROP INVENTORY

## CALENDAR YEAR 2013

Prepared by: Shannon McDaniel
Landon Harris and Kyle Wolf

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**ABSTRACT**

This inventory represents the status and usage of all permitted, certificated, and claims of vested right groundwater rights for irrigation purposes located within Diamond Valley, Hydrographic Basin 10-153, for the year 2013. **Only those groundwater rights associated with irrigation purposes are represented in this report**. For a listing and summary of all other manners of use within the basin please refer to the Nevada Division of Water Resources Hydrographic Basin Summary.

The data presented are valid for the time period of this report and may vary from previously published figures as water rights within the basin are subject to administrative action, such as certification, cancellation, forfeiture or withdrawal on a continuing basis.

For the year 2013, the permitted and certificated groundwater rights for irrigation purposes totaled **31,583 acres** with a total duty of 125,332 acre-feet within Diamond Valley. An estimated **25,252 acres** were irrigated and 75,037 acre-feet were pumped during 2013.

## HYDROGRAPHIC BASIN SUMMARY

| | |
|---|---|
| HYDROGRAPHIC BASIN NUMBER | 153, REGION 10 |
| HYDROGRAPHIC BASIN NAME | DIAMOND VALLEY |
| COUNTIES | EUREKA AND ELKO |
| MAJOR COMMUNITIES | EUREKA |
| DESIGNATED BASIN | DESIGNATED - IRRIGATION DENIED |
| DENIALS BASED UPON WATER AVAILABILITY | ALL USES |
| ESTIMATED IRRIGATION PUMPAGE 2013 (ACRE-FEET) | 75,037* |

STATE ENGINEER'S ORDERS

| | |
|---|---|
| NO. 277 – PARTIAL DESIGNATION OF BASIN | AUGUST 5, 1964 |
| NO. 280 – AMENDED DESIGNATION OF BASIN | AUGUST 28, 1964 |
| NO. 541 – NOTICE OF CURTAILMENT | DECEMBER 22, 1975 |
| NO. 717 – NOTICE OF CURTAILMENT | JULY 10, 1978 |
| NO. 809 – TOTALIZING METERS | DECEMBER 1, 1982 |
| NO. 813 – AMENDMENT OF ORDER 809 | FEBRUARY 7, 1983 |
| NO. 815 – AMENDED DESIGNATION OF BASIN | APRIL 4, 1983 |
| NO. 1226 – AMENDED DESIGNATION OF BASIN | MARCH 26, 2013 |

COMMITTED GROUNDWATER RESOURCE FOR IRRIGATION PURPOSES: 125,332 ACRE-FEET
DATE: DECEMBER 2013

NOTE: Committed groundwater resource data are approximate for December 2013. Rights may be subject to change applications, certification, withdrawals, forfeiture and cancellations; each of these circumstances could impact the duty, diversion rate and acreage associated with a given right. Be advised this report acknowledges that other manner of uses may be present in the basin; however, only those groundwater rights associated with irrigation purposes are represented in this report.

* Acreage represented in this report may have surface water rights appurtenant. This report acknowledges those acres with surface water rights but is not intended to quantify, nor present any definitive use of those surface water rights. The data represent only the pumping of groundwater and the acreage to which it is applied.

## PURPOSE AND SCOPE

The purpose of this report is to inventory all of the groundwater resources allocated to irrigation and described by the Office of the State Engineer, Nevada Division of Water Resources (NDWR), and to estimate the amount of groundwater pumped for irrigation purposes within the Diamond Valley Hydrographic Basin (10-153), for the year 2013.

## DESCRIPTION OF THE STUDY AREA

The Diamond Valley Hydrographic Basin is located in central Nevada (Figure 1). Diamond Valley occupies approximately 735 square miles in Eureka and Elko Counties. The adjacent hydrographic basins are Huntington Valley (4-035) to the northeast, Pine Valley (4-053) to the northwest, Kobeh Valley (10-139) to the west, Antelope Valley (10-151) to the southwest, Little Smoky Valley, Northern Part (155A) and Newark Valley (10-154) to the east.

Diamond Valley is bounded by the Diamond Mountain Range to the east, by the Mahogany Hills to the south, and to the west by the Sulphur Spring Range. Diamond Valley is approximately 20 miles wide by 56 miles long with basin elevations ranging from approximately 5,760 feet above mean sea level on the valley floor to approximately 10,000 feet above mean sea level in the surrounding mountains. Irrigation occurs primarily in the south central part of the basin (Figure 2).

## GROUNDWATER LEVELS

Depths to groundwater in Diamond Valley are measured by multiple agencies on an annual basis. Sites at which water level measurements are made by or reported to NDWR include:

| | | |
|---|---|---|
| 153 N20 E52 26AABC1 | 153 N20 E52 26AABC2 | 153 N20 E53 02DDDD1 |
| 153 N20 E53 04DDBB2 | 153 N20 E53 10DDDD2 | 153 N20 E53 20BC 01 |
| 153 N20 E53 21CDDC1 | 153 N20 E53 28ADC 01 | 153 N20 E53 30ABCC2 |
| 153 N20 E53 30DCCC1 | 153 N20 E53 32BBBA1 | 153 N20 E53 32BDCC1 |
| 153 N21 E52 04BBAA1 | 153 N21 E52 10AAAC1 | 153 N21 E52 10AAAC2 |
| 153 N21 E53 01BCAA1 | 153 N21 E53 01CDCC2 | 153 N21 E53 02CCAA1 |
| 153 N21 E53 03BBDD2 | 153 N21 E53 03CDBB2 | 153 N21 E53 04CDBB1 |
| 153 N21 E53 06CDBB2 | 153 N21 E53 08BACC1 | 153 N21 E53 08DCAA1 |
| 153 N21 E53 09BBDD2 | 153 N21 E53 09DBDD1 | 153 N21 E53 11CDBB2 |
| 153 N21 E53 12CCBC2 | 153 N21 E53 12DCAA2 | 153 N21 E53 13DA 1 |
| 153 N21 E53 14CACC2 | 153 N21 E53 15BACC2 | 153 N21 E53 16CCAA3 |
| 153 N21 E53 20AACC2 | 153 N21 E53 21DCAA2 | 153 N21 E53 22BDBB2 |
| 153 N21 E53 23AACC1 | 153 N21 E53 23DACC1 | 153 N21 E53 24ADBB1 |
| 153 N21 E53 24CDDD1 | 153 N21 E53 27ACAA3 | 153 N21 E53 28BBDD1 |
| 153 N21 E53 33AACC2 | 153 N21 E53 34DDB 02 | 153 N21 E53 35BDBB2 |
| 153 N21 E53 36AD 1 | 153 N21 E53 36CDD 01 | 153 N21 E54 05BDBB1 |
| 153 N21 E54 05DCCC1 | 153 N21 E54 08CDDD1 | 153 N21 E54 20BACC2 |
| 153 N21 E54 20CCCC1 | 153 N21HE52 35ADD 2 | 153 N21HE54 32DCC 2 |
| 153 N21HE54 34BBD 1 | 153 N22 E51 01CBAB1 | 153 N22 E51 01DBBB1 |

| | | |
|---|---|---|
| 153 N22 E51 01DBBB2 | 153 N22 E51 12ADCD1 | 153 N22 E51H12DBBC1 |
| 153 N22 E51H13DADB1 | 153 N22 E52 07DBBD1 | 153 N22 E52 07DBBD2 |
| 153 N22 E52 11ACCB1 | 153 N22 E52 16CCCB1 | 153 N22 E52 17DDAC1 |
| 153 N22 E52 17DDCA1 | 153 N22 E52 18ACDB1 | 153 N22 E52 18CBDD1 |
| 153 N22 E52 18CBDD2 | 153 N22 E52 19CBBC1 | 153 N22 E52 20CBDC1 |
| 153 N22 E54 05CDBB2 | 153 N22 E54 05DDBB2 | 153 N22 E54 06CCCC1 |
| 153 N22 E54 07DDCD2 | 153 N22 E54 18CADD1 | 153 N22 E54 19CC 1 |
| 153 N22 E54 22CCDD1 | 153 N22 E54 28AACC1 | 153 N22 E54 28DCCC2 |
| 153 N22 E54 32DDCD1 | 153 N22 E54 33BBDD1 | 153 N23 E51 36ACDC1 |
| 153 N23 E52 13BBA 1 | 153 N23 E53 27BB 1 | 153 N23 E53 29CCCA1 |
| 153 N23 E53 31BBD 01 | 153 N23 E54 20DD 1 | 153 N23 E54 27ACC 1 |
| 153 N23 E54 29CDDD2 | 153 N23 E54 30DDD 2 | 153 N23 E54 32CDD 01 |
| 153 N24 E53 06BDAB1 | 153 N25 E54 28BCBC1 | |

Groundwater level data have also been collected by the U.S. Geological Survey (USGS) and can be accessed through their website (http://nevada.usgs.gov).

## METHODS TO ESTIMATE IRRIGATED ACREAGE

This report estimates the number of acres irrigated by the groundwater pumped under permits, certificates, and claims of vested right issued by the State Engineer. Table 1 and Figure 3 present the current and historic irrigated acreage and pumpage; Appendix A presents estimates detailed by certificate, permit, or vested claim number. The following methods were used to arrive at the estimated acreage:

- Field inspection of the place of use was conducted to estimate the number of acres under cultivation.
- In cases where field inspection of the place of use was not practical, aerial and/or satellite imagery were analyzed to determine acreages.

## METHODS TO ESTIMATE PUMPAGE

This report estimates the amount of groundwater pumped under the permits and certificates issued by the Nevada State Engineer as well as claims of vested right in the Diamond Valley Hydrographic Basin. The following methods were used to arrive at the estimated use:

- Where totalizing meters were in place, meter readings were taken and compared with previous data (if available).
- Where meters were not in place and the use was irrigation, pumpage was estimated by multiplying the number of hours the well was operated during the past year (determined from an hour meter reading or asking the water user) by the certificated diversion rate.
- Where there were no flow meters or other reliable options for estimating pumpage and the use was irrigation, pumpage was estimated by dividing the Net Irrigation Water Requirement (NIWR) for the crop grown by the efficiency of the irrigation method used, then multiplying by the number of acres irrigated. Irrigation efficiencies associated with three types of irrigation methods are: pivot at 85%; wheel line or other hand moved sprinklers at 75%; and flood at 60%. The pumpage amount estimated by this method was limited by the duty of the permit. For places where the groundwater rights are supplemental to surface water, groundwater use was estimated using the NIWR method above, but is adjusted based on available surface water for the year. Evapotranspiration and NIWR data by basin can be found on the NDWR website at: http://water.nv.gov/mapping/et/et_general.cfm. This approach using the NIWR to estimate pumpage was not used in previous inventories, and pumpage estimates for 2013 may differ significantly from estimates of previous years.
- Where lands are irrigated by both surface water and groundwater, the surface water supply for the irrigation season was considered in estimating groundwater pumpage.

# TABLES

Table 1. Diamond Valley historical irrigated acreage and pumpage data.

| Year | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| Acres Irrigated | 24,435 | 24,608 | 24,357 | 25,234 | 25,252 |
| Acre-Feet Pumped* | 70,900 | 71,400 | 70,600 | 73,200 | 75,037 |

* The NIWR method to estimate pumpage was used starting in 2013; estimates may differ significantly from previous years. Annual pumpage data for 2009 through 2012 are revised from previous crop inventories per State Engineer's Order 1264.

## FIGURES

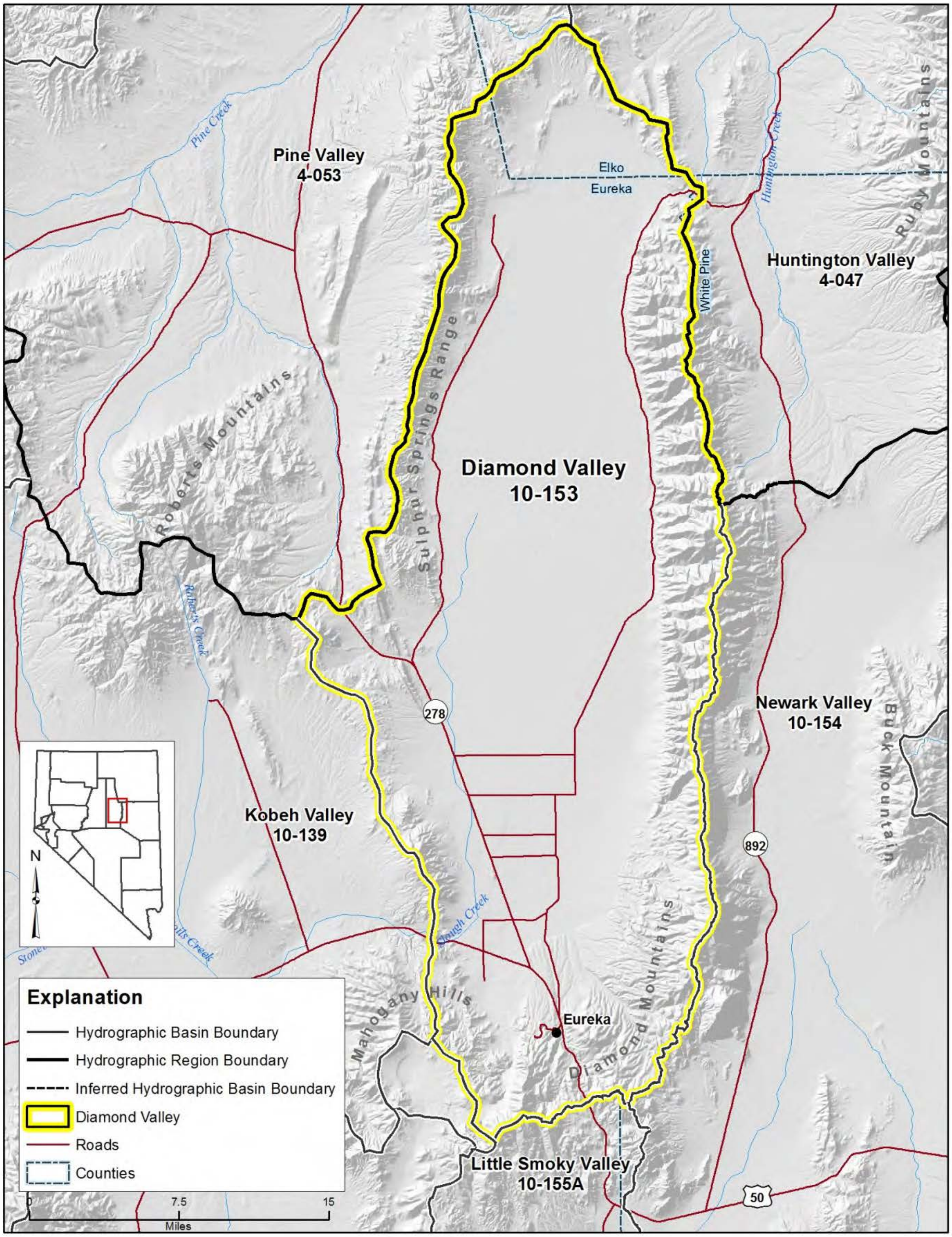


Figure 1. Physiographic map of Diamond Valley (Hydrographic Basin 10-153).

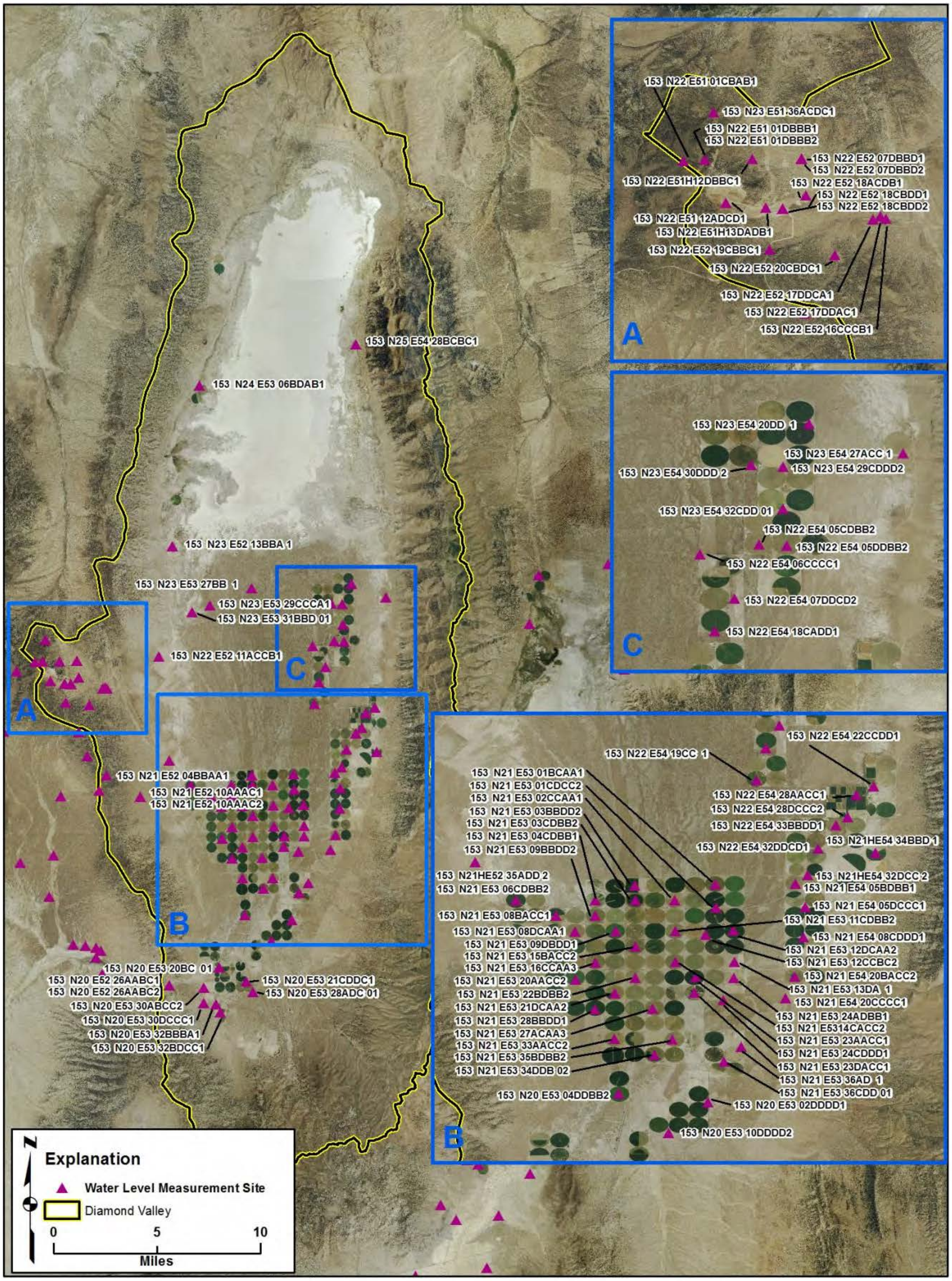


Figure 2. Map showing Diamond Valley irrigated acreage and water level monitoring sites.

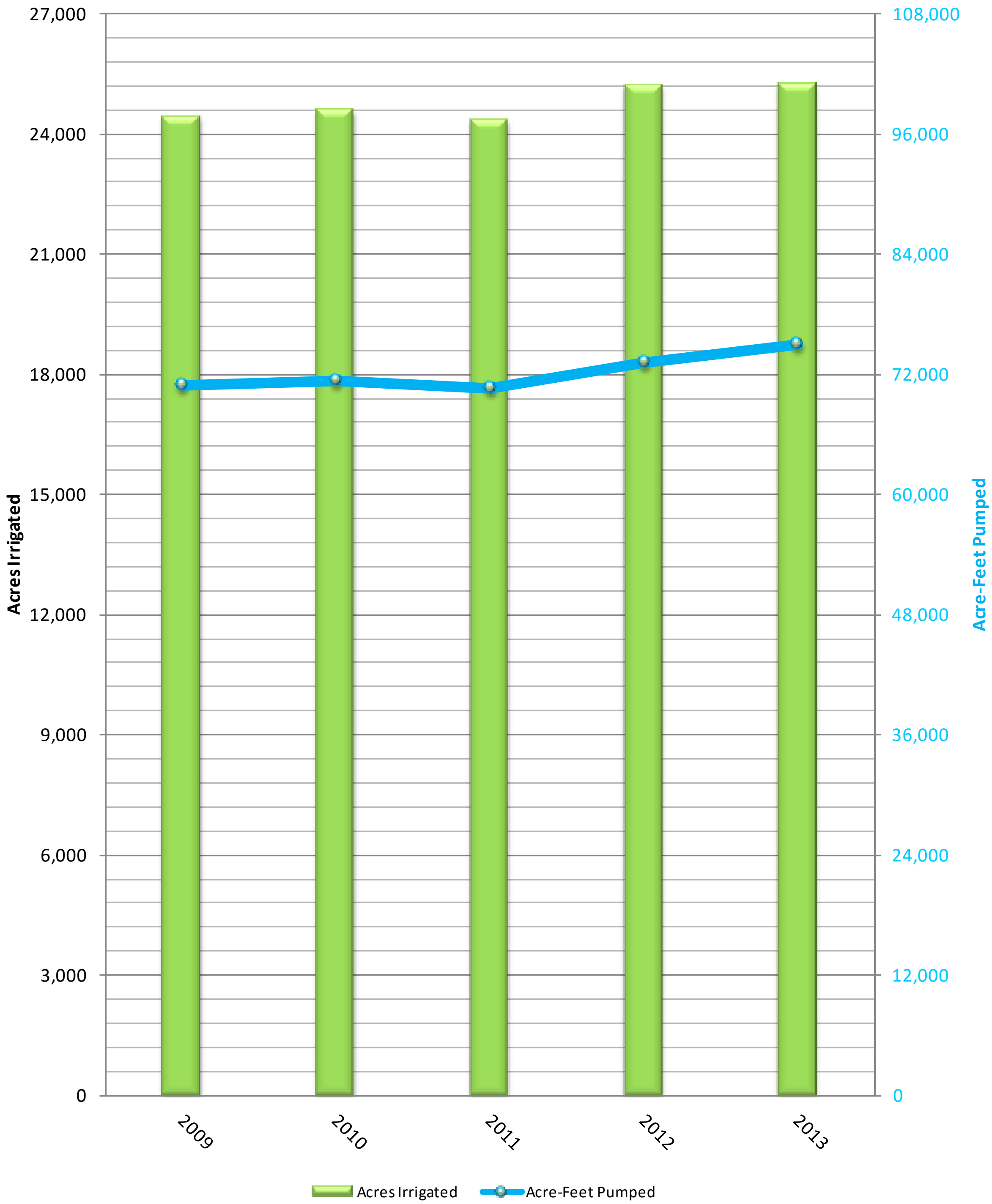


Figure 3. Graph showing Diamond Valley historical irrigated acreage and pumpage. The NIWR method to estimate pumpage was used starting in 2013; estimates may differ significantly from previous years. Annual pumpage data for 2009 through 2012 are revised from previous crop inventories per State Engineer's Order 1264.

**APPENDIX A. 2013 DIAMOND VALLEY CROP INVENTORY.**

## EXPLANATION OF COLUMN HEADINGS

| | |
|---|---|
| App No | The file number of the Application to Appropriate/Change Water or the Claim of Vested Right. |
| Status | Indicates the status of an application: Permit (PER), Certificated (CER), or a Claim of Vested Right (VST). |
| QQ | The quarter-quarter of the Section in which the point of diversion is located. |
| Q | The quarter of the Section in which the point of diversion is located. |
| Sec | The Section in which the point of diversion is located. |
| Twn | The Township in which the point of diversion is located. |
| Rng | The Range in which the point of diversion is located. |
| Sup | Indicates whether the groundwater right is part of a group of groundwater rights used to irrigate all or a portion of the same acreage (supplemental). A “Y” in this column signifies the groundwater right is supplemental to other groundwater rights. |
| Supplemental Application Number | The application number(s) of the water right(s) that are supplemental to one another. |
| Permitted Acres | The number of acres defined by the permit or certificate that is eligible to be irrigated. |
| Supple-mentally Adjusted Permitted Acres | The supplementally adjusted, total number of acres that is eligible to be irrigated under a supplemental group of water rights. |
| Permitted Duty Acre-Feet | The amount of water that may be pumped in a given year, or season, as defined by the permit, certificate, or claim of vested right. If there is a supplemental group, the total combined duty is listed as a supplementally adjusted duty. |
| Supple-mentally Adjusted Duty Acre-Feet | The supplementally adjusted, total combined duty that may be pumped in a given year, or season, for a supplemental group of water rights, expressed in acre-feet. The supplementally adjusted, total combined duty is listed at the end of a supplemental group in **bold**. |
| Owner of Record | The owner of the water right as recorded in the records of the State Engineer. A water right may have more than one owner of record. Only the first, alphabetically, is listed in this table. |
| Crop Type | Indicates whether or not a crop was in production during the water year. If a crop was in production, the common name description of the plants under cultivation if given (e.g. alfalfa). |

| | |
|---|---|
| Irrigation Method | The method by which the water is applied to the crop and ground (e.g. pivot). |
| Irrigated Acreage | The estimate of the number of acres irrigated associated with a particular water right. A "-" in this field indicates that pumpage was attributed to a senior supplemental permit or certificated water right. |
| Acreage Estimation Method | The method by which the number of acres irrigated was determined. F – Field inspection. I – Aerial or satellite imagery. |
| Acre-Feet Pumped | The estimate of the amount of water pumped under a particular water right, expressed in acre-feet. One acre-foot equals 325,851 gallons. A "-" in this field indicates that pumpage was attributed to a senior supplemental permit or certificated water right. |
| Pumpage Estimation | The method used to estimate the amount of water pumped. M – Totalizing meter readings. N – NIWR Method. |

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2013

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14948 | CER | SW | SE | 28 | 22N | 54E | Y | 53872 | 308.60 | 612.54 | 617.20 | 1,234.40 | PALMORE, DONALD FRANK | Alf, Grain | Flood | 310.30 | I | 1,241.20 | D |
| 18242 | CER | SW | NE | 7 | 22N | 54E | Y | 72370 | 320.00 | 320.00 | 1,280.00 | 1,280.00 | ANDERSEN, BONNIE G. | Alf | Pivot | 219.00 | I | 644.12 | N |
| 18621 | CER | SE | NE | 36 | 21N | 53E | Y | 18622, 44621 | 206.29 | 206.29 | 825.16 | 825.16 | ALLEN, ROGER & JUDY | Alf | Pivot | 88.00 | I | 258.82 | N |
| 18622 | CER | SW | NE | 36 | 21N | 53E | Y | 18621, 44621 | 206.29 | | 825.16 | | ALLEN, ROGER & JUDY | Alf | Pivot | -- | F | -- | N |
| 18623 | CER | | LT12 | 1 | 20N | 53E | Y | 22551 | 278.22 | 278.22 | 1,112.88 | 1,112.88 | MACHACEK, JERRY L. & TRINA L. | Alf | Pivot | 158.00 | I | 464.71 | N |
| 18714 | CER | SE | SE | 35 | 21N | 53E | | | 209.00 | 209.00 | 836.00 | 836.00 | BECK FAMILY TRUST | None | Flood | 0.00 | F | 0.00 | N |
| 18786 | CER | NE | NE | 13 | 21N | 53E | Y | 18787 | 320.00 | 320.00 | 1,280.00 | 1,280.00 | JUANITA RUTHEL MARTIN TRUST 95% | Alf | Pivot | 253.00 | I | 744.12 | N |
| 18787 | CER | NE | NW | 13 | 21N | 53E | Y | 18786 | 320.00 | | 1,280.00 | | JUANITA RUTHEL MARTIN TRUST 95% | Alf | Pivot | -- | F | -- | N |
| 18788 | CER | NE | SE | 13 | 21N | 53E | Y | 18789 | 320.00 | 320.00 | 1,280.00 | 1,280.00 | JUANITA RUTHEL MARTIN | Alf | Pivot | 120.00 | I | 352.94 | N |
| 18789 | CER | NE | SW | 13 | 21N | 53E | Y | 18788 | 320.00 | | 1,280.00 | | JUANITA RUTHEL MARTIN TRUST 95% | Alf | Pivot | -- | F | -- | N |
| 18794 | CER | NE | NE | 23 | 21N | 53E | Y | 31111 | 120.00 | 159.50 | 480.00 | 638.00 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 94.00 | I | 276.47 | N |
| 18796 | CER | NE | SE | 23 | 21N | 53E | | | 160.00 | 160.00 | 640.00 | 640.00 | SMITH, CRAIG ALLEN & SHELBA KAY | Alf | Pivot | 125.00 | I | 367.65 | N |
| 18797 | CER | NE | SW | 23 | 21N | 53E | | | 160.00 | 160.00 | 640.00 | 640.00 | SMITH, CRAIG ALLAN & SHELBA KAY | Alf | Pivot | 121.00 | I | 355.88 | N |
| 18802 | CER | SE | NE | 8 | 22N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | FRED L. ETCHEGARAY AND JOHN J. ETCHEGARAY, A NEVADA PARTNERSHIP | Alf | Pivot | 124.00 | I | 364.71 | N |
| 18834 | CER | SE | SE | 17 | 21N | 54E | Y | 19052 | 319.06 | 319.06 | 1,276.23 | 1,276.23 | NEWTON, DEBRA L. | Alf | Pivot | 244.00 | I | 717.65 | N |
| 18835 | CER | SE | SW | 17 | 21N | 54E | Y | 19053 | 319.45 | 319.45 | 1,277.80 | 1,277.81 | NEWTON, DEBRA L. | Alf | Pivot | 245.00 | I | 720.59 | N |
| 18851 | CER | SW | SE | 5 | 21N | 54E | | | 129.11 | 129.11 | 516.44 | 516.44 | EUREKA COUNTY; GALLAGHER FARMS, LLC | Grass Hay | Pivot | 130.00 | I | 367.06 | N |
| 18911 | CER | SE | SW | 16 | 21N | 54E | | | 294.00 | 294.00 | 1,176.00 | 1,176.00 | HILL, HOWARD SR.; HILL, KATHY | None | None | 0.00 | F | 0.00 | N |
| 18927 | CER | NE | NW | 26 | 21N | 53E | Y | 18928 | 320.00 | 320.00 | 1,280.00 | 1,280.00 | A.G. FARM COMMODITIES, INC. | Alf, Grass Hay | Pivot | 258.00 | I | 743.65 | N |
| 18928 | CER | NE | SW | 26 | 21N | 53E | Y | 18927 | 320.00 | | 1,280.00 | | A.G. FARM COMMODITIES, INC. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 18975 | CER | SW | NE | 11 | 20N | 53E | Y | 34950 | 307.50 | 307.50 | 1,230.00 | 1,230.00 | SESTANOVICH HAY & CATTLE LLC | Alf, Grain | Pivot | 251.68 | I | 680.94 | N |
| 18978 | CER | SE | NE | 4 | 21N | 53E | Y | 42019, 42020 | 255.84 | | 1,023.36 | 1,111.36 | COOPER, CHARLES C. | Alf | Pivot | 240.00 | I | 705.88 | N |
| 18981 | CER | SE | SE | 4 | 21N | 53E | Y | 39553 | 156.00 | 156.00 | 624.00 | 624.00 | COOPER, ERMYLE R. | Alf | Pivot | 125.00 | I | 367.65 | N |
| 18988 | CER | SE | SE | 10 | 20N | 53E | Y | 80780 | 160.00 | 160.00 | 640.00 | 640.00 | SESTANOVICH HAY & CATTLE LLC | Alf | Pivot | 126.00 | I | 370.59 | N |
| 18989 | CER | SE | NE | 10 | 20N | 53E | Y | 80781 | 160.00 | 160.00 | 640.00 | 640.00 | SESTANOVICH HAY & CATTLE LLC | None | None | -- | F | -- | N |
| 18999 | CER | SW | NE | 15 | 21N | 53E | Y | 42021 | 160.00 | 160.00 | 640.00 | 640.00 | COOPER, CHARLES E. | Alf | Pivot | 127.00 | I | 373.53 | N |
| 19014 | CER | NW | NE | 5 | 21N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | J & T FARMS, LLC | Alf | Pivot | 129.00 | I | 379.41 | N |
| 19015 | CER | NE | NW | 5 | 21N | 54E | Y | 82798T | 158.00 | 158.00 | 189.36 | 632.00 | J & T FARMS, LLC | Alf | Pivot | 128.00 | I | 376.47 | N |
| 19052 | CER | NW | NE | 17 | 21N | 54E | Y | 18834 | 319.06 | | 1,276.23 | | NEWTON, DEBRA L. | Alf | Pivot | -- | F | -- | N |
| 19053 | CER | NE | NW | 17 | 21N | 54E | Y | 18835 | 319.45 | | 1,277.80 | | NEWTON, DEBRA L. | Alf | Pivot | -- | F | -- | N |
| 19110 | CER | SW | SW | 22 | 22N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | MARK MOYLE FARMS, LLC | Alf | Flood | 157.00 | I | 628.00 | D |
| 19111 | CER | SW | SW | 27 | 22N | 54E | Y | 23893 | 155.50 | 155.50 | 622.00 | 622.00 | MILES, HAROLD R. | Grass Mix | Pivot | 58.00 | I | 170.59 | N |
| 19145 | CER | SE | SW | 32 | 23N | 54E | Y | 1 | 160.00 | 640.00 | 640.00 | 2,560.00 | MOYLE, JAMES L. | Grain, Grass | Pivot | 125.00 | I | 367.65 | N |
| 19191 | CER | SW | SW | 17 | 20N | 53E | Y | 24214 | 131.08 | 281.16 | 524.30 | 1,124.62 | ANDERSON, JERRY LEE | Alf, Grain | Pivot | 119.00 | I | 350.00 | N |
| 19192 | CER | SW | SE | 18 | 20N | 53E | Y | 29765 | 149.15 | 313.20 | 596.60 | 1,252.80 | HALPIN, SANDRA L. | Alf | Pivot | 124.00 | I | 364.71 | N |
| 19218 | CER | SE | SW | 21 | 20N | 53E | Y | 21561, 24378 | 206.60 | 222.42 | 735.68 | 889.68 | CRANE, WILLIAM A. CRANE | Alf | Pivot | 162.80 | I | 478.82 | N |
| 19279 | CER | SE | SE | 7 | 21N | 53E | | | 83.00 | 83.00 | 332.00 | 332.00 | DUBRAY, FERNO L. & CARRIE M. | Alf | Pivot | 66.50 | I | 195.59 | N |
| 19292 | CER | SW | NE | 21 | 21N | 53E | | | 139.80 | 139.80 | 559.20 | 559.20 | D.V. CORPORATION | Alf | Pivot | 112.00 | I | 329.41 | N |
| 19293 | CER | SW | SE | 21 | 21N | 53E | | | 132.40 | 132.40 | 529.60 | 529.60 | D.V. CORPORATION | Alf | Pivot | 107.00 | I | 314.71 | N |
| 19324 | CER | SE | SE | 2 | 20N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | SESTANOVICH HAY & CATTLE LLC | Alf | Pivot | 128.00 | I | 376.47 | N |
| 19360 | CER | SE | SW | 5 | 22N | 54E | | | 155.00 | 155.00 | 620.00 | 620.00 | ETCHEGARAY, LEROY W. | Alf | Pivot | 125.00 | I | 367.65 | N |
| 19361 | CER | SE | SE | 5 | 22N | 54E | | | 155.00 | 155.00 | 620.00 | 620.00 | ETCHEGARAY, LEROY W. | Alf | Pivot | 123.00 | I | 361.76 | N |
| 19378 | CER | NW | NW | 34 | 21N | 53E | Y | 2 | 244.80 | 314.00 | 979.20 | 1,256.00 | MOYLE, DUSTY L. | Alf | Pivot | 227.60 | I | 669.41 | N |
| 19379 | CER | NW | NE | 33 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | MOYLE, DUSTY L. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 19381 | CER | NW | SE | 33 | 21N | 53E | | | 240.00 | 240.00 | 960.00 | 960.00 | MOYLE, DUSTY L. | Alf | Pivot | 165.00 | I | 485.29 | N |
| 19411 | CER | NW | SW | 32 | 20N | 53E | | | 96.00 | 96.00 | 384.00 | 384.00 | HOMESTAKE MINING COMPANY OF CALIFORNIA | Alf | Pivot | 80.00 | I | 235.29 | N |
| 19490 | CER | | LT06 | 6 | 22N | 54E | | | 173.07 | 173.07 | 692.28 | 692.28 | SOLARLJOS LLC | None | Wheel Lines | 0.00 | F | 0.00 | N |
| 19492 | CER | NE | SE | 34 | 21N | 53E | Y | 20015 | 314.00 | 314.00 | 1,256.00 | 1,256.00 | CONLEY, BEVERLY A. AND CONLEY, KENNETH E. | Alf, Grass Hay | Pivot | 252.00 | I | 726.47 | N |
| 19500 | CER | | LT13 | 20 | 20N | 53E | | | 166.10 | 166.10 | 664.40 | 664.40 | CONLEY LAND & LIVESTOCK, LLC | Alf | Pivot | 125.00 | I | 367.65 | N |
| 19501 | CER | SW | NW | 20 | 20N | 53E | | | 164.48 | 164.48 | 657.92 | 657.92 | CONLEY LAND & LIVESTOCK, LLC | Grass Hay | Pivot | 113.00 | I | 319.06 | N |
| 19502 | CER | SW | SE | 20 | 20N | 53E | | | 152.27 | 152.27 | 609.08 | 609.08 | CONLEY LAND & LIVESTOCK, LLC | Alf, Grain | Pivot | 95.00 | I | 279.41 | N |
| 19526 | CER | SE | SW | 15 | 20N | 53E | | | 301.00 | 301.00 | 1,204.00 | 1,204.00 | BAUMAN, JAMES E. | Grass Hay | Pivot | 253.00 | I | 714.35 | N |
| 19541 | CER | SE | SE | 28 | 21N | 53E | | | 141.30 | 141.30 | 565.20 | 565.20 | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 123.00 | I | 361.76 | N |
| 19542 | CER | NE | NE | 28 | 21N | 53E | | | 117.00 | 117.00 | 468.00 | 468.00 | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 116.00 | I | 341.18 | N |
| 19563 | CER | SE | SE | 1 | 21N | 53E | Y | 19971, 28160 | 319.87 | 319.87 | 1,279.48 | 1,279.48 | PLASKETT, TOMMYE J. | Grass Hay | Pivot | 252.00 | I | 741.18 | N |
| 19760 | CER | SE | SE | 8 | 21N | 54E | Y | 28061 | 319.00 | 319.00 | 1,276.00 | 1,276.00 | BURNHAM FARMS, LLC | Alf | Pivot | 244.00 | I | 717.65 | N |
| 19904 | CER | SE | NE | 29 | 21N | 53E | Y | 24609, 78905 | 158.00 | 280.80 | 632.00 | 1,108.14 | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 126.00 | I | 370.59 | N |
| 19965 | CER | NW | SE | 12 | 21N | 53E | Y | 78447 | 158.00 | 158.00 | 632.00 | 632.00 | RAND, JOSEPH L. AND ELLEN M. | Alf | Pivot | 130.00 | I | 382.35 | N |
| 19966 | CER | SW | NE | 12 | 21N | 53E | Y | 80581 | 156.00 | 156.00 | 218.20 | 624.00 | RAND, ELLEN M. | Alf | Pivot | 128.00 | I | 376.47 | N |
| 19971 | CER | SW | NE | 1 | 21N | 53E | Y | 19563, 28160 | 319.87 | | 779.16 | | PLASKETT, TOMMYE J. | Grass Hay | Pivot | -- | F | -- | N |
| 19972 | CER | SE | NW | 1 | 21N | 53E | Y | 3 | 320.33 | 320.33 | 1,281.32 | 1,281.32 | PLASKETT, TOMMYE J. | Alf, Grass Hay | Pivot | 251.00 | I | 723.53 | N |
| 19973 | CER | SE | SW | 1 | 21N | 53E | Y | 3 | 320.33 | | 1,281.32 | | PLASKETT, TOMMYE | Alf, Grass Hay | Pivot | -- | F | -- | N |



JA1169

SE ROA 856

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2013

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20000 | CER | NW | NE | 34 | 21N | 53E | Y | [2] | 156.00 | | 624.00 | | MOYLE, DUSTY L. | Alf | Pivot | -- | F | -- | N |
| 20015 | CER | NW | SW | 34 | 21N | 53E | Y | 19492 | 158.00 | | 632.00 | | MOYLE, DUSTY L. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 20046 | CER | SE | NW | 33 | 22N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | BURNHAM FARMS, LLC | Alf | Pivot | 125.00 | I | 367.65 | N |
| 20087 | CER | SE | NE | 20 | 21N | 53E | Y | 24607 | 156.00 | 308.00 | 624.00 | 1,232.00 | DIAMOND VALLEY RANCH, LLC | Grass hay | Pivot | 126.00 | I | 355.76 | N |
| 20088 | CER | NE | NW | 20 | 21N | 53E | Y | 24606 | 158.00 | 312.00 | 632.00 | 1,248.00 | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 126.00 | I | 370.59 | N |
| 20366 | CER | SE | NW | 22 | 22N | 54E | | | 159.58 | 159.58 | 638.31 | 638.31 | MARK MOYLE FARMS, LLC | Grass Mix | Pivot | 134.00 | I | 378.35 | N |
| 20487 | CER | NE | NW | 22 | 21N | 53E | | | 127.70 | 127.70 | 510.80 | 510.80 | MARSHALL, REESE W. | Alf | Pivot | 125.00 | I | 367.65 | N |
| 20565 | CER | SE | NW | 32 | 20N | 53E | | | 73.00 | 73.00 | 292.00 | 292.00 | EUREKA COUNTY | Pasture | Pivot | 64.00 | I | 188.24 | N |
| 20694 | CER | SE | NE | 21 | 20N | 53E | Y | 21399 | 172.22 | 253.29 | 688.88 | 1,013.16 | MICHEL AND MARGARET ANN ETCHEVERRY FAMILY LIMITED PARTNERSHIP | Alf | Pivot | 63.00 | I | 185.29 | N |
| 21085 | CER | SE | NW | 35 | 21N | 53E | Y | 23462, 23803 | 156.40 | 327.60 | 625.60 | 1,310.40 | MILLER, ANTHONY | Grass Hay | Pivot | 126.00 | I | 355.76 | N |
| 21399 | CER | SW | NW | 22 | 20N | 53E | Y | 20694 | 253.29 | | 1,013.16 | | MICHEL AND MARGARET ANN ETCHEVERRY FAMILY LIMITED PARTNERSHIP | Alf | Pivot | 63.00 | I | 185.29 | N |
| 21426 | CER | SW | SE | 15 | 21N | 53E | | | 160.00 | 160.00 | 640.00 | 640.00 | MORRISON, LLOYD & BELINDA FAYE | Alf | Pivot | 127.00 | I | 373.53 | N |
| 21428 | CER | SE | NE | 11 | 21N | 53E | | | 156.00 | 156.00 | 624.00 | 624.00 | BENSON, PATTI E. AND KENNETH F. | Grass Hay | Pivot | 133.00 | I | 375.53 | N |
| 21561 | CER | SE | NW | 21 | 20N | 53E | Y | 19218, 24378 | 129.92 | | 519.68 | | EUREKA MOLY LLC | Alf | Pivot | -- | F | -- | N |
| 21839 | CER | SW | SW | 16 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | ALLEN, MAX D. | Alf | Pivot | 131.00 | I | 385.29 | N |
| 21841 | CER | SE | NW | 21 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | MICHEL & MARGARET ETHCEVERRY FAMILY LP | Alf | Pivot | 125.00 | I | 367.65 | N |
| 21843 | CER | SW | SW | 15 | 21N | 53E | | | 156.00 | 156.00 | 624.00 | 624.00 | MORRISON, BELINDA FAYE | Alf | Pivot | 123.00 | I | 361.76 | N |
| 21844 | CER | SW | NW | 15 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | COOPER, CHARLES E. | Grass Hay | Pivot | 126.00 | I | 355.76 | N |
| 21929 | CER | SW | NW | 28 | 21N | 53E | | | 157.60 | 157.60 | 630.40 | 630.40 | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 130.00 | I | 382.35 | N |
| 21930 | CER | SW | NE | 27 | 21N | 53E | | | 158.80 | 158.80 | 635.20 | 635.20 | AMERICAN FIRST FEDERAL | Alf | Pivot | 126.00 | I | 370.59 | N |
| 22194 | CER | SE | SW | 3 | 21N | 53E | | | 134.00 | 134.00 | 536.00 | 536.00 | BAILEY, TIMOTHY LEE AND CONSTANCE MARIE | Alf | Pivot | 127.00 | I | 373.53 | N |
| 22195 | CER | SE | SE | 3 | 21N | 53E | | | 155.50 | 155.50 | 622.00 | 622.00 | BAILEY, TIMOTHY LEE AND CONSTANCE MARIE | Grass Hay | Pivot | 131.00 | I | 369.88 | N |
| 22217 | CER | SE | NE | 20 | 20N | 53E | | | 163.57 | 163.57 | 654.28 | 654.28 | CONLEY LAND AND LIVESTOCK LLC | Alf | Pivot | 88.00 | I | 258.82 | N |
| 22316 | CER | SW | SE | 27 | 21N | 53E | | | 157.20 | 157.20 | 628.80 | 628.80 | AMERICAN FIRST FEDERAL | Alf | Pivot | 121.00 | I | 355.88 | N |
| 22352 | CER | SW | SE | 19 | 22N | 54E | | | 32.20 | 32.20 | 129.28 | 129.28 | MARK MOYLE FARMS, LLC | | | No Estimate | | No Estimate | |
| 22353 | CER | SW | NE | 19 | 22N | 54E | | | 158.00 | 158.00 | 632.00 | 632.00 | MORRISON, BELINDA F. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 22551 | CER | SE | SW | 36 | 21N | 53E | Y | 18623 | 181.69 | | 726.76 | | ALLEN, ROGER & JUDY | Alf, Grain | Pivot | -- | F | -- | N |
| 22566 | CER | SW | SE | 8 | 21N | 53E | | | 117.00 | 117.00 | 468.00 | 468.00 | MILLER, LAVON AND KRISTI | Alf | Pivot | 120.00 | I | 352.94 | N |
| 22567 | CER | SW | NE | 8 | 21N | 53E | | | 117.00 | 117.00 | 468.00 | 468.00 | MILLER, LAVON AND KRISTI | Alf | Pivot | 123.00 | I | 361.76 | N |
| 22648 | CER | SW | NE | 3 | 21N | 53E | Y | 22921 | 296.72 | 296.72 | 1,186.88 | 1,186.88 | BENSON, KENNETH F. | Alf | Pivot, Wheel Lines | 271.00 | I | 856.27 | N |
| 22921 | CER | SW | NW | 3 | 21N | 53E | Y | 22648 | 296.72 | | 1,186.88 | | BENSON, KENNETH F. | Alf | Pivot, Wheel Lines | -- | F | -- | N |
| 22922 | CER | | LT01 | 2 | 21N | 53E | Y | 36321, 36322 | 161.59 | 161.59 | 646.36 | 646.36 | BENSON, PATTI E. AND KENNETH F. | Grass Hay | Pivot | 130.00 | I | 367.06 | N |
| 22982 | CER | SW | NE | 22 | 21N | 53E | | | 315.20 | 315.20 | 1,260.80 | 1,260.80 | AMERICAN FIRST FEDERAL | Alf | Pivot | 254.00 | I | 747.06 | N |
| 23271 | CER | SE | SE | 32 | 22N | 54E | Y | 29278 | 317.70 | 317.70 | 1,270.80 | 1,270.80 | BURNHAM FARMS, LLC | Alf, Grass Hay | Pivot | 247.00 | I | 712.35 | N |
| 23272 | CER | SW | SW | 32 | 22N | 54E | Y | 28641 | 160.00 | 320.00 | 640.00 | 1,280.00 | BURNHAM FARMS, LLC | Alf | Pivot | 120.00 | I | 352.94 | N |
| 23462 | CER | | LT01 | 35 | 21N | 53E | Y | 21085, 23803 | 304.00 | | 1,216.00 | | EUREKA COUNTY | Grass Hay | Pivot | 128.00 | I | 361.41 | N |
| 23711 | CER | SE | SW | 21 | 20N | 53E | Y | 23738, 23739 | 225.69 | 225.69 | 902.76 | 902.76 | EUREKA MOLLY, LLC | Alf | Pivot | 174.90 | I | 514.41 | N |
| 23738 | CER | NW | SW | 28 | 20N | 53E | Y | 23711, 23739 | 225.69 | | 902.76 | | EUREKA MOLLY, LLC | Alf | Pivot | -- | F | -- | N |
| 23739 | CER | | LT07 | 28 | 20N | 53E | Y | 23711, 23738 | 225.69 | | 902.76 | | EUREKA MOLLY, LLC | Alf | Pivot | -- | F | -- | N |
| 23803 | CER | SW | SW | 35 | 21N | 53E | Y | 21085, 23462 | 171.20 | | 684.80 | | MILLER, ANTHONY | Grass Hay | Pivot | -- | F | -- | N |
| 23893 | CER | SW | SW | 22 | 22N | 54E | Y | 19111 | 76.50 | | 306.00 | | MILES, HAROLD R. | Grass Mix | Pivot | -- | F | -- | N |
| 23808 | CER | NE | SW | 5 | 21N | 54E | | | 136.00 | 136.00 | 544.00 | 544.00 | J & T FARMS, LLC | Alf | Pivot | 128.00 | I | 376.47 | N |
| 23918 | CER | SW | NE | 33 | 21HN | 54E | | | 11.10 | 11.10 | 44.40 | 44.40 | NORTON, WILIAM H. JR. | Alf | Pivot | 32.80 | I | 96.47 | N |
| 24127 | CER | SW | NE | 10 | 21N | 53E | Y | 24128 | 320.00 | 320.00 | 1,280.00 | 1,280.00 | CONAWAY, DALE R. | Alf | Pivot | 268.00 | I | 772.47 | N |
| 24128 | CER | SW | SE | 10 | 21N | 53E | Y | 24127 | 320.00 | | 1,280.00 | | CONAWAY, DALE R. | Alf | Pivot | -- | F | -- | N |
| 24129 | CER | SW | NW | 10 | 21N | 53E | Y | 24130 | 310.20 | 310.20 | 1,240.80 | 1,240.80 | MORRISON, ALBERTA J. | Alf | Pivot | 254.00 | I | 747.06 | N |
| 24130 | CER | SW | SW | 10 | 21N | 53E | Y | 24129 | 310.20 | | 1,240.80 | | MORRISION, ALBERTA J. | Alf | Pivot | -- | F | -- | N |
| 24214 | CER | SW | NW | 17 | 20N | 53E | Y | 19191 | 156.25 | | 624.99 | | ANDERSON, EDWARD B. | Alf, Grain | Pivot, Flood | 128.00 | I | 386.27 | N |
| 24262 | CER | SW | NW | 9 | 21N | 53E | Y | [4] | 472.00 | 472.00 | 476.52 | 1,888.00 | DIAMOND VALLEY HAY CO. | Alf, Grass Hay | Pivot | 489.00 | I | 476.52 | N |
| 24263 | CER | NW | NE | 9 | 21N | 53E | Y | [4] | 472.00 | | 452.40 | | DIAMOND VALLEY HAY CO. | Alf, Grass Hay | Pivot | -- | F | 452.40 | N |
| 24264 | CER | SW | SE | 9 | 21N | 53E | Y | [4] | 472.00 | | 928.92 | | DIAMOND VALLEY HAY CO. | Alf, Grass Hay | Pivot | -- | F | 495.08 | N |
| 24265 | CER | SW | SW | 9 | 21N | 53E | Y | [4] | 236.00 | | 944.00 | | DIAMOND VALLEY HAY CO. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 24272 | CER | SE | SW | 8 | 21N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | BURNHAM FARMS, LLC | Alf | Pivot | 120.00 | I | 352.94 | N |

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2013

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24378 | CER | | LT04 | 21 | 20N | 53E | Y | 19218, 21561 | 74.70 | | 298.80 | | COUNTY OF EUREKA | Alf | Pivot | 38.50 | I | 113.24 | N |
| 24574 | CER | SW | SW | 8 | 21N | 53E | | | 170.17 | 170.17 | 680.68 | 680.68 | MORRISON, D. LLOYD | Alf | Pivot | 124.00 | I | 364.71 | N |
| 24605 | CER | NW | NE | 34 | 21N | 53E | Y | [2] | 79.00 | | 316.00 | | MOYLE, DUSTY L. | Alf | Pivot | 22.40 | I | 65.88 | N |
| 24606 | CER | NW | SW | 20 | 21N | 53E | Y | 20088 | 308.00 | | 1,232.00 | | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 126.00 | I | 370.59 | N |
| 24607 | CER | SE | SE | 20 | 21N | 53E | Y | 20087 | 308.00 | | 1,232.00 | | LIBERTY LIVESTOCK CO | Alf | Pivot | 126.00 | I | 370.59 | N |
| 24609 | CER | SE | NE | 29 | 21N | 53E | Y | 19904, 78905 | 280.80 | | 1,108.14 | | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | -- | F | -- | N |
| 25757 | CER | NE | NE | 35 | 21N | 53E | | | 100.50 | 100.50 | 402.00 | 402.00 | BECK FAMILY TRUST | None | None | 0.00 | F | 0.00 | N |
| 26437 | CER | SE | SE | 30 | 23N | 54E | | | 127.20 | 127.20 | 508.80 | 508.80 | ALLEN, ROGER B. & JUDY B. | Grain, Grass | Pivot | 125.00 | I | 308.82 | N |
| 26664 | CER | SE | NE | 24 | 21N | 53E | | | 40.00 | 40.00 | 160.00 | 160.00 | KEPHART, MARY A. | Alf | Pivot | 33.00 | I | 97.06 | N |
| 27976 | CER | NE | SE | 2 | 21N | 53E | | | 126.12 | 126.12 | 504.48 | 504.48 | MARSHALL FAMILY TRUST | Grass Hay | Pivot | 124.00 | I | 350.12 | N |
| 28035 | CER | SW | SE | 6 | 21N | 53E | Y | 28036 | 50.39 | 119.64 | 201.56 | 478.56 | BAILEY, CAROLYN | Alf | Pivot | 50.39 | I | 148.21 | N |
| 28036 | CER | SW | SE | 6 | 21N | 53E | Y | 28035 | 69.25 | | 277.00 | | BAILEY, CAROYLN | Alf | Pivot | 69.25 | I | 203.68 | N |
| 28061 | CER | NW | SE | 8 | 21N | 54E | Y | 19760 | 125.60 | | 502.40 | | BURNHAM FARMS, LLC | Alf | Pivot | -- | F | -- | N |
| 28160 | CER | | LT03 | 1 | 21N | 53E | Y | 19563, 19971 | 125.08 | | 500.32 | | PLASKETT, TOMMYE J. | Grass Hay | Pivot | -- | F | -- | N |
| 28561 | CER | NE | SW | 33 | 22N | 54E | | | 130.00 | 130.00 | 520.00 | 520.00 | BLEHM, RONALD W. | Alf | Pivot | 124.00 | I | 364.71 | N |
| 28641 | CER | SW | NW | 32 | 22N | 54E | Y | 23272 | 160.00 | | 640.00 | | BURNHAM FARMS, LLC | Alf | Pivot | 122.00 | I | 358.82 | N |
| 29278 | CER | NW | NE | 32 | 22N | 54E | Y | 23271 | 120.00 | | 480.00 | | BURNHAM FARMS, LLC | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 29405 | CER | NE | NW | 8 | 21N | 53E | | | 147.83 | 147.83 | 591.32 | 591.32 | MORRISON, D. LLOYD | Alf | Pivot | 131.00 | F | 385.29 | N |
| 29557 | CER | SE | SE | 20 | 23N | 54E | | | 121.84 | 121.84 | 487.36 | 487.36 | MOYLE, JAMES L. & N. JANE | Alf | Pivot | 124.00 | I | 364.71 | N |
| 29765 | CER | SW | SE | 18 | 20N | 53E | Y | 19192 | 313.20 | | 1,252.80 | | HALPIN, SANDIE L. | Alf, Grain | Pivot | 124.00 | I | 364.71 | N |
| 29873 | CER | SE | SW | 32 | 23N | 54E | Y | [1] | 320.00 | | 1,280.00 | | MOYLE, JAMES L. | Alf | Pivot | 376.00 | I | 1,105.88 | N |
| 29895 | CER | SW | NE | 33 | 22N | 54E | | | 125.66 | 125.66 | 502.64 | 502.64 | CHANEY ASSOCIATES | Alf | Pivot | 124.00 | I | 364.71 | N |
| 30102 | CER | SE | NW | 32 | 23N | 54E | Y | [1] | 320.00 | | 890.27 | | MOYLE, JAMES L. | Alf | Pivot | -- | F | -- | N |
| 30913 | CER | SW | NE | 29 | 23N | 54E | | | 119.45 | 119.45 | 477.80 | 477.80 | MOYLE, DUSTY L. | Alf | Pivot | 127.00 | I | 373.53 | N |
| 30927 | CER | SE | SE | 33 | 22N | 54E | Y | 30928 | 125.66 | 125.66 | 69.12 | 502.64 | TROYER, JOHN AND LOUISE | Alf | Pivot | 125.00 | I | 69.12 | N |
| 30928 | CER | SE | SE | 33 | 22N | 54E | Y | 30927 | 125.66 | | 502.64 | | TROYER, JOHN AND LOUISE | Alf | Pivot | -- | I | 298.53 | N |
| 31062 | CER | SW | SW | 12 | 21N | 53E | | | 138.42 | 138.42 | 553.68 | 553.68 | RAND, JOSEPH L. AND ELLEN M. | Alf | Pivot | 128.00 | I | 376.47 | N |
| 31063 | CER | SE | NW | 12 | 21N | 53E | | | 130.80 | 130.80 | 523.20 | 523.20 | RAND, JOSEPH L. AND ELLEN M. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 31108 | CER | NE | NW | 14 | 21N | 53E | | | 135.36 | 135.36 | 541.44 | 541.44 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 123.00 | I | 361.76 | N |
| 31110 | CER | NE | SW | 14 | 21N | 53E | | | 135.36 | 135.36 | 541.44 | 541.44 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 31111 | CER | NE | NE | 23 | 21N | 53E | Y | 18794 | 39.50 | | 158.00 | | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 31.00 | I | 91.18 | N |
| 31113 | CER | NE | NW | 11 | 21N | 53E | | | 133.40 | 133.40 | 533.60 | 533.60 | MOYLE, DENISE L. AND HICKS, DEANNE, M | Alf | Pivot | 124.00 | I | 364.71 | N |
| 31114 | CER | NE | SW | 11 | 21N | 53E | | | 134.40 | 134.40 | 537.60 | 537.60 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 122.00 | I | 358.82 | N |
| 31454 | CER | SE | SE | 11 | 20N | 53E | | | 130.00 | 130.00 | 520.00 | 520.00 | HALPIN, JAYME L. | Alf | Pivot | 127.00 | I | 373.53 | N |
| 31455 | CER | SE | SW | 11 | 20N | 53E | Y | 81004 | 128.03 | 140.80 | 512.12 | 563.20 | HALPIN, JAYME L. | Alf | Pivot | 112.23 | I | 330.09 | N |
| 33018 | CER | SE | NE | 16 | 21N | 53E | | | 120.00 | 120.00 | 480.00 | 480.00 | MARTIN P. & KATHLEEN A. ETCHEVERRY TRUST & ETCHEVERRY, MARK T. & JENNIFER | Alf | Pivot | 127.00 | I | 373.53 | N |
| 33019 | CER | SW | SE | 16 | 21N | 53E | | | 120.00 | 120.00 | 480.00 | 480.00 | MARTIN P. & KATHLEEN A. ETCHEVERRY TRUST & ETCHEVERRY, MARK T. & JENNIFER | Alf | Pivot | 122.00 | I | 358.82 | N |
| 33668 | CER | NW | NE | 20 | 21N | 54E | Y | 33669 | 305.94 | 305.94 | 1,223.74 | 1,223.74 | WISEHART, LARRY | Alf | Pivot | 126.00 | I | 370.59 | N |
| 33669 | CER | SE | SE | 20 | 21N | 54E | Y | 33668 | 305.94 | | 1,223.74 | | WISEHART, LARRY | Alf | Pivot | -- | F | -- | N |
| 33670 | CER | SW | SW | 20 | 21N | 54E | Y | 33671 | 316.18 | 316.18 | 1,264.70 | 1,264.70 | WISEHART, LARRY | Alf | Pivot | 125.00 | I | 367.65 | N |
| 33671 | CER | NE | NW | 20 | 21N | 54E | Y | 33670 | 316.18 | | 1,264.70 | | WISEHART, LARRY | Alf | Pivot | -- | F | -- | N |
| 33817 | CER | NE | NW | 27 | 21N | 53E | | | 127.90 | 127.90 | 511.60 | 511.60 | SHUEY, CHRISTENE K. AND DAVID M. | Grass Hay | Pivot | 124.00 | I | 350.12 | N |
| 33818 | CER | SW | SW | 27 | 21N | 53E | | | 127.70 | 127.70 | 510.80 | 510.80 | SHUEY, CHRISTENE K. AND DAVID M. | Grass Hay | Pivot | 124.00 | I | 350.12 | N |
| 34561 | CER | SE | SW | 19 | 22N | 54E | | | 129.00 | 129.00 | 516.01 | 516.01 | MARK MOYLE FARMS, LLC | Grass Hay | Pivot | 124.00 | I | 350.12 | N |
| 34562 | CER | SE | NW | 19 | 22N | 54E | | | 124.87 | 124.87 | 499.48 | 499.48 | MARK MOYLE FARMS, LLC | Alf | Pivot | 124.87 | I | 367.26 | N |
| 34596 | CER | SE | NE | 7 | 21N | 53E | Y | 48225, 48226 | 237.10 | 237.10 | 501.82 | 948.40 | MORRISON, CHERYL A. | Alf | Pivot | 121.00 | I | 355.88 | N |
| 34939 | CER | SE | SW | 22 | 22N | 54E | Y | 48437 | 130.00 | 130.00 | 520.00 | 520.00 | MARK MOYLE FARMS, LLC | Alf | Pivot | 120.00 | I | 352.94 | N |
| 34948 | CER | NE | SW | 1 | 21N | 53E | Y | [3] | 126.40 | | 505.60 | | PLASKETT, TOMMYE J. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 34950 | CER | SE | NE | 11 | 20N | 53E | Y | 18975 | 125.68 | | 502.72 | | SESTANOVICH HAY & CATTLE LLC | Alf, Grain | Pivot | -- | I | -- | N |
| 35009 | CER | SW | NW | 16 | 21N | 53E | | | 160.00 | 160.00 | 640.00 | 640.00 | BENSON, KENNETH F. | Alf | Pivot | 125.00 | I | 367.65 | N |
| 35012 | CER | NE | SW | 22 | 21N | 53E | | | 127.90 | 127.90 | 511.60 | 511.60 | GOLD STREET FARM, LLC | Alf | Pivot | 122.00 | I | 358.82 | N |
| 35013 | CER | SE | SW | 21 | 21N | 53E | | | 136.66 | 136.66 | 546.64 | 546.64 | MICHEL & MARGARET ETHCEVERRY FAMILY LP | Alf | Pivot | 124.00 | I | 364.71 | N |
| 35374 | CER | SW | SW | 7 | 21N | 53E | | | 27.11 | 27.11 | 108.44 | 108.44 | DUBRAY, FERNO L. & CARRIE M. | Alf | Pivot | 22.00 | I | 64.71 | N |
| 35375 | CER | SE | SE | 7 | 21N | 53E | | | 96.76 | 96.76 | 387.04 | 387.04 | DUBRAY, FERNO L. AND CARRIE M. | Grass Hay | Pivot | 92.00 | I | 259.76 | N |
| 35418 | CER | | LT16 | 29 | 20N | 53E | | | 1.00 | 1.00 | 4.00 | 4.00 | RUBIO, DAVID M. | Grass | Sprikler | 1.00 | F | 3.20 | N |
| 36070 | CER | SE | SE | 32 | 23N | 54E | Y | [1] | 160.00 | | 640.00 | | MOYLE, JAMES L. | Alf | Pivot | -- | F | -- | N |
| 36321 | CER | | LT01 | 2 | 21N | 53E | Y | 22922, 36322 | 161.59 | | 304.01 | | BENSON, PATTI E. AND KENNETH F. | Grass Hay | Pivot | -- | F | -- | N |
| 36322 | CER | | LT01 | 2 | 21N | 53E | Y | 22922, 36321 | 161.59 | | 323.18 | | BENSON, PATTI E. AND KENNETH F. | Grass Hay | Pivot | -- | F | -- | N |
| 39156 | CER | SE | NE | 5 | 22N | 54E | Y | 55535 | 312.56 | 312.56 | 1,250.24 | 1,250.24 | ETCHEGARAY, FRED L. | Alf | Pivot | 246.00 | I | 723.53 | N |
| 39552 | CER | SE | SW | 4 | 21N | 53E | Y | 39554 | 138.03 | 138.03 | 552.12 | 552.12 | COOPER, ERMYLE R. | Alf | Pivot | 129.00 | I | 379.41 | N |
| 39553 | CER | SE | SE | 4 | 21N | 53E | Y | 18981 | 135.81 | | 543.24 | | COOPER, ERMYLE R. | Alf | Pivot | -- | F | -- | N |
| 39554 | CER | SE | SW | 4 | 21N | 53E | Y | 39552 | 138.03 | | 552.12 | | COOPER, ERMYLE R. | Alf | Pivot | -- | F | -- | N |
| 40010 | CER | SE | NE | 32 | 21HN | 54E | Y | 40013 | 114.66 | 125.66 | 458.64 | 502.64 | MILLER, LYNFORD & SUSAN | Grain | Pivot | 114.00 | I | 281.65 | N |



JA1171

SE ROA 858

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2013

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40011 | CER | SW | NW | 32 | 21HN | 54E | Y | 40014 | 27.40 | 125.66 | 108.59 | 501.59 | BURNHAM FARMS, LLC | Alf | Pivot | 27.40 | I | 80.59 | N |
| 40013 | CER | SE | NE | 32 | 21HN | 54E | Y | 40010 | 11.00 | | 44.00 | | MILLER, LYNFORD & SUSAN | Grain | Pivot | 11.00 | I | 27.18 | N |
| 40014 | CER | SW | NW | 32 | 21HN | 54E | Y | 40011 | 98.26 | | 393.04 | | BLEHM, GLADYS A. | Grain | Pivot | 99.60 | I | 246.07 | N |
| 40402 | CER | SE | NW | 30 | 23N | 54E | | | 127.20 | 127.20 | 508.80 | 508.80 | MOYLE, DUSTY L. | Wheat | Pivot | 129.00 | I | 311.12 | N |
| 41883 | CER | | LT07 | 28 | 20N | 53E | Y | 41884 | 39.20 | 39.20 | 156.80 | 156.80 | MILLER, OWEN J. AND CHERYL | Alf | Pivot | 30.10 | I | 88.53 | N |
| 41884 | CER | | LT11 | 28 | 20N | 53E | Y | 41883 | 39.20 | | 156.80 | | MILLER, OWEN J. AND CHERYL | Alf | Pivot | -- | F | -- | N |
| 42019 | CER | SE | NW | 4 | 21N | 53E | Y | 18978, 42020 | 121.90 | | 455.24 | | COOPER, CHARLES C. | Alf | Pivot | -- | F | -- | N |
| 42020 | CER | SE | NW | 4 | 21N | 53E | Y | 18978, 42019 | 121.90 | | 88.00 | | COOPER, CHARLES C. | Alf | Pivot | -- | F | -- | N |
| 42021 | CER | SW | NE | 15 | 21N | 53E | Y | 18999 | 137.20 | | 548.80 | | COOPER, CHARLES E. | Alf | Pivot | -- | F | -- | N |
| 42367 | CER | SE | NW | 24 | 21N | 53E | Y | [5] | 120.00 | 120.00 | 40.00 | 480.00 | KEPHART, MARI ALICE | Alf | Pivot | 122.00 | I | 40.00 | N |
| 42368 | CER | SE | NW | 24 | 21N | 53E | Y | [5] | 120.00 | | 40.00 | | KEPHART, MARI ALICE | Alf | Pivot | -- | F | 40.00 | N |
| 42369 | CER | SE | NW | 24 | 21N | 53E | Y | [5] | 120.00 | | 120.00 | | KEPHART, MARI ALICE | Alf | Pivot | -- | F | 120.00 | N |
| 42370 | CER | SE | NW | 24 | 21N | 53E | Y | [5] | 120.00 | | 120.00 | | KEPHART, MARI ALICE | Alf | Pivot | -- | F | 120.00 | N |
| 42891 | CER | SE | NW | 1 | 20N | 53E | Y | [6] | 107.61 | 107.61 | 141.77 | 430.44 | MOLL, HOLLON D. & VELMA M. | Alf | Pivot | 111.28 | I | 141.77 | N |
| 43268 | CER | NW | NE | 18 | 22N | 54E | Y | 43270, 43836 | 250.00 | 250.00 | 782.10 | 1,000.00 | KENNETH P. STENTON | Alf, Grass Hay | Pivot | 250.00 | I | 250.00 | N |
| 43269 | CER | NW | NE | 18 | 21N | 53E | Y | [7] | 130.00 | 130.00 | 76.80 | 520.00 | BLANCO RANCH, LLC | Alf | Pivot | 135.00 | I | 76.80 | N |
| 43270 | CER | NE | SW | 18 | 22N | 54E | Y | 43268, 43836 | 250.00 | | 629.38 | | KENNETH P. STENTON | Alf, Grass Hay | Pivot | -- | F | 470.59 | N |
| 43271 | CER | NW | NW | 17 | 21N | 53E | Y | [8] | 520.00 | 520.00 | 525.62 | 2,080.00 | BERG PROPERTIES CALIFORNIA, LLC | Alf, Grass Hay | Pivot | 512.00 | I | 525.62 | N |
| 43272 | CER | NW | NE | 17 | 21N | 53E | Y | [8] | 520.00 | | 525.62 | | BERG PROPERTIES CALIFORNIA, LLC | Alf, Grass Hay | Pivot | -- | F | 525.62 | N |
| 43273 | CER | SW | SW | 17 | 21N | 53E | Y | [8] | 520.00 | | 514.39 | | BERG PROPERTIES CALIFORNIA, LLC | Alf, Grass Hay | Pivot | -- | F | 439.11 | N |
| 43274 | CER | NW | SE | 17 | 21N | 53E | Y | [8] | 520.00 | | 514.39 | | BERG PROPERTIES CALIFORNIA, LLC | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 43397 | CER | SE | SW | 20 | 23N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | MOYLE, JAMES L. & N. JANE | Alf | Pivot | 125.00 | F | 367.65 | N |
| 43836 | CER | NW | NE | 18 | 22N | 54E | Y | 43268, 43270 | 250.00 | | 1,000.00 | | KENNETH P. STENTON | Alf. Grass Hay | Pivot | -- | F | -- | N |
| 43837 | CER | NW | NE | 18 | 21N | 53E | Y | [7] | 130.00 | | 111.99 | | BLANCO RANCH, LLC | Alf | Pivot | -- | F | 111.99 | N |
| 43838 | CER | NW | NE | 18 | 21N | 53E | Y | [7] | 130.00 | | 111.99 | | BLANCO RANCH, LLC | Alf | Pivot | -- | F | 111.99 | N |
| 43839 | CER | NW | NE | 18 | 21N | 53E | Y | [7] | 130.00 | | 109.62 | | BLANCO RANCH, LLC | Alf | Pivot | -- | F | 96.28 | N |
| 43840 | CER | NW | NE | 18 | 21N | 53E | Y | [7] | 130.00 | | 109.62 | | BLANCO RANCH, LLC | Alf | Pivot | -- | F | -- | N |
| 44451 | CER | NE | NE | 28 | 22N | 54E | Y | 44452 | 303.40 | 303.40 | 576.58 | 1,213.60 | PALMORE, DONALD FRANK | Alf | Flood | 313.00 | I | 576.58 | N |
| 44452 | CER | SE | NW | 28 | 22N | 54E | Y | 44451 | 303.40 | | 640.00 | | PALMORE, DONALD FRANK | Alf | Flood | -- | F | 727.59 | N |
| 44604 | CER | NE | SW | 27 | 22N | 54E | Y | [9] | 125.70 | 125.70 | 137.36 | 502.80 | BURNHAM FARMS, LLC | Alf | Pivot | 125.00 | I | 137.36 | N |
| 44605 | CER | NE | SW | 27 | 22N | 54E | Y | [9] | 125.70 | | 137.36 | | BURNHAM FARMS, LLC | Alf | Pivot | -- | F | 137.36 | N |
| 44606 | CER | NE | SW | 27 | 22N | 54E | Y | [9] | 125.70 | | 18.88 | | BURNHAM FARMS, LLC | Alf | Pivot | -- | F | 18.88 | N |
| 44607 | CER | NE | SW | 27 | 22N | 54E | Y | [9] | 125.70 | | 136.00 | | BURNHAM FARMS, LLC | Alf | Pivot | -- | F | 74.05 | N |
| 44609 | CER | NE | SW | 27 | 22N | 54E | Y | [9] | 125.70 | | 236.80 | | BURNHAM FARMS, LLC | Alf | Pivot | -- | F | -- | N |
| 44610 | CER | NE | SW | 27 | 22N | 54E | Y | [9] | 125.70 | | 120.00 | | BURNHAM FARMS, LLC | Alf | Pivot | -- | F | -- | N |
| 44621 | CER | SE | NW | 36 | 21N | 53E | Y | 18621, 18622 | 206.29 | | 825.16 | | ALLEN, ROGER & JUDY | Alf | Pivot | -- | I | -- | N |
| 46287 | CER | NW | SW | 2 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | GROTH, DANIEL E.. | Grain | Pivot | 130.00 | I | 321.18 | N |
| 46348 | CER | | LT05 | 1 | 21N | 53E | Y | [3] | 131.28 | | 525.12 | | PLASKETT, TOMMYE J. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 46461 | CER | SW | NW | 29 | 23N | 54E | | | 144.00 | 144.00 | 576.00 | 576.00 | MOYLE, DUSTY L. | Grass Hay | Piovt | 126.00 | I | 355.76 | N |
| 46505 | CER | SW | NW | 8 | 21N | 54E | | | 127.60 | 127.60 | 510.40 | 510.40 | BURNHAM FARMS, LLC | Alf | Pivot | 126.00 | I | 370.59 | N |
| 47518 | CER | | LT05 | 29 | 20N | 53E | Y | [10] | 317.54 | 317.54 | 504.24 | 1,270.16 | ANDERSON, EDWARD B. | Alf | Pivot | 254.00 | I | 747.06 | N |
| 47519 | CER | | LT05 | 29 | 20N | 53E | Y | [10] | 317.54 | | 278.40 | | ANDERSON, EDWARD B. | Alf | Pivot | -- | F | 504.24 | N |
| 47520 | CER | | LT05 | 29 | 20N | 53E | Y | [10] | 317.54 | | 638.72 | | ANDERSON, EDWARD B. | Alf | Pivot | -- | F | 242.82 | N |
| 47521 | CER | | LT05 | 29 | 20N | 53E | Y | [10] | 317.54 | | 168.24 | | ANDERSON, EDWARD B. | Alf | Pivot | -- | F | -- | N |
| 47591 | CER | SW | NE | 30 | 23N | 54E | | | 127.20 | 127.20 | 508.80 | 508.80 | ALLEN, ROGER B. & JUDY B. | Grain | Pivot | 126.00 | F | 311.29 | N |
| 48225 | CER | SE | NW | 7 | 21N | 53E | Y | 34596, 48226 | 120.58 | | 482.30 | | MORRISON, CHERYL A. | Grass Hay | Pivot | 113.00 | I | 319.06 | N |
| 48226 | CER | SE | NW | 7 | 21N | 53E | Y | 34596, 48225 | 120.58 | | 300.00 | | MORRISON, CHERYL A. | Grass Hay | Pivot | -- | F | -- | N |
| 48437 | CER | SE | SW | 22 | 22N | 54E | Y | 34939 | 130.00 | | 272.80 | | MOYLE, MARK STEPHEN | Alf | Pivot | -- | F | -- | N |
| 48871 | CER | SE | NE | 4 | 21N | 54E | Y | [11] | 213.20 | 213.20 | 296.50 | 852.70 | GALLAGHER FARMS, LLC; A NEVADA LIMITED LIABILITY COMPANY | Alf, Grass Hay | Pivot | 205.00 | I | 296.50 | N |
| 48872 | CER | SE | NE | 4 | 21N | 54E | Y | [11] | 213.20 | | 327.10 | | GALLAGHER FARMS, LLC; A NEVADA LIMITED LIABILITY COMPANY | Alf, Grass Hay | Pivot | -- | F | 297.50 | N |
| 48948 | CER | SE | SW | 6 | 21N | 53E | Y | 55272 | 119.64 | 124.78 | 478.56 | 499.12 | BAILEY, CAROLYN | Alf | Pivot | 121.00 | I | 355.88 | N |
| 49185 | CER | SE | SW | 29 | 23N | 54E | | | 125.68 | 125.68 | 502.72 | 502.72 | MOYLE, DUSTY L. | Alf | Pivot | 123.00 | I | 361.76 | N |
| 49188 | CER | SE | SW | 29 | 23N | 54E | | | 125.68 | 125.68 | 502.72 | 502.72 | MOYLE, DUSTY L. | Grass Hay | Pivot | 129.00 | I | 364.24 | N |
| 49853 | CER | SW | SW | 7 | 21N | 53E | Y | 49854 | 29.63 | 29.63 | 118.52 | 118.52 | DUBRAY, FERNO L. & CARRIE M. | None | None | 0.00 | F | 0.00 | N |
| 49854 | CER | | LT08 | 7 | 21N | 53E | Y | 49853 | 29.63 | | 118.52 | | DUBRAY, FERNO L. & CARRIE M. | None | None | 0.00 | F | 0.00 | N |
| 50095 | CER | SE | SW | 30 | 23N | 54E | | | 127.20 | 127.20 | 508.80 | 508.80 | MOYLE, DUSTY L. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 50581 | CER | SE | NW | 6 | 24N | 53E | Y | 50582 | 275.01 | 275.01 | 249.66 | 1,100.04 | SADLER RANCH, LLC | Alf | Pivot | 235.00 | I | 249.66 | N |
| 50582 | CER | NW | SW | 6 | 24N | 53E | Y | 50581 | 275.01 | | 1,100.04 | | SADLER RANCH, LLC | Alf | Pivot | -- | F | 441.52 | N |
| 50650 | CER | SW | NW | 32 | 23N | 54E | Y | [1] | 160.00 | | 640.00 | | MOYLE, JAMES L. | Alf | Pivot | -- | F | -- | N |
| 50962 | CER | NW | NW | 13 | 23N | 52E | Y | 50963, 57838 | 75.30 | 118.30 | 129.20 | 473.20 | KOBEH VALLEY RANCH LLC | None | None | 0.00 | F | 0.00 | N |

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2013

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50963 | CER | NW | NW | 13 | 23N | 52E | Y | 50962, 57838 | 75.30 | | 172.00 | | KOBEH VALLEY RANCH LLC | None | None | 0.00 | F | 0.00 | N |
| 51647 | CER | SW | NW | 2 | 21N | 53E | | | 144.70 | 144.70 | 578.80 | 578.80 | GROTH, DANIEL E. | Alf | Pivot | 125.00 | I | 367.65 | N |
| 53872 | CER | NE | SW | 28 | 22N | 54E | Y | 14948 | 303.94 | | 617.20 | | PALMORE, DONALD FRANK | Alf, Grain | Flood | -- | I | -- | N |
| 55535 | CER | SW | NW | 5 | 22N | 54E | Y | 39156 | 125.60 | | 502.40 | | ETCHEGARAY, FRED L. | Alf | Pivot | -- | F | -- | N |
| 55727 | CER | SE | SW | 6 | 21N | 53E | Y | 48948 | 5.14 | | 20.56 | | BAILEY, CAROLYN | Alf | Pivot | 5.14 | I | 15.12 | N |
| 56652 | CER | SE | NW | 24 | 21N | 53E | Y | [5] | 120.00 | | 160.00 | | KEPHART, MARI A. | Alf | Pivot | -- | F | 38.82 | N |
| 57835 | PER | SE | SW | 13 | 23N | 52E | | | | | 0.00 | | KOBEH VALLEY RANCH LLC | | | | | 0.00 | |
| 57836 | PER | SE | SW | 13 | 23N | 52E | | | | | 0.00 | | KOBEH VALLEY RANCH LLC | | | | | 0.00 | |
| 57838 | CER | NW | NW | 13 | 23N | 52E | Y | 50962, 50963 | 118.30 | | 172.00 | | KOBEH VALLEY RANCH LLC | None | None | 0.00 | F | 0.00 | N |
| 57839 | PER | SE | SW | 13 | 23N | 52E | | | | | 0.00 | | KOBEH VALLEY RANCH LLC | | | | | 0.00 | |
| 57840 | PER | SE | SW | 13 | 23N | 52E | | | | | 0.00 | | KOBEH VALLEY RANCH LLC | | | | | 0.00 | |
| 63497 | CER | SE | SW | 36 | 24N | 52E | | | 120.71 | 120.71 | 408.30 | 408.30 | BAILEY, BARBARA | Alf, Grass | Pivot | 120.00 | I | 352.94 | N |
| 64630 | CER | SE | NW | 1 | 20N | 53E | Y | [6] | 107.61 | | 288.67 | | MOLL, HOLLON D. & VELMA M. | Alf | Pivot | -- | I | 185.52 | N |
| 64631 | CER | SE | NW | 1 | 20N | 53E | Y | [6] | 107.61 | | 288.67 | | MOLL, HOLLON D. & VELMA M. | Alf | Pivto | -- | F | -- | N |
| 64632 | CER | SE | NW | 1 | 20N | 53E | Y | [6] | 107.61 | | 71.71 | | MOLL, HOLLON D. & VELMA M. | Alf | Pivot | -- | F | -- | N |
| 64633 | CER | SE | NW | 1 | 20N | 53E | Y | [6] | 107.61 | | 288.67 | | MOLL, HOLLON D. & VELMA M. | Alf | Pivot | -- | F | -- | N |
| 66062 | PER | SE | SW | 13 | 23N | 52E | | | | | 0.00 | | KOBEH VALLEY RANCH LLC | | | | | 0.00 | |
| 67172 | CER | SW | SW | 34 | 21HN | 54E | | | 123.77 | 123.77 | 495.07 | 495.07 | MARK & TERESA MOYLE FAMILY TRUST | Grass Hay | Pivot | 127.00 | I | 358.59 | N |
| 68923 | PER | NW | NW | 32 | 20N | 53E | | | 60.50 | 60.50 | 242.00 | 242.00 | EUREKA COUNTY | None | Wheel Lines | 0.00 | F | 0.00 | N |
| 70587 | CER | NE | NW | 4 | 21N | 54E | Y | [11] | 211.46 | | 123.56 | | GALLAGHER FARMS, LLC; A NEVADA LIMITED LIABILITY COMPANY | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 70588 | CER | NE | NW | 4 | 21N | 54E | Y | [11] | 205.82 | | 229.11 | | GALLAGHER FARMS, LLC; A NEVADA LIMITED LIABILITY COMPANY | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 70940 | CER | SW | SE | 19 | 22N | 54E | | | 125.68 | 125.68 | 502.72 | 502.72 | MARK MOYLE FARMS, LLC | Alf | Pivot | 129.00 | I | 379.41 | N |
| 71748 | CER | SE | SE | 8 | 22N | 54E | | | 126.70 | 126.70 | 506.80 | 506.80 | FRED L. ETCHEGARAY AND JOHN J. ETCHEGARAY, A NEVADA PARTNERSHIP | Pasture | Pivot | 128.00 | I | 376.47 | N |
| 72370 | PER | | LT02 | 7 | 22N | 54E | Y | 18242 | 320.00 | | 1,280.00 | | ANDERSEN, HARLOW B. & BONNIE G. | Alf | Pivot | -- | F | -- | N |
| 73899 | PER | SE | SW | 4 | 22N | 54E | | | 157.75 | 157.75 | 631.18 | 631.18 | DENNIS L WEST & KIM KENNEDY WEST | Alf | Pivot | 130.00 | I | 382.35 | N |
| 73570 | PER | NE | SW | 5 | 25N | 53E | Y | [12] | 305.92 | 305.92 | 33.20 | 530.00 | RENNER, IRA R. & MONTIRA | Alf, Grass Hay | Pivot | 232.00 | I | 33.20 | D |
| 73571 | PER | NE | SW | 5 | 25N | 53E | Y | [12] | 305.92 | | 128.40 | | RENNER, IRA R. & MONTIRA | Alf, Grass Hay | Pivot | -- | F | 128.40 | D |
| 73572 | PER | SE | NW | 5 | 25N | 53E | Y | [12] | 305.92 | | 128.40 | | RENNER, IRA R. & MONTIRA | Alf, Grass Hay | Pivot | -- | F | 128.40 | D |
| 73573 | PER | SE | NW | 5 | 25N | 53E | Y | [12] | 305.92 | | 240.00 | | RENNER, IRA R. & MONTIRA | Alf, Grass Hay | Pivot | -- | F | 240.00 | D |
| 76358 | PER | NE | NW | 23 | 21N | 53E | | | 136.36 | 136.36 | 545.44 | 545.44 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 122.00 | I | 358.82 | N |
| 77082 | PER | SE | NW | 13 | 24N | 52E | Y | 82704T, 82705T | 225.52 | 225.52 | 402.08 | 902.08 | SADLER RANCH, LLC | Alf | Wheel Lines | 225.00 | I | 750.00 | N |
| 77569 | PER | NW | SE | 14 | 21N | 53E | Y | 81269 | 133.40 | 133.40 | 207.22 | 533.60 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 77646 | CER | SE | SE | 33 | 21HN | 54E | Y | [13] | 256.06 | 256.06 | 123.60 | 1,024.24 | WILLIAM H NORTON | Alf | Pivot | 256.06 | I | 123.60 | N |
| 77665 | PER | NW | SE | 27 | 23N | 54E | Y | 77666 | 165.00 | 165.00 | 153.76 | 547.88 | JOSEPH L RAND AND ELLEN M RAND REVOCABLE LIVING TRUST DATED MAY 9 1996 | Alf | Pivot | 128.00 | I | 153.76 | N |
| 77666 | PER | SE | NW | 27 | 23N | 54E | Y | 77665 | 165.00 | | 394.12 | | JOSEPH L RAND AND ELLEN M RAND REVOCABLE LIVING TRUST DATED MAY 9 1996 | Alf | Pivot | -- | F | 222.71 | N |
| 77673 | CAN | NE | SE | 11 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | BENSON, PATTI E. | Alf | Pivot | 127.00 | I | 373.53 | N |
| 77695 | CER | SE | SE | 33 | 21HN | 54E | Y | [13] | 256.06 | | 469.92 | | WILLIAM H NORTON | Alf | Pivot | -- | F | 469.92 | N |
| 77696 | CER | SE | SE | 33 | 21HN | 54E | Y | [13] | 256.06 | | 295.12 | | WILLIAM H NORTON | Alf | Pivot | -- | F | 159.60 | N |
| 78062 | PER | NW | NE | 14 | 21N | 53E | | | 157.00 | 157.00 | 628.00 | 628.00 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 121.00 | I | 355.88 | N |
| 78447 | PER | NW | SE | 12 | 21N | 53E | Y | 19965 | 158.00 | | 0.00 | | RAND, JOSEPH L. AND ELLEN M. | Alf | Pivot | -- | F | -- | N |
| 78568 | CER | NW | NW | 34 | 21HN | 54E | | | 81.95 | 81.95 | 327.80 | 327.80 | MARK & TERESA MOYLE FAMILY TRUST DATED 12/22/1999 | Alf | Pivot | 90.00 | I | 264.71 | N |
| 78771 | PER | NW | SE | 4 | 20N | 53E | Y | [14] | 257.20 | 257.20 | 362.40 | 1,028.80 | J.W.L. PROPERTIES, LLC | Alf, Grass Hay | Pivot | 257.00 | I | 362.40 | N |
| 78772 | PER | | LT16 | 4 | 20N | 53E | Y | [14] | 257.20 | | 128.00 | | J.W.L. PROPERTIES, LLC | Alf, Grass Hay | Pivot | -- | F | 128.00 | N |
| 78773 | PER | | LT16 | 4 | 20N | 53E | Y | [14] | 257.20 | | 398.40 | | J.W.L. PROPERTIES, LLC | Alf, Grass Hay | Pivot | -- | F | 250.42 | N |
| 78774 | PER | SW | SE | 4 | 20N | 53E | Y | [14] | 257.20 | | 52.00 | | J.W.L. PROPERTIES, LLC | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 78775 | PER | SW | SE | 4 | 20N | 53E | Y | [14] | 257.20 | | 88.00 | | J.W.L. PROPERTIES, LLC | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 78905 | PER | SW | NE | 28 | 21N | 53E | Y | 19904, 24609 | 274.80 | | 1,099.20 | | DIAMOND VALLEY RANCH LLC | Alf | Pivot | -- | F | -- | N |
| 78906 | PER | SW | NE | 28 | 21N | 53E | | | 146.10 | 146.10 | 584.40 | 584.40 | DIAMOND VALLEY RANCH LLC | None | None | 0.00 | F | 0.00 | N |
| 80581 | PER | SW | NE | 12 | 21N | 53E | Y | 19966 | 156.00 | | 405.80 | | RAND, JOSEPH L AND ELLEN M | Alf | Pivot | -- | F | -- | N |
| 80717 | CER | SW | SE | 32 | 21HN | 54E | Y | [15] | 78.00 | 155.00 | 136.00 | 620.00 | NORTON, WILLIAM H JR AND PATRICIA A | Alf | Pivot | -- | F | -- | N |
| 80718 | CER | SE | SW | 33 | 21HN | 54E | Y | [13] | 256.06 | | 135.60 | | NORTON, WILLIAM H JR | Alf | Pivot | -- | F | -- | N |

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2013

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80780 | PER | SE | SE | 10 | 20N | 53E | Y | 18988 | 160.00 | | 640.00 | | SESTANOVICH HAY & CATTLE LLC | Grass Hay | Pivot | -- | F | -- | N |
| 80781 | PER | SE | NE | 10 | 20N | 53E | Y | 18989 | 160.00 | | 640.00 | | SESTANOVICH HAY & CATTLE LLC | None | None | -- | F | -- | N |
| 80879 | CER | SW | SE | 32 | 21HN | 54E | Y | [15] | 77.00 | | 249.52 | | NORTON, WILLIAM H JR AND PATRICIA A | Alf | Pivot | -- | F | -- | N |
| 80880 | CER | SW | SE | 32 | 21HN | 54E | Y | [15] | 78.00 | | 87.28 | | NORTON, WILLIAM H JR AND PATRICIA A | Alf | Pivot | -- | F | -- | N |
| 80881 | CER | SW | SE | 32 | 21HN | 54E | Y | [15] | 78.00 | | 44.00 | | NORTON, WILLIAM H JR AND PATRICIA A | Alf | Pivot | -- | F | -- | N |
| 80926 | CER | SW | SE | 32 | 21HN | 54E | Y | [15] | 155.00 | | 103.20 | | NORTON, WILLIAM H JR | Alf | Pivot | 155.00 | I | 455.88 | N |
| 81004 | PER | SE | SW | 11 | 20N | 53E | Y | 31455 | 12.77 | | 51.08 | | HALPIN, JAYME L | Alf | Pivot | 12.77 | I | 37.56 | N |
| 81268 | PER | SE | NE | 32 | 23N | 54E | Y | [1] | 320.00 | | 1,280.00 | | MOYLE, JAMES L AND N JANE | Alf, Grain, Grass | Pivot | -- | F | -- | N |
| 81269 | PER | NE | SE | 14 | 21N | 53E | Y | 77569 | 133.40 | | 207.22 | | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | -- | F | -- | N |
| 81650 | PER | | LT15 | 21 | 20N | 53E | | | 26.61 | 26.61 | 106.45 | 106.45 | EUREKA MOLLY, LLC | | | No Estimate | | No Estimate | |
| 82368T | PER | NW | NE | 34 | 21N | 53E | Y | [2] | 156.00 | | 485.33 | | SHADY MEADOWS, INC | Alf | Pivot | -- | F | -- | N |
| 82704T | PER | NE | NW | 24 | 24N | 52E | Y | 77082, 82705T | 225.52 | | 500.00 | | SADLER RANCH, LLC | Alf | Wheel Lines | -- | F | -- | N |
| 82705T | PER | NW | SE | 23 | 24N | 52E | Y | 77082, 82704T | 225.52 | | 204.74 | | SADLER RANCH, LLC | Alf | Wheel Lines | -- | F | -- | N |
| 82798T | PER | SE | NW | 5 | 21N | 54E | Y | 19015 | 158.00 | | 442.64 | | J & T FARMS, LLC | Alf | Pivot | -- | F | -- | N |

**Total Suplementally Adjusted Permitted/Certificated Acreage** 31,583.10
**Total Suplementally Adjusted Permitted/Certificated Pumpage** 125,332.08

**Total Estimated Acreage** 25,251.57
**Total Estimated Pumpage** 75,036.99

[1] PERMITS 19145, 29873, 30102, 36070, 50650 AND 81268 HAVE A TOTAL COMBINED DUTY OF 2,560.00 AFA.

[2] PERMITS 19378, 20000, 24605 AND 82368T HAVE A TOTAL COMBINED DUTY OF 2,560.00 AFA.

[3] PERMITS 19972, 19973, 34948 AND 46348 HAVE A TOTAL COMBINED DUTY OF 1,281.32 AFA.

[4] PERMITS 24262, 24263, 24264 AND 24265 HAVE A TOTAL COMBINED DUTY OF 1,888.00 AFA.

[5] PERMITS 42367, 42368, 42369, 42370 AND 56652 HAVE A TOTAL COMBINED DUTY OF 480.00 AFA.

[6] PERMITS 42891, 64630, 64631, 64632 AND 64633 HAVE A TOTAL COMBINED DUTY OF 430.44 AFA.

[7] PERMITS 43269, 43837, 43838, 43839 AND 43840 HAVE A TOTAL COMBINED DUTY OF 520.00 AFA.

[8] PERMITS 43271, 43272, 43273 AND 43274 HAVE A TOTAL COMBINED DUTY OF 2,080.00 AFA.

[9] PERMITS 44604, 44605, 44606, 44607, 44609 AND 44610 HAVE A TOTAL COMBINED DUTY OF 502.00 AFA.

[10] PERMITS 47518, 47519, 47520 AND 47521 HAVE A TOTAL COMBINED DUTY OF 1,270.16 AFA.

[11] PERMITS 48871, 48872, 70587 AND 70588 HAVE A TOTAL COMBINED DUTY OF 852.7 AFA.

[12] PERMITS 73570, 73571, 73572 AND 73573 HAVE A TOTAL COMBINED DUTY OF 530.00 AFA.

[13] PERMITS 77646, 77695, 77696 AND 80718 HAVE A TOTAL COMBINED DUTY OF 1,024.24 AFA.

[14] PERMITS 78771, 78772, 78773, 78774 AND 78775 HAVE A TOTAL COMBINED DUTY OF 1,028.8 AFA.

[15] PERMITS 80717, 80879, 80880, 80881 AND 80926 HAVE A TOTAL COMBINED DUTY OF 620.00 AFA.

**STATE OF NEVADA**

**DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES**

**DIVISION OF WATER RESOURCES**

**JASON KING, P.E.**
**STATE ENGINEER**

# DIAMOND VALLEY
# HYDROGRAPHIC BASIN 10-153

## CROP INVENTORY

## CALENDAR YEAR 2014

Prepared by: Shannon McDaniel
Landon Harris and Kyle Wolf

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## LIST OF FIGURES

## ABSTRACT

This inventory represents the status and usage of all permitted, certificated, and claims of vested right groundwater rights for irrigation purposes located within Diamond Valley, Hydrographic Basin 10-153, for the year 2014. **Only those groundwater rights associated with irrigation purposes are represented in this report**. For a listing and summary of all other manners of use within the basin please refer to the Nevada Division of Water Resources Hydrographic Basin Summary.

The data presented are valid for the time period of this report and may vary from previously published figures as water rights within the basin are subject to administrative action, such as certification, cancellation, forfeiture or withdrawal on a continuing basis.

For the year 2014, the permitted and certificated groundwater rights for irrigation purposes totaled **31,425 acres** with a total duty of 124,700 acre-feet within Diamond Valley. An estimated **24,676 acres** were irrigated and 73,136 acre-feet were pumped during 2014.

## HYDROGRAPHIC BASIN SUMMARY

| | |
|---|---|
| HYDROGRAPHIC BASIN NUMBER | 153, REGION 10 |
| HYDROGRAPHIC BASIN NAME | DIAMOND VALLEY |
| COUNTIES | EUREKA AND ELKO |
| MAJOR COMMUNITIES | EUREKA |
| DESIGNATED BASIN | DESIGNATED - IRRIGATION DENIED |
| DENIALS BASED UPON WATER AVAILABILITY | ALL USES |
| ESTIMATED IRRIGATION PUMPAGE 2014 (ACRE-FEET) | 73,136* |

STATE ENGINEER'S ORDERS

| | |
|---|---|
| NO. 277 – PARTIAL DESIGNATION OF BASIN | AUGUST 5, 1964 |
| NO. 280 – AMENDED DESIGNATION OF BASIN | AUGUST 28, 1964 |
| NO. 541 – NOTICE OF CURTAILMENT | DECEMBER 22, 1975 |
| NO. 717 – NOTICE OF CURTAILMENT | JULY 10, 1978 |
| NO. 809 – TOTALIZING METERS | DECEMBER 1, 1982 |
| NO. 813 – AMENDMENT OF ORDER 809 | FEBRUARY 7, 1983 |
| NO. 815 – AMENDED DESIGNATION OF BASIN | APRIL 4, 1983 |
| NO. 1226 – AMENDED DESIGNATION OF BASIN | MARCH 26, 2013 |

COMMITTED GROUNDWATER RESOURCE FOR IRRIGATION PURPOSES: 124,700 ACRE-FEET
DATE: DECEMBER 2014

NOTE: Committed groundwater resource data are approximate for December 2014. Rights may be subject to change applications, certification, withdrawals, forfeiture and cancellations; each of these circumstances could impact the duty, diversion rate and acreage associated with a given right. Be advised this report acknowledges that other manner of uses may be present in the basin; however, only those groundwater rights associated with irrigation purposes are represented in this report.

* Acreage represented in this report may have surface water rights appurtenant. This report acknowledges those acres with surface water rights but is not intended to quantify, nor present any definitive use of those surface water rights. The data represent only the pumping of groundwater and the acreage to which it is applied.

## PURPOSE AND SCOPE

The purpose of this report is to inventory all of the groundwater resources allocated to irrigation and described by the Office of the State Engineer, Nevada Division of Water Resources (NDWR), and to estimate the amount of groundwater pumped for irrigation purposes within the Diamond Valley Hydrographic Basin (10-153), for the year 2014.

## DESCRIPTION OF THE STUDY AREA

The Diamond Valley Hydrographic Basin is located in central Nevada (Figure 1), occupying approximately 735 square miles in Eureka and Elko Counties. The adjacent hydrographic basins are Huntington Valley (4-035) to the northeast, Little Smoky Valley - Northern Part (155A) and Newark Valley (10-154) to the east, Antelope Valley (10-151) to the southwest, Kobeh Valley (10-139) to the west, and Pine Valley (4-053) to the northwest.

Diamond Valley is bounded by the Diamond Mountain Range to the east, by the Mahogany Hills to the south, and to the west by the Sulphur Spring Range. Diamond Valley is approximately 20 miles wide by 56 miles long with basin elevations ranging from approximately 5,760 feet above mean sea level on the valley floor to approximately 10,000 feet in the surrounding mountains. Irrigation occurs primarily in the south central part of the basin (Figure 2).

## GROUNDWATER LEVELS

Depths to groundwater in Diamond Valley are measured by multiple agencies on an annual basis. Sites at which water level measurements are made by or reported to NDWR include:

| | | |
|---|---|---|
| 153 N20 E52 26AABC1 | 153 N20 E52 26AABC2 | 153 N20 E53 02DDDD1 |
| 153 N20 E53 04DDBB2 | 153 N20 E53 10DDDD2 | 153 N20 E53 20BC 01 |
| 153 N20 E53 21CDDC1 | 153 N20 E53 28ADC 01 | 153 N20 E53 30ABCC2 |
| 153 N20 E53 30DCCC1 | 153 N20 E53 32BBBA1 | 153 N20 E53 32BDCC1 |
| 153 N21 E52 04BBAA1 | 153 N21 E52 10AAAC1 | 153 N21 E52 10AAAC2 |
| 153 N21 E53 01BCAA1 | 153 N21 E53 01CDCC2 | 153 N21 E53 02CCAA1 |
| 153 N21 E53 03BBDD2 | 153 N21 E53 03CDBB2 | 153 N21 E53 04CDBB1 |
| 153 N21 E53 06CDBB2 | 153 N21 E53 08BACC1 | 153 N21 E53 08DCAA1 |
| 153 N21 E53 09BBDD2 | 153 N21 E53 09DBDD1 | 153 N21 E53 11CDBB2 |
| 153 N21 E53 12CCBC2 | 153 N21 E53 12DCAA2 | 153 N21 E53 13DA 1 |
| 153 N21 E53 14CACC2 | 153 N21 E53 15BACC2 | 153 N21 E53 16CCAA3 |
| 153 N21 E53 20AACC2 | 153 N21 E53 21DCAA2 | 153 N21 E53 22BDBB2 |
| 153 N21 E53 23AACC1 | 153 N21 E53 23DACC1 | 153 N21 E53 24ADBB1 |
| 153 N21 E53 24CDDD1 | 153 N21 E53 27ACAA3 | 153 N21 E53 28BBDD1 |
| 153 N21 E53 33AACC2 | 153 N21 E53 34DDB 02 | 153 N21 E53 35BDBB2 |
| 153 N21 E53 36AD 1 | 153 N21 E53 36CDD 01 | 153 N21 E54 05BDBB1 |
| 153 N21 E54 05DCCC1 | 153 N21 E54 08CDDD1 | 153 N21 E54 20BACC2 |
| 153 N21 E54 20CCCC1 | 153 N21HE52 35ADD 2 | 153 N21HE54 32DCC 2 |
| 153 N21HE54 34BBD 1 | 153 N22 E51 01CBAB1 | 153 N22 E51 01DBBB1 |
| 153 N22 E51 01DBBB2 | 153 N22 E51 12ADCD1 | 153 N22 E51H12DBBC1 |

| | | |
|---|---|---|
| 153 N22 E51H13DADB1 | 153 N22 E52 07DBBD1 | 153 N22 E52 07DBBD2 |
| 153 N22 E52 11ACCB1 | 153 N22 E52 16CCCB1 | 153 N22 E52 17DDAC1 |
| 153 N22 E52 17DDCA1 | 153 N22 E52 18ACDB1 | 153 N22 E52 18CBDD1 |
| 153 N22 E52 18CBDD2 | 153 N22 E52 19CBBC1 | 153 N22 E52 20CBDC1 |
| 153 N22 E54 05CDBB2 | 153 N22 E54 05DDBB2 | 153 N22 E54 06CCCC1 |
| 153 N22 E54 07DDCD2 | 153 N22 E54 18CADD1 | 153 N22 E54 19CC 1 |
| 153 N22 E54 22CCDD1 | 153 N22 E54 28AACC1 | 153 N22 E54 28DCCC2 |
| 153 N22 E54 32DDCD1 | 153 N22 E54 33BBDD1 | 153 N23 E51 36ACDC1 |
| 153 N23 E52 13BBA 1 | 153 N23 E53 27BB 1 | 153 N23 E53 29CCCA1 |
| 153 N23 E53 31BBD 01 | 153 N23 E54 20DD 1 | 153 N23 E54 27ACC 1 |
| 153 N23 E54 29CDDD2 | 153 N23 E54 30DDD 2 | 153 N23 E54 32CDD 01 |
| 153 N24 E53 06BDAB1 | 153 N25 E54 28BCBC1 | |

Groundwater level data have also been collected by the U.S. Geological Survey (USGS) and can be accessed through their website (http://nevada.usgs.gov).

## METHODS TO ESTIMATE IRRIGATED ACREAGE

This report estimates the number of acres irrigated by the groundwater pumped under permits, certificates, and claims of vested right issued by the State Engineer. Table 1 and Figure 3 present the current and historic irrigated acreage and pumpage; Appendix A presents estimates detailed by certificate, permit, or vested claim number. The following methods were used to arrive at the estimated acreage:

- Field inspection of the place of use was conducted to estimate the number of acres under cultivation.
- In cases where field inspection of the place of use was not practical, aerial and/or satellite imagery were analyzed to determine acreages.

## METHODS TO ESTIMATE PUMPAGE

This report estimates the amount of groundwater pumped under the permits and certificates issued by the Nevada State Engineer as well as claims of vested right in the Diamond Valley Hydrographic Basin. The following methods were used to arrive at the estimated use:

- Where totalizing meters were in place, meter readings were taken and compared with previous data (if available).
- Where meters were not in place and the use was irrigation, pumpage was estimated by multiplying the number of hours the well was operated during the past year (determined from an hour meter reading or asking the water user) by the certificated diversion rate.
- Where there were no flow meters or other reliable options for estimating pumpage and the use was irrigation, pumpage was estimated by dividing the Net Irrigation Water Requirement (NIWR) for the crop grown by the efficiency of the irrigation method used, then multiplying by the number of acres irrigated. Irrigation efficiencies associated with three types of irrigation methods are: pivot at 85%; wheel line or other hand moved sprinklers at 75%; and flood at 60%. The pumpage amount estimated by this method was limited by the duty of the permit. For places where the groundwater rights were supplemental to surface water, groundwater use was estimated using the NIWR method above, but adjusted based on available surface water for the year. Evapotranspiration and NIWR data by basin can be found on the NDWR website at: http://water.nv.gov/mapping/et/et_general.cfm. This approach using the NIWR to estimate pumpage was used starting in 2013; this and subsequent pumpage estimates may differ significantly from estimates of previous years.
- Where lands are irrigated by both surface water and groundwater, the surface water supply for the irrigation season was considered in estimating groundwater pumpage.

## TABLES

Table 1. Diamond Valley historical irrigated acreage and pumpage data.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Acres Irrigated | 24,608 | 24,357 | 25,234 | 25,252 | 24,676 |
| Acre-Feet Pumped* | 71,400 | 70,600 | 73,200 | 75,037 | 73,136 |

* The NIWR method to estimate pumpage was used starting in 2013; estimates may differ significantly from previous years. Annual pumpage data for 2010 through 2012 are revised from previous crop inventories per State Engineer's Order 1264.

## FIGURES

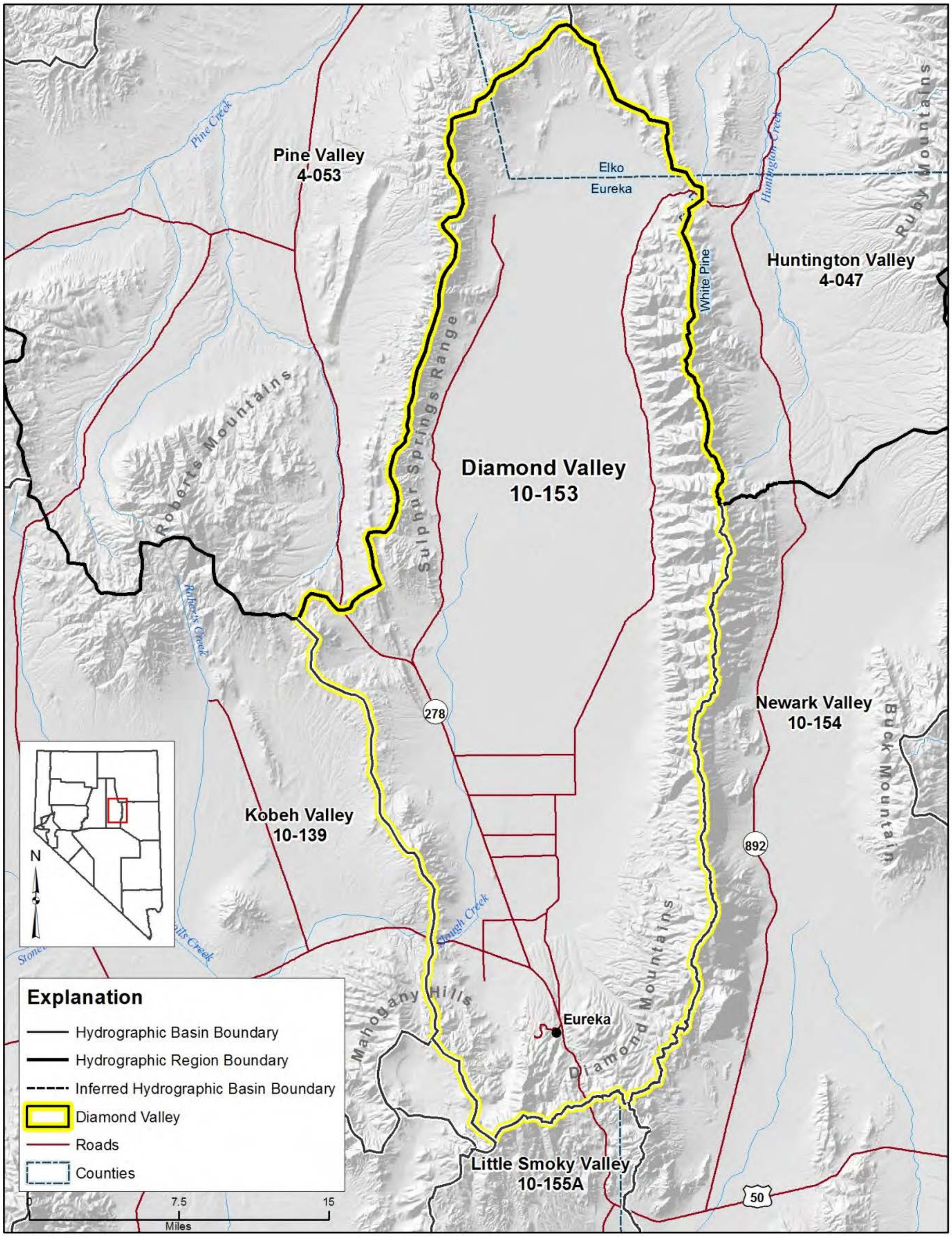


Figure 1. Physiographic map of Diamond Valley (Hydrographic Basin 10-153).

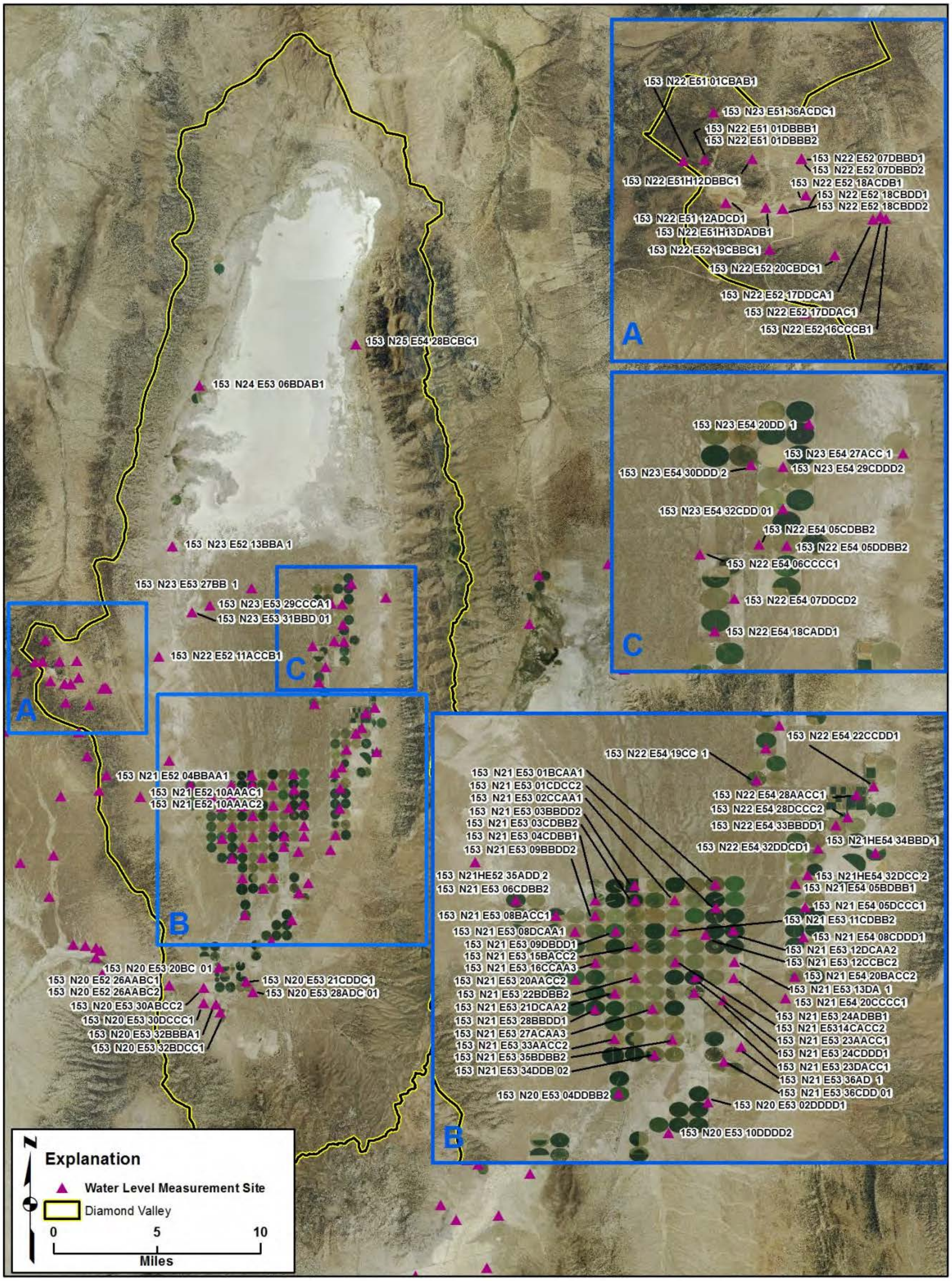


Figure 2. Map showing Diamond Valley irrigated acreage and water level monitoring sites.



JA1184

SE ROA 871

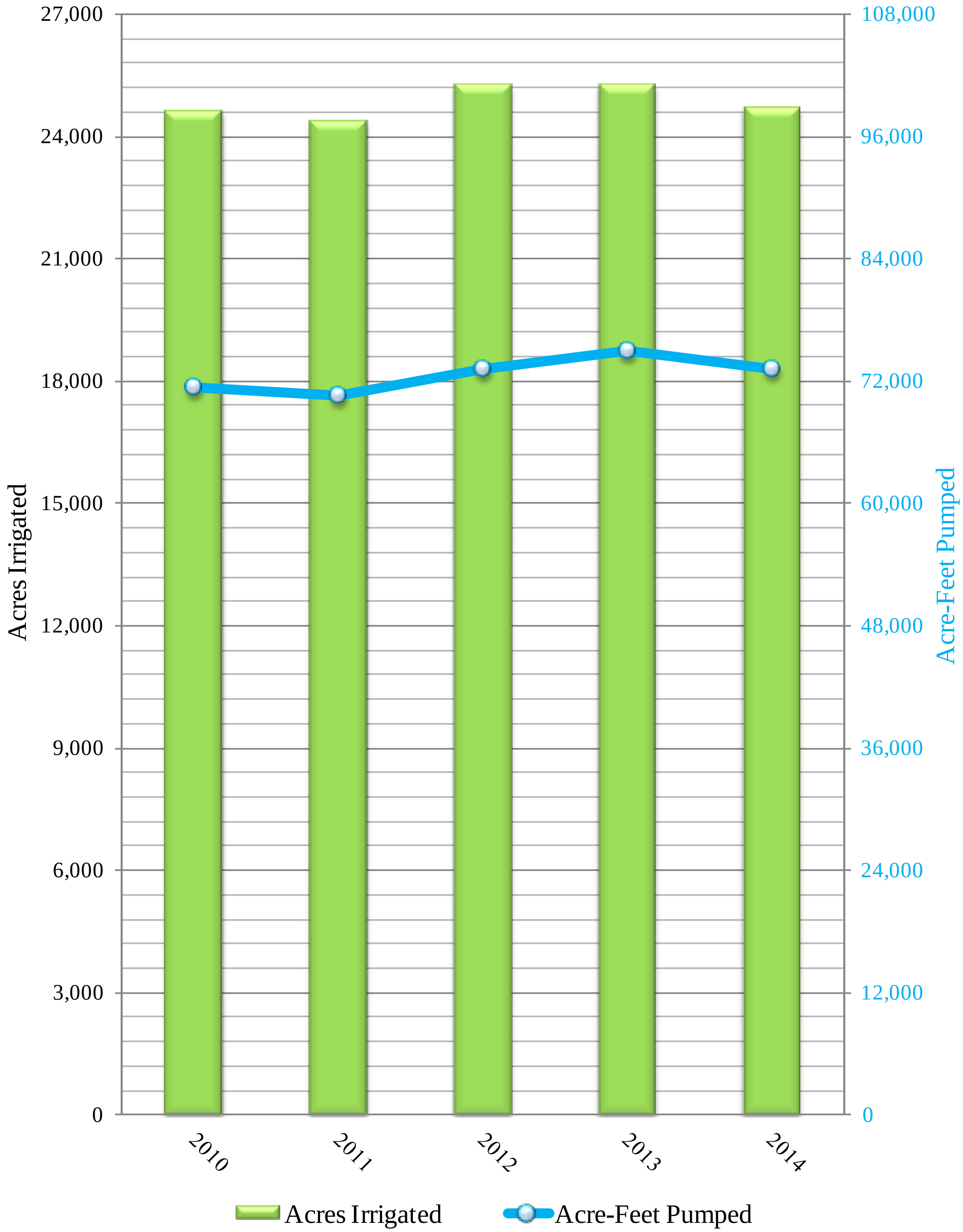


Figure 3. Graph showing Diamond Valley historical irrigated acreage and pumpage. The NIWR method to estimate pumpage was used starting in 2013; estimates may differ significantly from previous years. Annual pumpage data for 2010 through 2012 are revised from previous crop inventories per State Engineer's [Order 1264](Order 1264).

## APPENDIX A. 2014 DIAMOND VALLEY CROP INVENTORY.

## EXPLANATION OF COLUMN HEADINGS

| | |
|---|---|
| App No | The file number of the Application to Appropriate/Change Water or the Claim of Vested Right. |
| Status | Indicates the status of an application: Permit (PER), Certificated (CER), or a Claim of Vested Right (VST). |
| QQ | The quarter-quarter of the Section in which the point of diversion is located. |
| Q | The quarter of the Section in which the point of diversion is located. |
| Sec | The Section in which the point of diversion is located. |
| Twn | The Township in which the point of diversion is located. |
| Rng | The Range in which the point of diversion is located. |
| Sup | Indicates whether the groundwater right is part of a group of groundwater rights used to irrigate all or a portion of the same acreage (supplemental). A “Y” in this column signifies the groundwater right is supplemental to other groundwater rights. |
| Supplemental Application Number | The application number(s) of the water right(s) that are supplemental to one another. |
| Permitted Acres | The number of acres defined by the permit or certificate that is eligible to be irrigated. |
| Supple-mentally Adjusted Permitted Acres | The supplementally adjusted, total number of acres that is eligible to be irrigated under a supplemental group of water rights. |
| Permitted Duty Acre-Feet | The amount of water that may be pumped in a given year, or season, as defined by the permit, certificate, or claim of vested right. If there is a supplemental group, the total combined duty is listed as a supplementally adjusted duty. |
| Supple-mentally Adjusted Duty Acre-Feet | The supplementally adjusted, total combined duty that may be pumped in a given year, or season, for a supplemental group of water rights, expressed in acre-feet. The supplementally adjusted, total combined duty is listed at the end of a supplemental group in **bold**. |
| Owner of Record | The owner of the water right as recorded in the records of the State Engineer. A water right may have more than one owner of record. Only the first, alphabetically, is listed in this table. |
| Crop Type | Indicates whether or not a crop was in production during the water year. If a crop was in production, the common name description of the plants under cultivation if given (e.g. alfalfa). |

| | |
|---|---|
| Irrigation Method | The method by which the water is applied to the crop and ground (e.g. pivot). |
| Irrigated Acreage | The estimate of the number of acres irrigated associated with a particular water right. A "-" in this field indicates that pumpage was attributed to a senior supplemental permit or certificated water right. |
| Acreage Estimation Method | The method by which the number of acres irrigated was determined. F – Field inspection. I – Aerial or satellite imagery. |
| Acre-Feet Pumped | The estimate of the amount of water pumped under a particular water right, expressed in acre-feet. One acre-foot equals 325,851 gallons. A "-" in this field indicates that pumpage was attributed to a senior supplemental permit or certificated water right. |
| Pumpage Estimation | The method used to estimate the amount of water pumped. M – Totalizing meter readings. N – NIWR Method. D – Duty. |

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2014

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14948 | CER | SW | SE | 28 | 22N | 54E | Y | 53872 | 308.60 | 612.54 | 617.20 | 1,234.40 | PALMORE, DONALD FRANK | Alf, Grain | Flood | 308.60 | I | 617.20 | D |
| 18242 | CER | SW | NE | 7 | 22N | 54E | Y | 72370 | 320.00 | 320.00 | 1,280.00 | 1,280.00 | ANDERSEN, BONNIE G. | Alf | Pivot | 219.00 | I | 644.12 | N |
| 18621 | CER | SE | NE | 36 | 21N | 53E | Y | 18622, 44621 | 206.29 | 206.29 | 825.16 | 825.16 | ALLEN, ROGER & JUDY | Alf | Pivot | 88.00 | I | 258.82 | N |
| 18622 | CER | SW | NE | 36 | 21N | 53E | Y | 18621, 44621 | 206.29 | | 825.16 | | ALLEN, ROGER & JUDY | Alf | Pivot | -- | F | -- | N |
| 18623 | CER | | LT12 | 1 | 20N | 53E | Y | 22551 | 278.22 | 278.22 | 1,112.88 | 1,112.88 | MACHACEK, JERRY L. & TRINA L. | Alf, Grass | Pivot | 158.00 | I | 464.71 | N |
| 18714 | CER | SE | SE | 35 | 21N | 53E | | | 209.00 | 209.00 | 836.00 | 836.00 | BECK FAMILY TRUST | None | Flood | 0.00 | F | 0.00 | N |
| 18786 | CER | NE | NE | 13 | 21N | 53E | Y | 18787 | 320.00 | 320.00 | 1,280.00 | 1,280.00 | JUANITA RUTHEL MARTIN TRUST 95% | None | Pivot | 0.00 | F | 0.00 | N |
| 18787 | CER | NE | NW | 13 | 21N | 53E | Y | 18786 | 320.00 | | 1,280.00 | | JUANITA RUTHEL MARTIN TRUST 95% | None | Pivot | -- | F | -- | N |
| 18788 | CER | NE | SE | 13 | 21N | 53E | Y | 18789 | 320.00 | 320.00 | 1,280.00 | 1,280.00 | JUANITA RUTHEL MARTIN | Grass Hay | Pivot | 120.00 | I | 338.82 | N |
| 18789 | CER | NE | SW | 13 | 21N | 53E | Y | 18788 | 320.00 | | 1,280.00 | | JUANITA RUTHEL MARTIN TRUST 95% | Grass Hay | Pivot | -- | F | -- | N |
| 18794 | CER | NE | NE | 23 | 21N | 53E | Y | 31111 | 120.00 | 159.50 | 480.00 | 638.00 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 94.00 | I | 276.47 | N |
| 18796 | CER | NE | SE | 23 | 21N | 53E | | | 160.00 | 160.00 | 640.00 | 640.00 | SMITH, CRAIG ALLEN & SHELBA KAY | Grass Hay | Pivot | 125.00 | I | 352.94 | N |
| 18797 | CER | NE | SW | 23 | 21N | 53E | | | 160.00 | 160.00 | 640.00 | 640.00 | SMITH, CRAIG ALLAN & SHELBA KAY | Alf | Pivot | 121.00 | I | 355.88 | N |
| 18802 | CER | SE | NE | 8 | 22N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | FRED L. ETCHEGARAY AND JOHN J. ETCHEGARAY, A NEVADA PARTNERSHIP | Grain | Pivot | 124.00 | I | 306.35 | N |
| 18834 | CER | SE | SE | 17 | 21N | 54E | Y | 19052 | 319.06 | 319.06 | 1,276.23 | 1,276.23 | NEWTON, DEBRA L. | Alf, Grass Hay | Pivot | 244.00 | I | 717.65 | N |
| 18835 | CER | SE | SW | 17 | 21N | 54E | Y | 19053 | 319.45 | 319.45 | 1,277.80 | 1,277.81 | NEWTON, DEBRA L. | Alf | Pivot | 245.00 | I | 720.59 | N |
| 18851 | CER | SW | SE | 5 | 21N | 54E | | | 129.11 | 129.11 | 516.44 | 516.44 | EUREKA COUNTY; GALLAGHER FARMS, LL | Alf | Pivot | 129.11 | I | 379.74 | N |
| 18911 | CER | SE | SW | 16 | 21N | 54E | | | 294.00 | 294.00 | 1,176.00 | 1,176.00 | HILL, HOWARD SR.; HILL, KATHY | None | None | 0.00 | F | 0.00 | N |
| 18927 | CER | NE | NW | 26 | 21N | 53E | Y | 18928 | 320.00 | 320.00 | 1,280.00 | 1,280.00 | A.G. FARM COMMODITIES, INC. | Alf, Grass Hay | Pivot | 258.00 | I | 743.65 | N |
| 18928 | CER | NE | SW | 26 | 21N | 53E | Y | 18927 | 320.00 | | 1,280.00 | | A.G. FARM COMMODITIES, INC. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 18975 | CER | SW | NE | 11 | 20N | 53E | Y | 34950 | 181.82 | 307.50 | 727.28 | 1,230.00 | SESTANOVICH HAY & CATTLE LLC | Alf | Pivot | 126.00 | I | 370.59 | N |
| 18978 | CER | SE | NE | 4 | 21N | 53E | Y | 42019, 42020 | 255.84 | | 1,023.36 | 1,111.36 | COOPER, CHARLES C. | Alf | Pivot | 240.00 | I | 705.88 | N |
| 18981 | CER | SE | SE | 4 | 21N | 53E | Y | 39553 | 156.00 | 156.00 | 624.00 | 624.00 | COOPER, ERMYLE R. | Grass Hay | Pivot | 0.00 | F | 0.00 | N |
| 18988 | CER | SE | SE | 10 | 20N | 53E | Y | 80780 | 160.00 | 160.00 | 640.00 | 640.00 | SESTANOVICH HAY & CATTLE LLC | Alf | Pivot | 126.00 | I | 370.59 | N |
| 18989 | CER | SE | NE | 10 | 20N | 53E | Y | 80781 | 160.00 | 160.00 | 640.00 | 640.00 | SESTANOVICH HAY & CATTLE LLC | None | None | -- | F | -- | N |
| 18999 | CER | SW | NE | 15 | 21N | 53E | Y | 42021 | 22.80 | 160.00 | 91.20 | 640.00 | COOPER, CHARLES E. | None | None | 0.00 | F | 0.00 | N |
| 19014 | CER | NW | NE | 5 | 21N | 54E | Y | [1] | 160.00 | 454.00 | 640.00 | 1,816.00 | J & T FARMS, LLC | Grass Hay | Pivot | 129.00 | I | 364.24 | N |
| 19052 | CER | NW | NE | 17 | 21N | 54E | Y | 18834 | 319.06 | | 1,276.23 | | NEWTON, DEBRA L. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 19053 | CER | NE | NW | 17 | 21N | 54E | Y | 18835 | 319.45 | | 1,277.80 | | NEWTON, DEBRA L. | Alf | Pivot | -- | F | -- | N |
| 19110 | CER | SW | SW | 22 | 22N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | MARK MOYLE FARMS, LLC | Grass Hay | Wheel Lines | 157.00 | I | 502.40 | N |
| 19111 | CER | SW | SW | 27 | 22N | 54E | Y | 23893 | 155.50 | 155.50 | 622.00 | 622.00 | MILES, HAROLD R. | Alf | Pivot | 58.00 | I | 170.59 | N |
| 19145 | CER | SE | SW | 32 | 23N | 54E | Y | [2] | 160.00 | 640.00 | 640.00 | 2,560.00 | MOYLE, JAMES L. | Grass Hay | Pivot | 125.00 | I | 352.94 | N |
| 19191 | CER | SW | SW | 17 | 20N | 53E | Y | 24214 | 131.08 | 281.16 | 524.30 | 1,124.62 | ANDERSON, JERRY LEE | Alf, Grain | Pivot | 119.00 | I | 350.00 | N |
| 19192 | CER | SW | SE | 18 | 20N | 53E | Y | 29765 | 149.15 | 313.20 | 596.60 | 1,252.80 | HALPIN, SANDRA L. | Alf | Pivot | 124.00 | I | 364.71 | N |
| 19218 | CER | SE | SW | 21 | 20N | 53E | Y | 21561, 24378 | 206.60 | 222.42 | 735.68 | 889.68 | CRANE, WILLIAM A. CRANE | Alf | Pivot | 162.80 | I | 478.82 | N |
| 19279 | CER | SE | SE | 7 | 21N | 53E | | | 83.00 | 83.00 | 332.00 | 332.00 | DUBRAY, FERNO L. & CARRIE M. | Alf | Pivot | 66.50 | I | 195.59 | N |
| 19292 | CER | SW | NE | 21 | 21N | 53E | | | 139.80 | 139.80 | 559.20 | 559.20 | D.V. CORPORATION | Alf | Pivot | 112.00 | I | 329.41 | N |
| 19293 | CER | SW | SE | 21 | 21N | 53E | | | 132.40 | 132.40 | 529.60 | 529.60 | D.V. CORPORATION | Alf | Pivot | 107.00 | I | 314.71 | N |
| 19324 | CER | SE | SE | 2 | 20N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | SESTANOVICH HAY & CATTLE LLC | Pasture | Pivot | 128.00 | I | 376.47 | N |
| 19360 | CER | SE | SW | 5 | 22N | 54E | | | 155.00 | 155.00 | 620.00 | 620.00 | ETCHEGARAY, LEROY W. | Alf | Pivot | 125.00 | I | 367.65 | N |
| 19361 | CER | SE | SE | 5 | 22N | 54E | | | 155.00 | 155.00 | 620.00 | 620.00 | ETCHEGARAY, LEROY W. | Alf | Pivot | 123.00 | I | 361.76 | N |
| 19378 | CER | NW | NW | 34 | 21N | 53E | Y | [3] | 244.80 | 314.00 | 979.20 | 1,256.00 | MOYLE, DUSTY L. | Alf, Grass Hay | Pivot | 227.60 | I | 669.41 | N |
| 19379 | CER | NW | NE | 33 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | MOYLE, DUSTY L. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 19381 | CER | NW | SE | 33 | 21N | 53E | | | 240.00 | 240.00 | 960.00 | 960.00 | MOYLE, DUSTY L. | Alf | Pivot | 165.00 | I | 485.29 | N |

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2014

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19411 | CER | NW | SW | 32 | 20N | 53E | | | 96.00 | 96.00 | 384.00 | 384.00 | HOMESTAKE MINING COMPANY OF CALIFORNIA | Alf | Pivot | 80.00 | I | 235.29 | N |
| 19490 | CER | | LT06 | 6 | 22N | 54E | | | 173.07 | 173.07 | 692.28 | 692.28 | SOLARLJOS LLC | None | Wheel Lines | 0.00 | F | 0.00 | N |
| 19492 | CER | NE | SE | 34 | 21N | 53E | Y | 20015 | 314.00 | 314.00 | 1,256.00 | 1,256.00 | CONLEY, BEVERLY A. AND CONLEY, KENNETH E. | Alf | Pivot | 252.00 | I | 741.18 | N |
| 19500 | CER | | LT13 | 20 | 20N | 53E | | | 166.10 | 166.10 | 664.40 | 664.40 | CONLEY LAND & LIVESTOCK, LLC | Alf | Pivot | 125.00 | I | 367.65 | N |
| 19501 | CER | SW | NW | 20 | 20N | 53E | | | 164.48 | 164.48 | 657.92 | 657.92 | CONLEY LAND & LIVESTOCK, LLC | Grass Hay | Pivot | 113.00 | I | 319.06 | N |
| 19502 | CER | SW | SE | 20 | 20N | 53E | | | 152.27 | 152.27 | 609.08 | 609.08 | CONLEY LAND & LIVESTOCK, LLC | Alf, Grain | Pivot | 95.00 | I | 279.41 | N |
| 19526 | CER | SE | SW | 15 | 20N | 53E | | | 301.00 | 301.00 | 1,204.00 | 1,204.00 | BAUMAN, JAMES E. | Grass Hay | Pivot | 253.00 | I | 714.35 | N |
| 19541 | CER | SE | SE | 28 | 21N | 53E | | | 141.30 | 141.30 | 565.20 | 565.20 | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 123.00 | I | 361.76 | N |
| 19542 | CER | NE | NE | 28 | 21N | 53E | | | 117.00 | 117.00 | 468.00 | 468.00 | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 116.00 | I | 341.18 | N |
| 19563 | CER | SE | SE | 1 | 21N | 53E | Y | 19971, 28160 | 319.87 | 319.87 | 1,279.48 | 1,279.48 | PLASKETT, TOMMYE J. | Grass Hay | Pivot | 252.00 | I | 741.18 | N |
| 19760 | CER | SE | SE | 8 | 21N | 54E | Y | 28061 | 319.00 | 319.00 | 1,276.00 | 1,276.00 | BURNHAM FARMS, LLC | Alf | Pivot | 244.00 | I | 717.65 | N |
| 19904 | CER | SE | NE | 29 | 21N | 53E | Y | 24609, 78905 | 158.00 | 280.80 | 632.00 | 1,108.14 | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 126.00 | I | 370.59 | N |
| 19965 | CER | NW | SE | 12 | 21N | 53E | Y | 78447 | 158.00 | 158.00 | 632.00 | 632.00 | RAND, JOSEPH L. AND ELLEN M. | Alf | Pivot | 130.00 | I | 382.35 | N |
| 19966 | CER | SW | NE | 12 | 21N | 53E | Y | 80581 | 156.00 | 156.00 | 218.20 | 624.00 | RAND, ELLEN M. | Alf | Pivot | 128.00 | I | 376.47 | N |
| 19971 | CER | SW | NE | 1 | 21N | 53E | Y | 19563, 28160 | 319.87 | | 779.16 | | PLASKETT, TOMMYE J. | Grass Hay | Pivot | -- | F | -- | N |
| 19972 | CER | SE | NW | 1 | 21N | 53E | Y | [4] | 320.33 | 320.33 | 1,281.32 | 1,281.32 | PLASKETT, TOMMYE J. | Alf, Grass Hay | Pivot | 251.00 | I | 723.53 | N |
| 19973 | CER | SE | SW | 1 | 21N | 53E | Y | [4] | 320.33 | | 1,281.32 | | PLASKETT, TOMMYE | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 20000 | CER | NW | NE | 34 | 21N | 53E | Y | [3] | 156.00 | | 624.00 | | MOYLE, DUSTY L. | Alf | Pivot | -- | F | -- | N |
| 20015 | CER | NW | SW | 34 | 21N | 53E | Y | 19492 | 158.00 | | 632.00 | | MOYLE, DUSTY L. | Alf | Pivot | -- | F | -- | N |
| 20046 | CER | SE | NW | 33 | 22N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | BURNHAM FARMS, LLC | Grass Hay | Pivot | 125.00 | I | 352.94 | N |
| 20087 | CER | SE | NE | 20 | 21N | 53E | Y | 24607 | 156.00 | 308.00 | 624.00 | 1,232.00 | DIAMOND VALLEY RANCH, LLC | Grass hay | Pivot | 126.00 | I | 355.76 | N |
| 20088 | CER | NE | NW | 20 | 21N | 53E | Y | 24606 | 158.00 | 312.00 | 632.00 | 1,248.00 | DIAMOND VALLEY RANCH, LLC | Grass Hay | Pivot | 126.00 | I | 355.76 | N |
| 20366 | CER | SE | NW | 22 | 22N | 54E | | | 159.58 | 159.58 | 638.31 | 638.31 | MARK MOYLE FARMS, LLC | Grass Mix | Pivot | 134.00 | I | 378.35 | N |
| 20487 | CER | NE | NW | 22 | 21N | 53E | | | 127.70 | 127.70 | 510.80 | 510.80 | MARSHALL, REESE W. | Alf | Pivot | 125.00 | I | 367.65 | N |
| 20565 | CER | SE | NW | 32 | 20N | 53E | | | 73.00 | 73.00 | 292.00 | 292.00 | EUREKA COUNTY | Pasture | Pivot | 64.00 | I | 188.24 | N |
| 20694 | CER | SE | NE | 21 | 20N | 53E | Y | 21399 | 172.22 | 253.29 | 688.88 | 1,013.16 | ETCHEVERRY FAMILY LIMITED PARTNERSHIP | Alf | Pivot | 63.00 | I | 185.29 | N |
| 21085 | CER | SE | NW | 35 | 21N | 53E | Y | 23462, 23803 | 156.40 | 327.60 | 625.60 | 1,310.40 | MILLER, ANTHONY | Alf | Pivot | 126.00 | I | 370.59 | N |
| 21399 | CER | SW | NW | 22 | 20N | 53E | Y | 20694 | 253.29 | | 1,013.16 | | ETCHEVERRY FAMILY LIMITED PARTNERSHIP | Alf | Pivot | 63.00 | I | 185.29 | N |
| 21426 | CER | SW | SE | 15 | 21N | 53E | | | 160.00 | 160.00 | 640.00 | 640.00 | MORRISON, LLOYD & BELINDA FAYE | Alf | Pivot | 127.00 | I | 373.53 | N |
| 21428 | CER | SE | NE | 11 | 21N | 53E | | | 156.00 | 156.00 | 624.00 | 624.00 | BENSON, PATTI E. AND KENNETH F. | Grass Hay | Pivot | 133.00 | I | 375.53 | N |
| 21561 | CER | SE | NW | 21 | 20N | 53E | Y | 19218, 24378 | 129.92 | | 519.68 | | EUREKA MOLY LLC | Alf | Pivot | -- | F | -- | N |
| 21839 | CER | SW | SW | 16 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | ALLEN, MAX D. | Alf | Pivot | 131.00 | I | 385.29 | N |
| 21841 | CER | SE | NW | 21 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | MICHEL & MARGARET ETHCEVERRY FAMILY LP | Alf | Pivot | 125.00 | I | 367.65 | N |
| 21843 | CER | SW | SW | 15 | 21N | 53E | | | 156.00 | 156.00 | 624.00 | 624.00 | MORRISON, BELINDA FAYE | Alf | Pivot | 123.00 | I | 361.76 | N |
| 21844 | CER | SW | NW | 15 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | COOPER, CHARLES E. | Grass Hay | Pivot | 126.00 | I | 355.76 | N |
| 21929 | CER | SW | NW | 28 | 21N | 53E | | | 157.60 | 157.60 | 630.40 | 630.40 | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 130.00 | I | 382.35 | N |
| 21930 | CER | SW | NE | 27 | 21N | 53E | | | 158.80 | 158.80 | 635.20 | 635.20 | AMERICAN FIRST FEDERAL | Alf | Pivot | 126.00 | I | 370.59 | N |
| 22194 | CER | SE | SW | 3 | 21N | 53E | | | 134.00 | 134.00 | 536.00 | 536.00 | BAILEY, TIMOTHY LEE AND CONSTANCE MARIE | Alf | Pivot | 127.00 | I | 373.53 | N |
| 22195 | CER | SE | SE | 3 | 21N | 53E | | | 155.50 | 155.50 | 622.00 | 622.00 | BAILEY, TIMOTHY LEE AND CONSTANCE MARIE | Grass Hay | Pivot | 131.00 | I | 369.88 | N |
| 22217 | CER | SE | NE | 20 | 20N | 53E | | | 163.57 | 163.57 | 654.28 | 654.28 | CONLEY LAND AND LIVESTOCK LLC | Alf | Pivot | 82.00 | I | 241.18 | N |
| 22316 | CER | SW | SE | 27 | 21N | 53E | | | 157.20 | 157.20 | 628.80 | 628.80 | AMERICAN FIRST FEDERAL | Alf | Pivot | 121.00 | I | 355.88 | N |
| 22352 | CER | SW | SE | 19 | 22N | 54E | | | 32.20 | 32.20 | 129.28 | 129.28 | MARK MOYLE FARMS, LLC | | | No Estimate | | No Estimate | |
| 22353 | CER | SW | NE | 19 | 22N | 54E | | | 158.00 | 158.00 | 632.00 | 632.00 | MORRISON, BELINDA F. | Grass Hay | Pivot | 126.00 | I | 355.76 | N |
| 22551 | CER | SE | SW | 36 | 21N | 53E | Y | 18623 | 181.69 | | 726.76 | | ALLEN, ROGER & JUDY | Alf, Grain | Pivot | -- | F | -- | N |



JA1190

SE ROA 877

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2014

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22566 | CER | SW | SE | 8 | 21N | 53E | | | 117.00 | 117.00 | 468.00 | 468.00 | MILLER, LAVON AND KRISTI | Alf, Grass | Pivot | 120.00 | I | 352.94 | N |
| 22567 | CER | SW | NE | 8 | 21N | 53E | | | 117.00 | 117.00 | 468.00 | 468.00 | MILLER, LAVON AND KRISTI | Grass Hay | Pivot | 123.00 | I | 347.29 | N |
| 22648 | CER | SW | NE | 3 | 21N | 53E | Y | 22921 | 296.72 | 296.72 | 1,186.88 | 1,186.88 | BENSON, KENNETH F. | Alf | Pivot, Wheel Lines | 271.00 | I | 856.27 | N |
| 22921 | CER | SW | NW | 3 | 21N | 53E | Y | 22648 | 296.72 | | 1,186.88 | | BENSON, KENNETH F. | Alf | Pivot, Wheel Lines | -- | F | -- | N |
| 22922 | CER | | LT01 | 2 | 21N | 53E | Y | 36321, 36322 | 161.59 | 161.59 | 646.36 | 646.36 | BENSON, PATTI E. AND KENNETH F. | Alf | Pivot | 130.00 | I | 382.35 | N |
| 22982 | CER | SW | NE | 22 | 21N | 53E | | | 315.20 | 315.20 | 1,260.80 | 1,260.80 | AMERICAN FIRST FEDERAL | Alf | Pivot | 254.00 | I | 747.06 | N |
| 23271 | CER | SE | SE | 32 | 22N | 54E | Y | 29278 | 317.70 | 317.70 | 1,270.80 | 1,270.80 | BURNHAM FARMS, LLC | Grass Hay | Pivot | 247.00 | I | 726.47 | N |
| 23272 | CER | SW | SW | 32 | 22N | 54E | Y | 28641 | 160.00 | 320.00 | 640.00 | 1,280.00 | BURNHAM FARMS, LLC | Alf, Grass Hay | Pivot | 242.00 | I | 640.00 | N |
| 23462 | CER | | LT01 | 35 | 21N | 53E | Y | 21085, 23803 | 304.00 | | 1,216.00 | | EUREKA COUNTY | Alf, Grass Hay | Pivot | 128.00 | I | 361.41 | N |
| 23711 | CER | SE | SW | 21 | 20N | 53E | Y | 23738, 23739 | 225.69 | 225.69 | 902.76 | 902.76 | EUREKA MOLLY, LLC | Alf | Pivot | 174.90 | I | 514.41 | N |
| 23738 | CER | NW | SW | 28 | 20N | 53E | Y | 23711, 23739 | 225.69 | | 902.76 | | EUREKA MOLLY, LLC | Alf | Pivot | -- | F | -- | N |
| 23739 | CER | | LT07 | 28 | 20N | 53E | Y | 23711, 23738 | 225.69 | | 902.76 | | EUREKA MOLLY, LLC | Alf | Pivot | -- | F | -- | N |
| 23803 | CER | SW | SW | 35 | 21N | 53E | Y | 21085, 23462 | 171.20 | | 684.80 | | MILLER, ANTHONY | Grass Hay | Pivot | -- | F | -- | N |
| 23893 | CER | SW | SW | 22 | 22N | 54E | Y | 19111 | 76.50 | | 306.00 | | MILES, HAROLD R. | Grass Mix | Pivot | -- | F | -- | N |
| 23918 | CER | SW | NE | 33 | 21HN | 54E | | | 11.10 | 11.10 | 44.40 | 44.40 | NORTON, WILIAM H. JR. | Alf | Pivot | 32.80 | I | 96.47 | N |
| 24127 | CER | SW | NE | 10 | 21N | 53E | Y | 24128 | 320.00 | 320.00 | 1,280.00 | 1,280.00 | CONAWAY, DALE R. | Alf, Grass Hay | Pivot | 268.00 | I | 772.47 | N |
| 24128 | CER | SW | SE | 10 | 21N | 53E | Y | 24127 | 320.00 | | 1,280.00 | | CONAWAY, DALE R. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 24129 | CER | SW | NW | 10 | 21N | 53E | Y | 24130 | 310.20 | 310.20 | 1,240.80 | 1,240.80 | MORRISON, ALBERTA J. | Alf, Grass Hay | Pivot | 254.00 | I | 732.12 | N |
| 24130 | CER | SW | SW | 10 | 21N | 53E | Y | 24129 | 310.20 | | 1,240.80 | | MORRISION, ALBERTA J. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 24214 | CER | SW | NW | 17 | 20N | 53E | Y | 19191 | 156.25 | | 624.99 | | ANDERSON, EDWARD B. | Alf, Grain | Pivot, Flood | 128.00 | I | 386.27 | N |
| 24262 | CER | SW | NW | 9 | 21N | 53E | Y | [5] | 472.00 | 472.00 | 476.52 | 1,888.00 | DIAMOND VALLEY HAY CO. | Alf, Timothy | Pivot | 489.00 | I | 476.52 | N |
| 24263 | CER | NW | NE | 9 | 21N | 53E | Y | [5] | 472.00 | | 452.40 | | DIAMOND VALLEY HAY CO. | Alf, Timothy | Pivot | -- | F | 452.40 | N |
| 24264 | CER | SW | SE | 9 | 21N | 53E | Y | [5] | 472.00 | | 928.92 | | DIAMOND VALLEY HAY CO. | Alf, Timothy | Pivot | -- | F | 495.08 | N |
| 24265 | CER | SW | SW | 9 | 21N | 53E | Y | [5] | 236.00 | | 944.00 | | DIAMOND VALLEY HAY CO. | Alf, Timothy | Pivot | -- | F | -- | N |
| 24272 | CER | SE | SW | 8 | 21N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | BURNHAM FARMS, LLC | Alf | Pivot | 120.00 | I | 352.94 | N |
| 24378 | CER | | LT04 | 21 | 20N | 53E | Y | 19218, 21561 | 74.70 | | 298.80 | | COUNTY OF EUREKA | Alf | Pivot | 38.50 | I | 113.24 | N |
| 24574 | CER | SW | SW | 8 | 21N | 53E | | | 170.17 | 170.17 | 680.68 | 680.68 | MORRISON, D. LLOYD | Alf | Pivot | 124.00 | I | 364.71 | N |
| 24605 | CER | NW | NE | 34 | 21N | 53E | Y | [3] | 79.00 | | 316.00 | | MOYLE, DUSTY L. | Alf, Grass Hay | Pivot | 22.40 | I | 65.88 | N |
| 24606 | CER | NW | SW | 20 | 21N | 53E | Y | 20088 | 308.00 | | 1,232.00 | | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | 126.00 | I | 370.59 | N |
| 24607 | CER | SE | SE | 20 | 21N | 53E | Y | 20087 | 308.00 | | 1,232.00 | | LIBERTY LIVESTOCK CO | Alf | Pivot | 126.00 | I | 370.59 | N |
| 24609 | CER | SE | NE | 29 | 21N | 53E | Y | 19904, 78905 | 280.80 | | 1,108.14 | | DIAMOND VALLEY RANCH, LLC | Alf | Pivot | -- | F | -- | N |
| 25757 | CER | NE | NE | 35 | 21N | 53E | | | 100.50 | 100.50 | 402.00 | 402.00 | BECK FAMILY TRUST | None | None | 0.00 | F | 0.00 | N |
| 26437 | CER | SE | SE | 30 | 23N | 54E | | | 127.20 | 127.20 | 508.80 | 508.80 | ALLEN, ROGER B. & JUDY B. | Alf | Pivot | 125.00 | I | 367.65 | N |
| 26664 | CER | SE | NE | 24 | 21N | 53E | | | 40.00 | 40.00 | 160.00 | 160.00 | KEPHART, MARY A. | Alf | Pivot | 33.00 | I | 97.06 | N |
| 27976 | CER | NE | SE | 2 | 21N | 53E | | | 126.12 | 126.12 | 504.48 | 504.48 | MARSHALL FAMILY TRUST | Alf | Pivot | 124.00 | I | 364.71 | N |
| 28035 | CER | SW | SE | 6 | 21N | 53E | Y | 28036 | 50.39 | 119.64 | 201.56 | 478.56 | BAILEY, CAROLYN | Grass Hay | Pivot | 50.39 | I | 142.28 | N |
| 28036 | CER | SW | SE | 6 | 21N | 53E | Y | 28035 | 69.25 | | 277.00 | | BAILEY, CAROYLN | Grass Hay | Pivot | 69.25 | I | 195.53 | N |
| 28061 | CER | NW | SE | 8 | 21N | 54E | Y | 19760 | 125.60 | | 502.40 | | BURNHAM FARMS, LLC | Alf | Pivot | -- | F | -- | N |
| 28160 | CER | | LT03 | 1 | 21N | 53E | Y | 19563, 19971 | 125.08 | | 500.32 | | PLASKETT, TOMMYE J. | Grass Hay | Pivot | -- | F | -- | N |
| 28561 | CER | NE | SW | 33 | 22N | 54E | | | 130.00 | 130.00 | 520.00 | 520.00 | BLEHM, RONALD W. | Alf | Pivot | 124.00 | I | 364.71 | N |
| 28641 | CER | SW | NW | 32 | 22N | 54E | Y | 23272 | 160.00 | | 640.00 | | BURNHAM FARMS, LLC | Grass Hay | Pivot | -- | I | 43.29 | N |
| 29278 | CER | NW | NE | 32 | 22N | 54E | Y | 23271 | 120.00 | | 480.00 | | BURNHAM FARMS, LLC | Grass Hay | Pivot | -- | F | -- | N |
| 29405 | CER | NE | NW | 8 | 21N | 53E | | | 147.83 | 147.83 | 591.32 | 591.32 | MORRISON, D. LLOYD | Alf | Pivot | 131.00 | F | 385.29 | N |



JA1191

SE ROA 878

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2014

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29557 | CER | SE | SE | 20 | 23N | 54E | | | 121.84 | 121.84 | 487.36 | 487.36 | MOYLE, JAMES L. & N. JANE | Alf | Pivot | 121.84 | I | 358.35 | N |
| 29765 | CER | SW | SE | 18 | 20N | 53E | Y | 19192 | 313.20 | | 1,252.80 | | HALPIN, SANDIE L. | Alf, Grain | Pivot | 124.00 | I | 364.71 | N |
| 29873 | CER | SE | SW | 32 | 23N | 54E | Y | [2] | 320.00 | | 1,280.00 | | MOYLE, JAMES L. | Alf | Pivot | 376.00 | I | 1,105.88 | N |
| 29895 | CER | SW | NE | 33 | 22N | 54E | | | 125.66 | 125.66 | 502.64 | 502.64 | CHANEY ASSOCIATES | Alf, Grass Hay | Pivot | 124.00 | I | 364.71 | N |
| 30102 | CER | SE | NW | 32 | 23N | 54E | Y | [2] | 320.00 | | 890.27 | | MOYLE, JAMES L. | Alf | Pivot | -- | F | -- | N |
| 30913 | CER | SW | NE | 29 | 23N | 54E | | | 119.45 | 119.45 | 477.80 | 477.80 | MOYLE, DUSTY L. | Grass Hay | Pivot | 127.00 | I | 358.59 | N |
| 30927 | CER | SE | SE | 33 | 22N | 54E | Y | 30928 | 125.66 | 125.66 | 69.12 | 502.64 | TROYER, JOHN AND LOUISE | Alf | Pivot | 125.00 | I | 69.12 | N |
| 30928 | CER | SE | SE | 33 | 22N | 54E | Y | 30927 | 125.66 | | 502.64 | | TROYER, JOHN AND LOUISE | Alf | Pivot | -- | I | 298.53 | N |
| 31062 | CER | SW | SW | 12 | 21N | 53E | | | 138.42 | 138.42 | 553.68 | 553.68 | RAND, JOSEPH L. AND ELLEN M. | Timothy | Pivot | 128.00 | I | 361.41 | N |
| 31063 | CER | SE | NW | 12 | 21N | 53E | | | 130.80 | 130.80 | 523.20 | 523.20 | RAND, JOSEPH L. AND ELLEN M. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 31108 | CER | NE | NW | 14 | 21N | 53E | | | 135.36 | 135.36 | 541.44 | 541.44 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 123.00 | I | 361.76 | N |
| 31110 | CER | NE | SW | 14 | 21N | 53E | | | 135.36 | 135.36 | 541.44 | 541.44 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 31111 | CER | NE | NE | 23 | 21N | 53E | Y | 18794 | 39.50 | | 158.00 | | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 31.00 | I | 91.18 | N |
| 31113 | CER | NE | NW | 11 | 21N | 53E | | | 133.40 | 133.40 | 533.60 | 533.60 | MOYLE, DENISE L. AND HICKS, DEANNE, M | Alf | Pivot | 124.00 | I | 364.71 | N |
| 31114 | CER | NE | SW | 11 | 21N | 53E | | | 134.40 | 134.40 | 537.60 | 537.60 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 122.00 | I | 358.82 | N |
| 31454 | CER | SE | SE | 11 | 20N | 53E | | | 130.00 | 130.00 | 520.00 | 520.00 | HALPIN, JAYME L. | Alf | Pivot | 127.00 | I | 373.53 | N |
| 31455 | CER | SE | SW | 11 | 20N | 53E | Y | 81004 | 128.03 | 140.80 | 512.12 | 563.20 | HALPIN, JAYME L. | Alf, Grass | Pivot | 112.23 | I | 330.09 | N |
| 33018 | CER | SE | NE | 16 | 21N | 53E | | | 120.00 | 120.00 | 480.00 | 480.00 | MARTIN P. & KATHLEEN A. ETCHEVERRY TRUST & ETCHEVERRY, MARK T. & | Alf | Pivot | 127.00 | I | 373.53 | N |
| 33019 | CER | SW | SE | 16 | 21N | 53E | | | 120.00 | 120.00 | 480.00 | 480.00 | MARTIN P. & KATHLEEN A. ETCHEVERRY TRUST & ETCHEVERRY, MARK T. & JENNIFER | Alf | Pivot | 122.00 | I | 358.82 | N |
| 33668 | CER | NW | NE | 20 | 21N | 54E | Y | 33669 | 305.94 | 305.94 | 1,223.74 | 1,223.74 | WISEHART, LARRY | Alf | Pivot | 126.00 | I | 370.59 | N |
| 33669 | CER | SE | SE | 20 | 21N | 54E | Y | 33668 | 305.94 | | 1,223.74 | | WISEHART, LARRY | Alf | Pivot | -- | F | -- | N |
| 33670 | CER | SW | SW | 20 | 21N | 54E | Y | 33671 | 316.18 | 316.18 | 1,264.70 | 1,264.70 | WISEHART, LARRY | Alf | Pivot | 125.00 | I | 367.65 | N |
| 33671 | CER | NE | NW | 20 | 21N | 54E | Y | 33670 | 316.18 | | 1,264.70 | | WISEHART, LARRY | Alf | Pivot | -- | F | -- | N |
| 33817 | CER | NE | NW | 27 | 21N | 53E | | | 127.90 | 127.90 | 511.60 | 511.60 | SHUEY, CHRISTENE K. AND DAVID M. | Grass Hay | Pivot | 124.00 | I | 350.12 | N |
| 33818 | CER | SW | SW | 27 | 21N | 53E | | | 127.70 | 127.70 | 510.80 | 510.80 | SHUEY, CHRISTENE K. AND DAVID M. | Grass Hay | Pivot | 124.00 | I | 350.12 | N |
| 34561 | CER | SE | SW | 19 | 22N | 54E | | | 129.00 | 129.00 | 516.01 | 516.01 | MARK MOYLE FARMS, LLC | Alf | Pivot | 124.00 | I | 364.71 | N |
| 34562 | CER | SE | NW | 19 | 22N | 54E | | | 124.87 | 124.87 | 499.48 | 499.48 | MARK MOYLE FARMS, LLC | Alf | Pivot | 124.87 | I | 367.26 | N |
| 34596 | CER | SE | NE | 7 | 21N | 53E | Y | 48225, 48226 | 237.10 | 237.10 | 501.82 | 948.40 | MORRISON, CHERYL A. | Alf | Pivot | 121.00 | I | 355.88 | N |
| 34939 | CER | SE | SW | 22 | 22N | 54E | Y | 48437 | 130.00 | 130.00 | 520.00 | 520.00 | MARK MOYLE FARMS, LLC | Alf | Pivot | 120.00 | I | 352.94 | N |
| 34948 | CER | NE | SW | 1 | 21N | 53E | Y | [4] | 126.40 | | 505.60 | | PLASKETT, TOMMYE J. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 34950 | CER | SE | NE | 11 | 20N | 53E | Y | 18975 | 125.68 | | 502.72 | | SESTANOVICH HAY & CATTLE LLC | Alf | Pivot | 125.68 | I | 369.65 | N |
| 35009 | CER | SW | NW | 16 | 21N | 53E | | | 160.00 | 160.00 | 640.00 | 640.00 | BENSON, KENNETH F. | Grass Hay | Pivot | 120.00 | I | 338.82 | N |
| 35012 | CER | NE | SW | 22 | 21N | 53E | | | 127.90 | 127.90 | 511.60 | 511.60 | GOLD STREET FARM, LLC | Alf | Pivot | 122.00 | I | 358.82 | N |
| 35013 | CER | SE | SW | 21 | 21N | 53E | | | 136.66 | 136.66 | 546.64 | 546.64 | MICHEL & MARGARET ETHCEVERRY FAMILY LP | Alf | Pivot | 124.00 | I | 364.71 | N |
| 35374 | CER | SW | SW | 7 | 21N | 53E | | | 27.11 | 27.11 | 108.44 | 108.44 | DUBRAY, FERNO L. & CARRIE M. | Alf | Pivot | 22.00 | I | 64.71 | N |
| 35375 | CER | SE | SE | 7 | 21N | 53E | | | 96.76 | 96.76 | 387.04 | 387.04 | DUBRAY, FERNO L. AND CARRIE M. | Alf | Pivot | 92.00 | I | 270.59 | N |
| 35418 | CER | | LT16 | 29 | 20N | 53E | | | 1.00 | 1.00 | 4.00 | 4.00 | RUBIO, DAVID M. | Grass | Sprikler | 1.00 | F | 3.20 | N |
| 36070 | CER | SE | SE | 32 | 23N | 54E | Y | [2] | 160.00 | | 640.00 | | MOYLE, JAMES L. | Alf | Pivot | -- | F | -- | N |
| 36321 | CER | | LT01 | 2 | 21N | 53E | Y | 22922, 36322 | 161.59 | | 304.01 | | BENSON, PATTI E. AND KENNETH F. | Alf | Pivot | -- | F | -- | N |
| 36322 | CER | | LT01 | 2 | 21N | 53E | Y | 22922, 36321 | 161.59 | | 323.18 | | BENSON, PATTI E. AND KENNETH F. | Alf | Pivot | -- | F | -- | N |
| 39156 | CER | SE | NE | 5 | 22N | 54E | Y | 55535 | 312.56 | 312.56 | 1,250.24 | 1,250.24 | ETCHEGARAY, FRED L. | Alf, Grain | Pivot | 246.00 | I | 665.65 | N |
| 39552 | CER | SE | SW | 4 | 21N | 53E | Y | 39554 | 138.03 | 138.03 | 552.12 | 552.12 | COOPER, ERMYLE R. | Alf | Pivot | 129.00 | I | 379.41 | N |
| 39553 | CER | SE | SE | 4 | 21N | 53E | Y | 18981 | 135.81 | | 543.24 | | COOPER, ERMYLE R. | Grass Hay | Pivot | 125.00 | I | 367.65 | N |
| 39554 | CER | SE | SW | 4 | 21N | 53E | Y | 39552 | 138.03 | | 552.12 | | COOPER, ERMYLE R. | Alf | Pivot | -- | F | -- | N |
| 40010 | CER | SE | NE | 32 | 21HN | 54E | Y | 40013 | 114.66 | 125.66 | 458.64 | 502.64 | MILLER, LYNFORD & SUSAN | Alf | Pivot | 114.00 | I | 335.29 | N |
| 40011 | CER | SW | NW | 32 | 21HN | 54E | Y | 40014 | 27.40 | 125.66 | 108.59 | 501.59 | BURNHAM FARMS, LLC | Alf | Pivot | 27.40 | I | 80.59 | N |

JA1192

SE ROA 879

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2014

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40013 | CER | SE | NE | 32 | 21HN | 54E | Y | 40010 | 11.00 | | 44.00 | | MILLER, LYNFORD & SUSAN | Grain | Pivot | 11.00 | I | 27.18 | N |
| 40014 | CER | SW | NW | 32 | 21HN | 54E | Y | 40011 | 98.26 | | 393.04 | | BLEHM, GLADYS A. | Alf | Pivot | 98.26 | I | 289.00 | N |
| 40402 | CER | SE | NW | 30 | 23N | 54E | | | 127.20 | 127.20 | 508.80 | 508.80 | MOYLE, DUSTY L. | Wheat | Pivot | 127.20 | I | 306.78 | N |
| 41883 | CER | | LT07 | 28 | 20N | 53E | Y | 41884 | 39.20 | 39.20 | 156.80 | 156.80 | MILLER, OWEN J. AND CHERYL | Alf | Pivot | 30.10 | I | 88.53 | N |
| 41884 | CER | | LT11 | 28 | 20N | 53E | Y | 41883 | 39.20 | | 156.80 | | MILLER, OWEN J. AND CHERYL | Alf | Pivot | -- | F | -- | N |
| 42019 | CER | SE | NW | 4 | 21N | 53E | Y | 18978, 42020 | 121.90 | | 455.24 | | COOPER, CHARLES C. | Alf | Pivot | -- | F | -- | N |
| 42020 | CER | SE | NW | 4 | 21N | 53E | Y | 18978, 42019 | 121.90 | | 88.00 | | COOPER, CHARLES C. | Alf | Pivot | -- | F | -- | N |
| 42021 | CER | SW | NE | 15 | 21N | 53E | Y | 18999 | 137.20 | | 548.80 | | COOPER, CHARLES E. | Grass Hay | Pivot | 127.00 | I | 358.59 | N |
| 42367 | CER | SE | NW | 24 | 21N | 53E | Y | [6] | 120.00 | 120.00 | 40.00 | 480.00 | KEPHART, MARI ALICE | Alf | Pivot | 120.00 | I | 40.00 | N |
| 42368 | CER | SE | NW | 24 | 21N | 53E | Y | [6] | 120.00 | | 40.00 | | KEPHART, MARI ALICE | Alf | Pivot | -- | F | 40.00 | N |
| 42369 | CER | SE | NW | 24 | 21N | 53E | Y | [5] | 120.00 | | 120.00 | | KEPHART, MARI ALICE | Alf | Pivot | -- | F | 120.00 | N |
| 42370 | CER | SE | NW | 24 | 21N | 53E | Y | [6] | 120.00 | | 120.00 | | KEPHART, MARI ALICE | Alf | Pivot | -- | F | 120.00 | N |
| 42891 | CER | SE | NW | 1 | 20N | 53E | Y | [7] | 107.61 | 107.61 | 141.77 | 430.44 | MOLL, HOLLON D. & VELMA M. | Alf | Pivot | 107.61 | I | 141.77 | N |
| 43268 | CER | NW | NE | 18 | 22N | 54E | Y | 43270, 43836 | 250.00 | 250.00 | 782.10 | 1,000.00 | KENNETH P. STENTON | Alf, Grass Hay | Pivot | 250.00 | I | 250.00 | N |
| 43269 | CER | NW | NE | 18 | 21N | 53E | Y | [8] | 130.00 | 130.00 | 76.80 | 520.00 | BLANCO RANCH, LLC | Alf | Pivot | 130.00 | I | 76.80 | N |
| 43270 | CER | NE | SW | 18 | 22N | 54E | Y | 43268, 43836 | 250.00 | | 629.38 | | KENNETH P. STENTON | Alf, Grass Hay | Pivot | -- | F | 470.59 | N |
| 43271 | CER | NW | NW | 17 | 21N | 53E | Y | [9] | 520.00 | 520.00 | 525.62 | 2,080.00 | BERG PROPERTIES CALIFORNIA, LLC | Alf, Grass Hay | Pivot | 512.00 | I | 525.62 | N |
| 43272 | CER | NW | NE | 17 | 21N | 53E | Y | [9] | 520.00 | | 525.62 | | BERG PROPERTIES CALIFORNIA, LLC | Alf, Grass Hay | Pivot | -- | F | 525.62 | N |
| 43273 | CER | SW | SW | 17 | 21N | 53E | Y | [9] | 520.00 | | 514.39 | | BERG PROPERTIES CALIFORNIA, LLC | Alf, Grass Hay | Pivot | -- | F | 454.64 | N |
| 43274 | CER | NW | SE | 17 | 21N | 53E | Y | [9] | 520.00 | | 514.39 | | BERG PROPERTIES CALIFORNIA, LLC | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 43397 | CER | SE | SW | 20 | 23N | 54E | | | 160.00 | 160.00 | 640.00 | 640.00 | MOYLE, JAMES L. & N. JANE | Alf | Pivot | 125.00 | F | 367.65 | N |
| 43836 | CER | NW | NE | 18 | 22N | 54E | Y | 43268, 43270 | 250.00 | | 1,000.00 | | KENNETH P. STENTON | Alf. Grass Hay | Pivot | -- | F | -- | N |
| 43837 | CER | NW | NE | 18 | 21N | 53E | Y | [8] | 130.00 | | 111.99 | | BLANCO RANCH, LLC | Alf | Pivot | -- | F | 111.99 | N |
| 43838 | CER | NW | NE | 18 | 21N | 53E | Y | [8] | 130.00 | | 111.99 | | BLANCO RANCH, LLC | Alf | Pivot | -- | F | 111.99 | N |
| 43839 | CER | NW | NE | 18 | 21N | 53E | Y | [8] | 130.00 | | 109.62 | | BLANCO RANCH, LLC | Alf | Pivot | -- | F | 81.57 | N |
| 43840 | CER | NW | NE | 18 | 21N | 53E | Y | [8] | 130.00 | | 109.62 | | BLANCO RANCH, LLC | Alf | Pivot | -- | F | -- | N |
| 44451 | CER | NE | NE | 28 | 22N | 54E | Y | 44452 | 303.40 | 303.40 | 576.58 | 1,213.60 | PALMORE, DONALD FRANK | Alf | Flood | 303.00 | I | 576.58 | N |
| 44452 | CER | SE | NW | 28 | 22N | 54E | Y | 44451 | 303.40 | | 640.00 | | PALMORE, DONALD FRANK | Alf | Flood | -- | F | 685.92 | N |
| 44604 | CER | NE | SW | 27 | 22N | 54E | Y | [10] | 125.70 | 125.70 | 137.36 | 502.80 | BURNHAM FARMS, LLC | Grass Hay | Pivot | 125.00 | I | 137.36 | N |
| 44605 | CER | NE | SW | 27 | 22N | 54E | Y | [10] | 125.70 | | 137.36 | | BURNHAM FARMS, LLC | Grass Hay | Pivot | -- | F | 137.36 | N |
| 44606 | CER | NE | SW | 27 | 22N | 54E | Y | [10] | 125.70 | | 18.88 | | BURNHAM FARMS, LLC | Grass Hay | Pivot | -- | F | 18.88 | N |
| 44607 | CER | NE | SW | 27 | 22N | 54E | Y | [10] | 125.70 | | 136.00 | | BURNHAM FARMS, LLC | Grass Hay | Pivot | -- | F | 59.34 | N |
| 44609 | CER | NE | SW | 27 | 22N | 54E | Y | [10] | 125.70 | | 236.80 | | BURNHAM FARMS, LLC | Grass Hay | Pivot | -- | F | -- | N |
| 44610 | CER | NE | SW | 27 | 22N | 54E | Y | [10] | 125.70 | | 120.00 | | BURNHAM FARMS, LLC | Grass Hay | Pivot | -- | F | -- | N |
| 44621 | CER | SE | NW | 36 | 21N | 53E | Y | 18621, 18622 | 206.29 | | 825.16 | | ALLEN, ROGER & JUDY | Alf | Pivot | -- | I | -- | N |
| 46287 | CER | NW | SW | 2 | 21N | 53E | | | 158.00 | 158.00 | 632.00 | 632.00 | GROTH, DANIEL E.. | Grass Hay | Pivot | 130.00 | I | 367.06 | N |
| 46348 | CER | | LT05 | 1 | 21N | 53E | Y | [4] | 131.28 | | 525.12 | | PLASKETT, TOMMYE J. | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 46461 | CER | SW | NW | 29 | 23N | 54E | | | 144.00 | 144.00 | 576.00 | 576.00 | MOYLE, DUSTY L. | Alf | Piovt | 126.00 | I | 370.59 | N |
| 46505 | CER | SW | NW | 8 | 21N | 54E | | | 127.60 | 127.60 | 510.40 | 510.40 | BURNHAM FARMS, LLC | Alf | Pivot | 126.00 | I | 370.59 | N |
| 47518 | CER | | LT05 | 29 | 20N | 53E | Y | [11] | 317.54 | 317.54 | 504.24 | 1,270.16 | ANDERSON, EDWARD B. | Alf | Pivot | 254.00 | I | 747.06 | N |
| 47519 | CER | | LT05 | 29 | 20N | 53E | Y | [11] | 317.54 | | 278.40 | | ANDERSON, EDWARD B. | Alf | Pivot | -- | F | 504.24 | N |
| 47520 | CER | | LT05 | 29 | 20N | 53E | Y | [11] | 317.54 | | 638.72 | | ANDERSON, EDWARD B. | Alf | Pivot | -- | F | 242.82 | N |
| 47521 | CER | | LT05 | 29 | 20N | 53E | Y | [11] | 317.54 | | 168.24 | | ANDERSON, EDWARD B. | Alf | Pivot | -- | F | -- | N |
| 47591 | CER | SW | NE | 30 | 23N | 54E | | | 127.20 | 127.20 | 508.80 | 508.80 | ALLEN, ROGER B. & JUDY B. | Grain | Pivot | 126.00 | F | 311.29 | N |

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2014

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48225 | CER | SE | NW | 7 | 21N | 53E | Y | 34596, 48226 | 120.58 | | 482.30 | | MORRISON, CHERYL A. | Grass Hay | Pivot | 113.00 | I | 319.06 | N |
| 48226 | CER | SE | NW | 7 | 21N | 53E | Y | 34596, 48225 | 120.58 | | 300.00 | | MORRISON, CHERYL A. | Grass Hay | Pivot | -- | F | -- | N |
| 48437 | CER | SE | SW | 22 | 22N | 54E | Y | 34939 | 130.00 | | 272.80 | | MOYLE, MARK STEPHEN | Alf | Pivot | -- | F | -- | N |
| 48871 | CER | SE | NE | 4 | 21N | 54E | Y | [12] | 213.20 | 213.20 | 296.50 | 852.70 | GALLAGHER FARMS, LLC; A NEVADA LIMITED LIABILITY COMPANY | Alf, Grass Hay | Pivot | 205.00 | I | 296.50 | N |
| 48872 | CER | SE | NE | 4 | 21N | 54E | Y | [12] | 213.20 | | 327.10 | | GALLAGHER FARMS, LLC; A NEVADA LIMITED LIABILITY COMPANY | Alf, Grass Hay | Pivot | -- | F | 297.50 | N |
| 48948 | CER | SE | SW | 6 | 21N | 53E | Y | 55272 | 119.64 | 124.78 | 478.56 | 499.12 | BAILEY, CAROLYN | Alf | Pivot | 121.00 | I | 355.88 | N |
| 49185 | CER | SE | SW | 29 | 23N | 54E | | | 125.68 | 125.68 | 502.72 | 502.72 | MOYLE, DUSTY L. | Alf | Pivot | 123.00 | I | 361.76 | N |
| 49188 | CER | SE | SW | 29 | 23N | 54E | | | 125.68 | 125.68 | 502.72 | 502.72 | MOYLE, DUSTY L. | Alf | Pivot | 125.68 | I | 369.65 | N |
| 49853 | CER | SW | SW | 7 | 21N | 53E | Y | 49854 | 29.63 | 29.63 | 118.52 | 118.52 | DUBRAY, FERNO L. & CARRIE M. | None | None | 0.00 | F | 0.00 | N |
| 49854 | CER | | LT08 | 7 | 21N | 53E | Y | 49853 | 29.63 | | 118.52 | | DUBRAY, FERNO L. & CARRIE M. | None | None | 0.00 | F | 0.00 | N |
| 50095 | CER | SE | SW | 30 | 23N | 54E | | | 127.20 | 127.20 | 508.80 | 508.80 | MOYLE, DUSTY L. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 50581 | CER | SE | NW | 6 | 24N | 53E | Y | 50582 | 275.01 | 275.01 | 249.66 | 1,100.04 | SADLER RANCH, LLC | Alf | Pivot | 235.00 | I | 249.66 | N |
| 50582 | CER | NW | SW | 6 | 24N | 53E | Y | 50581 | 275.01 | | 1,100.04 | | SADLER RANCH, LLC | Alf | Pivot | -- | F | 441.52 | N |
| 50650 | CER | SW | NW | 32 | 23N | 54E | Y | [2] | 160.00 | | 640.00 | | MOYLE, JAMES L. | Alf | Pivot | -- | F | -- | N |
| 50962 | CER | NW | NW | 13 | 23N | 52E | Y | 50963, 57838 | 75.30 | 118.30 | 129.20 | 473.20 | KOBEH VALLEY RANCH LLC | Alf | Wheel Lines | 118.30 | I | 129.20 | N |
| 50963 | CER | NW | NW | 13 | 23N | 52E | Y | 50962, 57838 | 75.30 | | 172.00 | | KOBEH VALLEY RANCH LLC | Alf | Wheel Lines | -- | I | 172.00 | N |
| 51647 | CER | SW | NW | 2 | 21N | 53E | | | 144.70 | 144.70 | 578.80 | 578.80 | GROTH, DANIEL E. | Alf | Pivot | 125.00 | I | 367.65 | N |
| 53872 | CER | NE | SW | 28 | 22N | 54E | Y | 14948 | 303.94 | | 617.20 | | PALMORE, DONALD FRANK | Alf, Grain | Flood | -- | I | 617.20 | N |
| 55535 | CER | SW | NW | 5 | 22N | 54E | Y | 39156 | 125.60 | | 502.40 | | ETCHEGARAY, FRED L. | Grain | Pivot | -- | F | -- | N |
| 55727 | CER | SE | SW | 6 | 21N | 53E | Y | 48948 | 5.14 | | 20.56 | | BAILEY, CAROLYN | Alf | Pivot | 5.14 | I | 15.12 | N |
| 56652 | CER | SE | NW | 24 | 21N | 53E | Y | [6] | 120.00 | | 160.00 | | KEPHART, MARI A. | Alf | Pivot | -- | F | 32.94 | N |
| 57835 | PER | SE | SW | 13 | 23N | 52E | | | | | 0.00 | | KOBEH VALLEY RANCH LLC | | | | | 0.00 | |
| 57836 | PER | SE | SW | 13 | 23N | 52E | | | | | 0.00 | | KOBEH VALLEY RANCH LLC | | | | | 0.00 | |
| 57838 | CER | NW | NW | 13 | 23N | 52E | Y | 50962, 50963 | 118.30 | | 172.00 | | KOBEH VALLEY RANCH LLC | Alf | Wheel Lines | -- | I | 93.13 | N |
| 57839 | PER | SE | SW | 13 | 23N | 52E | | | | | 0.00 | | KOBEH VALLEY RANCH LLC | | | | | 0.00 | |
| 57840 | PER | SE | SW | 13 | 23N | 52E | | | | | 0.00 | | KOBEH VALLEY RANCH LLC | | | | | 0.00 | |
| 63497 | CER | SE | SW | 36 | 24N | 52E | | | 120.71 | 120.71 | 408.30 | 408.30 | BAILEY, BARBARA | Alf, Grass | Pivot | 120.00 | I | 352.94 | N |
| 64630 | CER | SE | NW | 1 | 20N | 53E | Y | [7] | 107.61 | | 288.67 | | MOLL, HOLLON D. & VELMA M. | Alf | Pivot | -- | I | 185.52 | N |
| 64631 | CER | SE | NW | 1 | 20N | 53E | Y | [7] | 107.61 | | 288.67 | | MOLL, HOLLON D. & VELMA M. | Alf | Pivto | -- | F | -- | N |
| 64632 | CER | SE | NW | 1 | 20N | 53E | Y | [7] | 107.61 | | 71.71 | | MOLL, HOLLON D. & VELMA M. | Alf | Pivot | -- | F | -- | N |
| 64633 | CER | SE | NW | 1 | 20N | 53E | Y | [7] | 107.61 | | 288.67 | | MOLL, HOLLON D. & VELMA M. | Alf | Pivot | -- | F | -- | N |
| 66062 | PER | SE | SW | 13 | 23N | 52E | | | | | 0.00 | | KOBEH VALLEY RANCH LLC | | | | | 0.00 | |
| 67172 | CER | SW | SW | 34 | 21HN | 54E | | | 123.77 | 123.77 | 495.07 | 495.07 | MARK & TERESA MOYLE FAMILY TRUST | Alf | Pivot | 123.77 | I | 364.03 | N |
| 68923 | PER | NW | NW | 32 | 20N | 53E | | | 60.50 | 60.50 | 242.00 | 242.00 | EUREKA COUNTY | None | Wheel Lines | 0.00 | F | 0.00 | N |
| 70587 | CER | NE | NW | 4 | 21N | 54E | Y | [12] | 211.46 | | 123.56 | | GALLAGHER FARMS, LLC; A NEVADA LIMITED LIABILITY COMPANY | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 70588 | CER | NE | NW | 4 | 21N | 54E | Y | [12] | 205.82 | | 229.11 | | GALLAGHER FARMS, LLC; A NEVADA LIMITED LIABILITY COMPANY | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 70940 | CER | SW | SE | 19 | 22N | 54E | | | 125.68 | 125.68 | 502.72 | 502.72 | MARK MOYLE FARMS, LLC | Alf | Pivot | 125.68 | I | 369.65 | N |
| 71748 | CER | SE | SE | 8 | 22N | 54E | | | 126.70 | 126.70 | 506.80 | 506.80 | FRED L. ETCHEGARAY AND JOHN J. ETCHEGARAY, A NEVADA PARTNERSHIP | Pasture | Pivot | 128.00 | I | 376.47 | N |
| 72370 | PER | | LT02 | 7 | 22N | 54E | Y | 18242 | 320.00 | | 1,280.00 | | ANDERSEN, HARLOW B. & BONNIE G. | Alf | Pivot | -- | F | -- | N |
| 73899 | PER | SE | SW | 4 | 22N | 54E | | | 157.75 | 157.75 | 631.18 | 631.18 | DENNIS L WEST & KIM KENNEDY WEST | Alf | Pivot | 130.00 | I | 382.35 | N |
| 73570 | PER | NE | SW | 5 | 25N | 53E | Y | [13] | 305.92 | 305.92 | 33.20 | 530.00 | RENNER, IRA R. & MONTIRA | Grass Hay | Pivot | 232.00 | I | 33.20 | D |
| 73571 | PER | NE | SW | 5 | 25N | 53E | Y | [13] | 305.92 | | 128.40 | | RENNER, IRA R. & MONTIRA | Grass Hay | Pivot | -- | F | 128.40 | D |
| 73572 | PER | SE | NW | 5 | 25N | 53E | Y | [13] | 305.92 | | 128.40 | | RENNER, IRA R. & MONTIRA | Grass Hay | Pivot | -- | F | 128.40 | D |
| 73573 | PER | SE | NW | 5 | 25N | 53E | Y | [13] | 305.92 | | 240.00 | | RENNER, IRA R. & MONTIRA | Grass Hay | Pivot | -- | F | 240.00 | D |
| 76358 | PER | NE | NW | 23 | 21N | 53E | | | 136.36 | 136.36 | 545.44 | 545.44 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 122.00 | I | 358.82 | N |
| 77082 | PER | SE | NW | 13 | 24N | 52E | Y | [14] | 225.52 | 225.52 | 6.45 | 902.08 | SADLER RANCH, LLC | Grass Hay | Wheel Lines | 225.00 | I | 6.45 | N |

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2014

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 77083 | PER | SE | NW | 13 | 24N | 52E | Y | [14] | 225.52 | | 198.29 | | SADLER RANCH, LLC | Grass Hay | Wheel Lines | -- | F | 198.29 | N |
| 77569 | PER | NW | SE | 14 | 21N | 53E | Y | 81269 | 133.40 | 133.40 | 207.22 | 533.60 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 126.00 | I | 370.59 | N |
| 77646 | CER | SE | SE | 33 | 21HN | 54E | Y | [15] | 256.06 | 256.06 | 123.60 | 1,024.24 | WILLIAM H NORTON | Alf | Pivot | 256.06 | I | 123.60 | N |
| 77665 | PER | NW | SE | 27 | 23N | 54E | Y | 77666 | 165.00 | 165.00 | 153.76 | 547.88 | JOSEPH L RAND AND ELLEN M RAND REVOCABLE LIVING TRUST DATED MAY 9 1996 | Alf | Pivot | 128.00 | I | 153.76 | N |
| 77666 | PER | SE | NW | 27 | 23N | 54E | Y | 77665 | 165.00 | | 394.12 | | JOSEPH L RAND AND ELLEN M RAND REVOCABLE LIVING TRUST DATED MAY 9 1996 | Alf | Pivot | -- | F | 222.71 | N |
| 77695 | CER | SE | SE | 33 | 21HN | 54E | Y | [15] | 256.06 | | 469.92 | | WILLIAM H NORTON | Alf | Pivot | -- | F | 469.92 | N |
| 77696 | CER | SE | SE | 33 | 21HN | 54E | Y | [15] | 256.06 | | 295.12 | | WILLIAM H NORTON | Alf | Pivot | -- | F | 159.60 | N |
| 78062 | PER | NW | NE | 14 | 21N | 53E | | | 157.00 | 157.00 | 628.00 | 628.00 | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | 121.00 | I | 355.88 | N |
| 78447 | PER | NW | SE | 12 | 21N | 53E | Y | 19965 | 158.00 | | 0.00 | | RAND, JOSEPH L. AND ELLEN M. | Alf | Pivot | -- | F | -- | N |
| 78568 | CER | NW | NW | 34 | 21HN | 54E | | | 81.95 | 81.95 | 327.80 | 327.80 | MARK & TERESA MOYLE FAMILY TRUST DATED 12/22/1999 | Alf | Pivot | 81.95 | I | 241.03 | N |
| 78771 | PER | NW | SE | 4 | 20N | 53E | Y | [16] | 257.20 | 257.20 | 362.40 | 1,028.80 | J.W.L. PROPERTIES, LLC | Alf, Grass Hay | Pivot | 257.00 | I | 362.40 | N |
| 78772 | PER | | LT16 | 4 | 20N | 53E | Y | [16] | 257.20 | | 128.00 | | J.W.L. PROPERTIES, LLC | Alf, Grass Hay | Pivot | -- | F | 128.00 | N |
| 78773 | PER | | LT16 | 4 | 20N | 53E | Y | [16] | 257.20 | | 398.40 | | J.W.L. PROPERTIES, LLC | Alf, Grass Hay | Pivot | -- | F | 250.42 | N |
| 78774 | PER | SW | SE | 4 | 20N | 53E | Y | [16] | 257.20 | | 52.00 | | J.W.L. PROPERTIES, LLC | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 78775 | PER | SW | SE | 4 | 20N | 53E | Y | [16] | 257.20 | | 88.00 | | J.W.L. PROPERTIES, LLC | Alf, Grass Hay | Pivot | -- | F | -- | N |
| 78905 | PER | SW | NE | 28 | 21N | 53E | Y | 19904, 24609 | 274.80 | | 1,099.20 | | DIAMOND VALLEY RANCH LLC | Alf | Pivot | -- | F | -- | N |
| 78906 | PER | SW | NE | 28 | 21N | 53E | | | 146.10 | 146.10 | 584.40 | 584.40 | DIAMOND VALLEY RANCH LLC | None | None | 0.00 | F | 0.00 | N |
| 80581 | PER | SW | NE | 12 | 21N | 53E | Y | 19966 | 156.00 | | 405.80 | | RAND, JOSEPH L AND ELLEN M | Alf | Pivot | -- | F | -- | N |
| 80717 | CER | SW | SE | 32 | 21HN | 54E | Y | [17] | 78.00 | 155.00 | 136.00 | 620.00 | NORTON, WILLIAM H JR AND PATRICIA A | Alf | Pivot | -- | F | -- | N |
| 80718 | CER | SE | SW | 33 | 21HN | 54E | Y | [15] | 256.06 | | 135.60 | | NORTON, WILLIAM H JR | Alf | Pivot | -- | F | -- | N |
| 80780 | PER | SE | SE | 10 | 20N | 53E | Y | 18988 | 160.00 | | 640.00 | | SESTANOVICH HAY & CATTLE LLC | Grass Hay | Pivot | -- | F | -- | N |
| 80781 | PER | SE | NE | 10 | 20N | 53E | Y | 18989 | 160.00 | | 640.00 | | SESTANOVICH HAY & CATTLE LLC | None | None | -- | F | -- | N |
| 80879 | CER | SW | SE | 32 | 21HN | 54E | Y | [17] | 77.00 | | 249.52 | | NORTON, WILLIAM H JR AND PATRICIA A | Alf | Pivot | -- | F | -- | N |
| 80880 | CER | SW | SE | 32 | 21HN | 54E | Y | [17] | 78.00 | | 87.28 | | NORTON, WILLIAM H JR AND PATRICIA A | Alf | Pivot | -- | F | -- | N |
| 80881 | CER | SW | SE | 32 | 21HN | 54E | Y | [17] | 78.00 | | 44.00 | | NORTON, WILLIAM H JR AND PATRICIA A | Alf | Pivot | -- | F | -- | N |
| 80926 | CER | SW | SE | 32 | 21HN | 54E | Y | [17] | 155.00 | | 103.20 | | NORTON, WILLIAM H JR | Alf | Pivot | 155.00 | I | 455.88 | N |
| 81004 | PER | SE | SW | 11 | 20N | 53E | Y | 31455 | 12.77 | | 51.08 | | HALPIN, JAYME L | Alf | Pivot | 12.77 | I | 37.56 | N |
| 81268 | PER | SE | NE | 32 | 23N | 54E | Y | [2] | 320.00 | | 1,280.00 | | MOYLE, JAMES L AND N JANE | Alf, Grain, Grass | Pivot | -- | F | -- | N |
| 81269 | PER | NE | SE | 14 | 21N | 53E | Y | 77569 | 133.40 | | 207.22 | | MOYLE, DENISE L. AND HICKS, DEANNE M. | Alf | Pivot | -- | F | -- | N |
| 81650 | PER | | LT15 | 21 | 20N | 53E | | | 26.61 | 26.61 | 106.45 | 106.45 | EUREKA MOLLY, LLC | | | No Estimate | | No Estimate | |
| 83615 | PER | NE | NW | 5 | 21N | 54E | Y | [1] | 158.00 | | 189.36 | | J & T FARMS, LLC | None | None | 0.00 | F | 0.00 | N |
| 83616 | PER | NE | SW | 5 | 21N | 54E | Y | [1] | 136.00 | | 544.00 | | J & T FARMS, LLC | None | None | 0.00 | F | 0.00 | N |
| 83617 | PER | SE | NW | 5 | 21N | 54E | Y | [1] | 158.00 | | 442.64 | | J & T FARMS, LLC | None | None | 0.00 | F | 0.00 | N |
| 83672T | PER | NE | NW | 24 | 24N | 52E | Y | [14] | 225.52 | | 895.63 | | SADLER RANCH, LLC | Alf | Wheel Lines | -- | F | 342.96 | N |
| 83673T | PER | NW | SE | 23 | 24N | 52E | Y | [14] | 225.52 | | 6.45 | | SADLER RANCH, LLC | Alf | Wheel Lines | -- | F | -- | N |

**Total Suplementally Adjusted Permitted/Certificated Acreage** 31,425.10
**Total Suplementally Adjusted Permitted/Certificated Pumpage** 124,700.08

**Total Estimated Acreage** 24,676.39
**Total Estimated Pumpage** 73,135.66

## Crop Inventory and Groundwater Pumpage for Irrigation - Diamond Valley - Basin 153, 2014

| App No | Status | QQ | Q | Sec | Twn | Rng | Sup | Supplemental Application Number | Permitted Acres | Supplementally Adjusted Permitted Acres | Permitted Duty Acre-Feet | Supplementally Adjusted Duty Acre-Feet | Owner of Record | Crop Type | Irrigation Method | Irrigated Acres | Acreage Estimation Method | Acre-Feet Pumped | Pumpage Estimation Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

[1] PERMITS 19014, 83615, 83616 AND 83617 HAVE A TOTAL COMBINED DUTY OF 1,816.00 AFA.

[2] PERMITS 19145, 29873, 30102, 36070, 50650 AND 81268 HAVE A TOTAL COMBINED DUTY OF 2,560.00 AFA.

[3] PERMITS 19378, 20000 AND 24605 HAVE A TOTAL COMBINED DUTY OF 2,560.00 AFA.

[4] PERMITS 19972, 19973, 34948 AND 46348 HAVE A TOTAL COMBINED DUTY OF 1,281.32 AFA.

[5] PERMITS 24262, 24263, 24264 AND 24265 HAVE A TOTAL COMBINED DUTY OF 1,888.00 AFA.

[6] PERMITS 42367, 42368, 42369, 42370 AND 56652 HAVE A TOTAL COMBINED DUTY OF 480.00 AFA.

[7] PERMITS 42891, 64630, 64631, 64632 AND 64633 HAVE A TOTAL COMBINED DUTY OF 430.44 AFA.

[8] PERMITS 43269, 43837, 43838, 43839 AND 43840 HAVE A TOTAL COMBINED DUTY OF 520.00 AFA.

[9] PERMITS 43271, 43272, 43273 AND 43274 HAVE A TOTAL COMBINED DUTY OF 2,080.00 AFA.

[10] PERMITS 44604, 44605, 44606, 44607, 44609 AND 44610 HAVE A TOTAL COMBINED DUTY OF 502.00 AFA.

[11] PERMITS 47518, 47519, 47520 AND 47521 HAVE A TOTAL COMBINED DUTY OF 1,270.16 AFA.

[12] PERMITS 48871, 48872, 70587 AND 70588 HAVE A TOTAL COMBINED DUTY OF 852.7 AFA.

[13] PERMITS 73570, 73571, 73572 AND 73573 HAVE A TOTAL COMBINED DUTY OF 530.00 AFA.

[14] PERMITS 77082, 77083, 83672T AND 83673T HAVE A TOTAL COMBINED DUTY OF 902.08 AFA.

[15] PERMITS 77646, 77695, 77696 AND 80718 HAVE A TOTAL COMBINED DUTY OF 1,024.24 AFA.

[16] PERMITS 78771, 78772, 78773, 78774 AND 78775 HAVE A TOTAL COMBINED DUTY OF 1,028.8 AFA.

[17] PERMITS 80717, 80879, 80880, 80881 AND 80926 HAVE A TOTAL COMBINED DUTY OF 620.00 AFA.